EXPLORING THE ADOPTION OF THE NHS COVID-19 APP TO MANAGE THE COVID-19 PANDEMIC IN ENGLAND AND WALES: A SOCIOTECHNICAL PERSPECTIVE

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Doctor of Philosophy

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SEPTEMBER 2024

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Abstract

The quick spread of the COVID-19 pandemic prompted governments to adopt digital technologies as part of their strategies to manage the public health crisis. In England and Wales, the National Health Service (NHS) COVID-19 application (app) was created as a digital contact tracing tool to aid in the containment of the pandemic. This research investigates the app's mobilisation, promotion, and impacts. A sociotechnical framework is utilised to analyse the interconnectedness of technological design, policy structures, and societal acceptance. The study employs sociotechnical systems theories as theoretical lenses through which to comprehend how government agencies, private tech companies, healthcare organisations and public involvement influenced rates of uptake of the app.

This interdisciplinary research adopts a qualitative methodology; policy documents, government reports and promotional content are examined to evaluate how the app was conceived, promoted, and woven into pandemic response frameworks. The results indicate that the effective implementation of the NHS COVID-19 app necessitated collaboration across various sectors, as government entities ensured regulatory adherence, technology firms developed software frameworks, and public health bodies integrated the app into larger healthcare systems. Despite these collaborative endeavours, issues such as privacy concerns, public doubts, and challenges related to digital accessibility impacted adoption rates. The research reveals that efforts to build trust, such as the creation of clear data policies, focused public outreach and adaptive governance, enhanced public confidence over time.

The app was promoted through various channels, including government advertisements, endorsements from public figures, and social media influencers, which also carried initiatives to combat misinformation. Although the use of the app improved the efficiency of contact tracing and facilitated the fast identification of at-risk individuals, its

effectiveness was limited by technical issues (such as Bluetooth accuracy), data privacy worries, and inequalities in digital access. These observations highlight that technology alone does not ensure positive public health results—successful digital health interventions must involve systemic integration, public trust, and continual policy evolution.

This research adds to the scholarly conversation surrounding the adoption of digital health governance as it provides actionable insights for policymakers, healthcare providers, and technology creators. It emphasises the importance of transparent governance, interdisciplinary cooperation, and user-centred design in digital health projects. Digital health technologies that address equity issues, ethical considerations, and healthcare integration will be more effective enhancers of public health resilience during future emergencies.

Keywords: COVID-19, digital health, NHS COVID-19 app, sociotechnical systems, public health, contact tracing, governance

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Examiners: Dr Atta Addo and Professor Victoria Uren.

DEDICATION

I want to dedicate this thesis to God for giving me strength, to my wife, Constance Tweneboah, and to my children, Leola, Martinson, Christenson, and Mary Akomaning (my mother-in-law), for their unwavering sacrifices and support in many ways. I also want to dedicate it to my dad (Mr Joseph Kyere), Mum (Mrs Dora Antwiwaa), my brothers (Mr Takyi Johnson, Mr Joseph Kyeremeh, Mr Alexander Yeboah), and my sisters (Mrs Rose Yeboah, Mrs Janet Akosah) in Ghana, who have always prayed for me and encouraged me. Additionally, I dedicate it to my late sister, Grace Kisiwaa and late brother, Isaac Amponsah, who unfortunately did not live to see my academic journey; they would have been proud of me.

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LISTS OF ABBREVIATIONS

AES - Advanced Encryption Standard

ANT – Actor-Network Theory

API - Application Programming Interface

BBC - British Broadcasting Corporation

BLE - Bluetooth Low Energy

BMA - British Medical Association

BPS - British Psychological Society

CT - Computed Tomography

DHSC - Department of Health and Social Care

DPIA-Data Protection Impact Assessment

GDPR - General Data Protection Regulation

GPs - General Practitioners

H&M - Hennes & Mauritz

ICO - Information Commission Office

IT - Information Technology

NHS - National Health Service

ONS - Office for National Statistics

ORG - Open Rights Group

PHE - Public Health England

PM-Prime Minister

RCN - Royal College of Nursing

RQs. - Research Questions

SPJ - Society of Professional Journalists

UX - User Experience

WHO - World Health Organisation

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CHAPTER 1: INTRODUCTION

1.1 Opening Remarks

The COVID-19 pandemic prompted a substantial global shift towards digitised healthcare solutions (Alsaad and Al-Okaily, 2022). Incorporating innovative technological tools into healthcare strategies became increasingly important as the virus violently disrupted normal life. Digital resources transitioned into essential instruments for monitoring and controlling disease transmission. Contact tracing applications, such as the NHS COVID-19 app used in England and Wales, significantly aided nations' defence against the impact of the virus (Kendall et al., 2023) . This worldwide crisis emphasised technology's central role in healthcare and underscored the urgent need for advancements to navigate such perilous landscapes (Ming et al., 2020). Consequently, technology has catalysed transformative changes within healthcare practices, highlighting the importance of surveillance improvement, enhancing communications channels, and radically altering public emergency intervention techniques (Mora et al., 2021). These developments collectively show how digital inventions can counteract challenges like COVID-19, redefining how we approach future crises (Senbekov et al., 2020).

The NHS COVID-19 app developed in England and Wales has been widely recognised as a valuable tool during the pandemic. It is praised for its user-friendly design and seamless performance, contributing to the digital transformation of critical healthcare processes. This mobile application has encouraged other healthcare providers to enhance their operational processes and improve patient care protocols. Additionally, it has been noted for its role in addressing unmet needs and fostering stronger relationships among stakeholders in the healthcare sector.

The utilisation of the NHS COVID-19 app has demonstrated how technology can improve healthcare delivery and significantly enhance public health outcomes(Tello-Leal et al., 2016) . This and similar apps have revolutionised patient care by facilitating proactive measures based on real-time data analysis (Burton et al., 2022; Trincado-Munoz et al., 2024). Digital interventions, including the NHS COVID-19 app, were crucial in ensuring continuous care during the pandemic, particularly for vulnerable groups such as nursing home residents (Su et al., 2020). However, concerns about privacy standards need to be rigorously addressed when using new technologies (Dasgupta, 2023).

This research on the implementation and increased usage of the NHS COVID-19 app provides insights into the significant role of modern telemedicine in managing a crisis

such as a pandemic (Kendall *et al.*, 2023). Additionally, it includes information on how local areas responded and how the app was integrated into a more comprehensive public policy strategy. Despite the challenges associated with deploying digital solutions in crisis conditions (Griffin et al., 2022), integrating a mobile-phone-centred wellness solution could still positively affect general levels of health satisfaction. The information gathered from multiple sources suggests the usefulness of technological tools in enhancing the quality of collective wellness journeys (Senbekov *et al.*, 2020; Burton *et al.*, 2022). There are practical implications for introducing a technological element to serve patients. Trustworthiness and ethical considerations were found to be crucial for digital-based contact tracing efforts (Robbins et al., 2021). Observational results on the adoption- or preference-influencing factors provide insight into patient behaviours and needs (Panchal et al., 2021).

Researchers have studied factors influencing the adoption and retention of the NHS COVID-19 mobile app, shedding light on user attitudes towards digital health strategies (Panchal et al.,2021). Analysis of the use of such apps during public health crises has provided insights into the future trajectory of digital healthcare. It underscores the significant role of these technologies in managing emergent public health threats (Idris et al., 2021). The NHS COVID-19 app's contribution to the pandemic response highlights the importance of innovation and adaptability in healthcare systems (Pierobon et al., 2022).

1.2. Background of the study

From late 2019 to throughout 2020, healthcare systems worldwide encountered substantial challenges due to the SARS-CoV-2 virus, which sparked the COVID-19 pandemic (Adhikari et al., 2020; Konrad et al., 2020). The World Health Organisation's declaration of a global emergency in February 2020 triggered various country-specific responses to combat the crisis (Bashier et al., 2021). This pandemic exposed vulnerabilities in healthcare systems globally, highlighting the essential need for comprehensive strategies to manage health crises (Ornell et al., 2020). According to (Gumel et al. (2021), overcoming such significant challenges requires strengthening healthcare strategies across all fronts.

Digital technology, including mobile apps to trace potential infections, was crucial in combating COVID-19. Companies like Google and Apple developed tracing apps that prioritised user privacy. These apps successfully helped users reduce their possible exposure to the virus (Bassolas et al., 2021). Research, such as that conducted on the contact tracing apps, indicates that these apps did play a role in controlling the virus

(Dave and Gupta, 2021). Studies have shown that apps that track individuals' close contacts can help to impede the spread of a virus (Ferretti et al., 2020; Kendall et al., 2023). The way that people perceive these apps is shaped by their encounters with the virus and their overall health (Mustafa et al., 2022; Zhang and Wu, 2020). Recent research indicates that these health apps played a crucial role in swiftly identifying cases, promptly notifying individuals and containing the spread of the virus, thereby significantly contributing to crisis management. These apps should be integrated into broader health strategies, including communication, testing, and tailored plans that address specific illnesses and interpersonal interactions (Juul and Strogatz, 2023). However, Williams et al. (2021) highlighted that privacy concerns should be carefully weighed against the benefits of utilising these apps. Longitudinal studies indicate evolving attitudes, emphasising the importance of safeguarding privacy in these endeavours (Simko et al., 2022). Daniore et al. (2021) state that digital tracking can significantly contribute to controlling pandemics when considering disease modelling.

Considering the context in which the NHS COVID-19 app in England and Wales was launched is crucial in assessing its adoption, implementation and efficacy. The app was introduced as part of a broader strategy for managing the pandemic, considering the regions' specific social, political, and technological circumstances (Alsaad and Al-Okaily, 2022). At its launch, the urgent need to scale up contact tracing measures was essential for public health efforts to control virus transmission.

Key factors, such as the severity of COVID-19 cases at that time and the healthcare infrastructure capacity, influenced the initial rollout strategies. Government responses also played a significant role in shaping the app's adoption among users. The level of digital literacy in the communities served, and considerations regarding data protection and governance trust issues were also crucial in determining its societal acceptance (Kendall *et al.*, 2023).

The development of decentralised designs for user privacy rights was undertaken with the understanding that their success would depend substantially on fostering confidence amongst all end-users, irrespective of regional diversity (Troncoso et al., 2020). The creation of politically intensive applications faced repercussions from other crisis containment activities conducted by governmental bodies, further complicating the communications between surveillance agencies tasked with maintaining operative watch over disease outbreaks (Garett and Young, 2022). Innovative technological specialists introduced brand-new specifications onto the digital stage, necessitating interdepartmental collaboration between tech companies and traditional medical

facilities to address challenges related to functionality, accessibility, system compatibility, and compliance with current legislation (Troncoso *et al.*, 2020).

1.3. Research Problem

This research examines the digital adoption in public health crisis management through an investigation of the use of the NHS COVID-19 app during the pandemic. It employs a sociotechnical perspective, analysing the interaction between technological advancements, societal structures, and the institutions that implement digital health interventions. The study investigates how the nation adapted to new technologies for healthcare management in response to the COVID-19 crisis. This event prompted the convergence of the development and implementation of technological solutions at the national level and required active citizen participation. This study investigates how various sectors—national authorities, health institutions and the public—contributed to the successful adoption of the app to manage health crises in England and Wales. The app was designed to reduce virus transmission and ensure adherence to safety guidelines. To enable its use, regulatory measures were applied to guide its integration into public health management, while the government worked to raise awareness and to encourage user engagement.

From a broader perspective, the study examines how societal elements are integrated with the tools at hand, and this offers critical insights into the overall context. Of significance was the influence of pre-existing systems and ethical considerations, particularly regarding data handling, which shaped people's preparedness for intervention strategies. Data collected on the app covers its development to implementation, which was aimed at addressing challenges posed by the COVID-19 pandemic.

A detailed examination highlights the NHS's essential efforts to leverage a technical solution to combat health crises while maintaining open dialogue with the public. This communication was a key to the building of trust for the app's adoption. Rather than relying solely on established infrastructure of health, the initiative depended heavily on collaboration among various stakeholders. This teamwork ultimately demonstrated the solution's reliability, showcasing how the app was positioned to achieve its intended objectives.

User privacy and security concerns significantly shaped recruitment and advertising strategies, thereby influencing public confidence. The media played a significant role in the moulding of public opinion, and this shows how perceptions could sway discussions

around contact tracing. This feedback loop enabled the assessment of shifting political decisions and determined how successes and shortcomings could be addressed moving forward.

The exploration of the NHS COVID-19 app exemplifies how societies adapt digital solutions to address their unique needs, existing systems, and global challenges. The use of technology must be balanced with public involvement while adhering to ethical standards and political frameworks. This experience effectively enhances our understanding of how health technologies can be integrated into public healthcare systems and suggests promising ways to manage future health crises.

1.4. Rationale for the study

The study is significant as it investigates into a relatively novel and underexplored area. It examines the utilisation of digital health tools, such as the NHS COVID-19 app, and their integration into lives and society. Unlike previous studies that primarily focused on the technological aspects of user perspectives, this research centres on how these tools interact with the broader societal context. The investigation focuses on the NHS COVID-19 app, utilising the sociotechnical framework to analyse the interconnectedness of the app's features and societal usage. This approach aids in gaining insights into the app's efficacy or inefficiency during the pandemic. It is a two-way approach that focuses on the reciprocity of society's influence on the app's design and how it impacted society after it was deployed into the population. The study examines the utilisation of digital health tools, particularly the NHS COVID-19 app, during health crises in real-world settings. The research provides practical examples of how the app and similar technologies integrate into healthcare systems and influence people's behaviour, beliefs and regulations.

Additionally, the study identifies effective methods for raising awareness about digital health tools by analysing the promotion of the NHS COVID-19 app, highlighting the interconnectedness of technology, societal trust and community engagement. The research provides insights into improving digital health projects by incorporating new perspectives within the sociotechnical framework. It offers practical advice and addresses knowledge gaps, providing details to enhance the development, dissemination and use of technology tools such as the NHS COVID-19 app. The analysis of how the app was shared and used and its impact during the pandemic offers valuable guidance for the future creation and implementation of digital health tools. These findings

hold significant relevance for shaping public health strategies in the future.

The study examines the impact of digital health tools, such as the NHS COVID-19 app, during a health crisis. It highlights significant challenges, including logistics, technical issues, and user acceptance, that require to be addressed for effective utilisation. This information is pertinent for health leaders and policymakers to prepare for emergencies where these technologies could be crucial. Additionally, the study provides insights into how the app was promoted to increase user adoption, offering recommendations for future efforts to generate public interest in digital health tools. The research indicates that various communication methods, including traditional media, social platforms and local community engagement, effectively built trust and overcame apprehensions. This data can inform improved strategies for communicating health-related information to the public, ensuring increased understanding and utilisation of these tools for potential future benefits.

The findings related to the NHS COVID-19 app have demonstrated the potential of digital health in enhancing disease management. The app was found to have played a significant role in disease tracking, virus transmission prevention and support for healthcare delivery. These findings offer valuable perspectives for creating resilient digital healthcare systems to tackle future health crises. Moreover, the research underscores the significant influence of human-technology interaction on the success of health programmes, going beyond mere technological proficiency. This understanding can contribute to formulating health strategies that consider both technological aspects and societal dynamics, ensuring that technology aligns with people's lives in beneficial ways.

Analysing the implementation, marketing approach, and impact of the NHS COVID-19 app offers an essential example for understanding and making informed decisions in healthcare situations. The rapid emergence of COVID-19 necessitated prompt and effective measures, with this app playing a complementary role in England and Wales’s crisis management strategies. Understanding the widespread adoption of digital healthcare tools, as demonstrated by the rapid dissemination of this app, provides valuable insights for improving future coordination among relevant stakeholders. This ensures that similar tools can be deployed more efficiently and effectively during urgent situations. However, applying these insights to future healthcare initiatives requires thorough evaluation.

The investigation presented in this thesis has focused on approaches to promote user acceptance of software and encourage public participation in modern technological

advancements. This analysis aims to uncover the most effective approaches to addressing users' reservations and gaining trust while promoting extensive use. The findings will provide valuable insights for shaping engagement models in the future.

This analysis will provide valuable insights for the development of future applications. A comprehensive analysis of the factors contributing to success or failure will offer helpful guidance for healthcare professionals and policymakers in making informed decisions regarding technology-based treatments. My primary objective is to offer a close analysis of the above aspects. The research aims to create improved strategies and assist the implementation of digitalised healthcare services to enhance the country's overall well-being and effectively prepare for future challenges.

1.5. Research objectives and questions

The research aims to comprehensively understand the impact of the NHS COVID-19 app on pandemic management and its broader implications for digital healthcare in England and Wales. The key objectives of this inquiry include:

1**.** *Exploring the Mobilisation of the NHS COVID-19 App:* The journey of the NHS COVID-19 app, from development to deployment and its role in managing public health during the pandemic, involved collaboration between government agencies, healthcare providers and technology companies. The rollout faced various challenges but ultimately led to the app becoming an essential tool in public health management.

2. *Analysing Strategies for Promoting the App's Adoption:* This goal examines how the public were encouraged to use the app. It centres on communication and outreach initiatives, encompassing traditional and social media utilisation, community participation, and engagement with influencers and local authorities. The objective is to evaluate the effectiveness of these different strategies in fostering adoption and gaining public trust while identifying and addressing any obstacles.

3. *Assessing the Impact of the NHS COVID-19 App on Pandemic Management*: This task focuses on assessing the role of mobile applications in mitigating COVID-19 repercussions. Specifically, we will examine their capacity to strengthen contact tracking measures, curb virus spread and provide relief for the health infrastructure. The technological performance of these apps as a tool against the pandemic will be evaluated, including user adherence to guidelines within the apps and the measurement of any reduction in spreading instances due to the functioning of the digital platform.

4. *Examining the Broader Implications for Digital Healthcare:* The NHS COVID-19 app is also analysed for its potential impact on the future of healthcare technology. This

involves assessing the app's contribution to integrating technology into the healthcare system and identifying lessons for adopting new technology in the future. Additionally, observations are made regarding public perceptions of digital health, concerns about health data security, and the potential advancements in technology within the healthcare sector.

The investigation examines the app's role in addressing critical questions about combating the pandemic and enhancing digital healthcare. This includes an analysis of the app's functionality, its dissemination, and its impact. The research questions central to the study are as follows:

Table 1. The thesis research questions and their brief explanations

No	Research Questions	Explanation
1	**How was the NHS COVID-19 app mobilised to manage the COVID-19 pandemic in England and Wales?**	This query examines the app's development and implementation strategies, emphasising collaboration between various stakeholders and the challenges faced during the process.
2	**What strategies were employed to promote the adoption of the NHS COVID-19 app in England and Wales?**	This question explores the various marketing strategies used to increase public adoption of this app. It includes examining how communication strategies, influential individuals and local governing bodies contributed to building trust in the product and overcoming doubts or uncertainties
3	**How did the NHS COVID-19 app shape pandemic management and digital healthcare in England and Wales?**	This inquiry focuses on exploring the role of one specific application in managing and controlling disease outbreaks. This includes examining its ability to improve contact tracing and slow the spread of viruses. The conversation also extends into broader discussions about digital healthcare, including the impact on public sentiment and potential future technological advancements.

Source: Author

The theory of sociotechnical is applied to examining the role of the NHS COVID-19 app

within healthcare. It seeks to understand the interactions between human behaviour, technological innovations, and institutional factors that impact public acceptance and utilisation of high-tech tools in healthcare. The theory is crucial for studying strengthening outcomes and shaping the future of healthcare in the UK.

1.6. Theoretical Framework

The application of an analytical framework that integrates sociotechnical perspectives provides a new lens through which to examine the NHS COVID-19 app with a focus on the interactions between technology and social processes. This approach is informed by Systems Theory, which was primarily articulated by Ludwig von Bertalanffy and emphasises that system functionality arises from the synergy of interacting components rather than the analysis of isolated elements (Bertalanffy, 1969; Grekousis and Liu, 2021). Baxter and Sommerville support this notion by advocating a comprehensive examination of technical and social factors to uncover the complexities of system dynamics (Kendall et al., 2023). By combining Actor-Network Theory (ANT), Systems Theory, and Structuration principles, it is possible to analyse strategies related to and the societal consequences of the adoption of this app within public health contexts. While sociotechnical theories provide insights into broad sociotechnical dynamics, sociomateriality theory is used selectively to explain the elements that influence mutual agreement and acceptance of technological changes, such as trust.

With contributions from scholars such as Bruno Latour and Michel Callon, the use of ANT facilitates exploration of the relationships between human and non-human entities that influence technology acceptance and subsequent policy outcomes (Callon, 1998; Dong et al., 2023; Latour, 2007). The ANT approach highlights interdependence and co-evolution, challenging conventional divisions between social and technical realms (Frimpong et al., 2022). Use of the ANT to examine the NHS COVID-19 app offers insights into the collaborative dynamics among stakeholders such as government agencies, medical organisations, developers, and end-users. These interactions shape trust levels and management of privacy concerns and legal considerations, which affect the overall acceptability and utility of the app (Jonker et al., 2020; Samuel and Sims, 2023). The involvement of key entities, such as the Department of Health and Social Care and NHS Digital, underscores their role in influencing public narratives and the outcomes that are associated with technology implementation.

Bertalanffy's Systems Theory serves as a valuable framework through which to

understand the NHS COVID-19 app as part of a more significant public health infrastructure. According to Systems Theory, system functionality emerges from the synergistic interactions among its components (Heaton et al., 2024). This perspective is particularly pertinent in the evaluation of the app's integration into a nation's government policies, technological capacities, and user engagement, which collectively enhance contact tracing capabilities and facilitate the mitigation of viral transmission (Petersen and Krisjansen, 2015). Iterative improvements to the app—in response to user feedback and technical challenges—illustrate how sociotechnical systems evolve based on ongoing interactions among diverse stakeholders (Mellor et al., 2023). Historical data from the app's implementation emphasises the importance of integrated systems as they point to significant public engagement and the app's consequential role in salutary effects such as preventing infections, hospitalisations, and fatalities (Markussen, 2023).

Incorporation of Structuration Theory, as posited by Giddens, deepens the analysis as it can be used to explain the reciprocal relationship between human agency and social structures (Giddens, 1984; Von Wyl et al., 2021). Unlike ANT's focus on the actors, Structuration Theory provides insights into how institutional norms, public policies, and individual behaviours dynamically shape and are simultaneously shaped by the adoption of technology. Structural analysis of the use of the NHS COVID-19 app helps to clarify how shifting public health regulations, evolving user engagement, and policy adjustments influenced the ongoing development and utilisation of the app over time. For instance, the decision to opt for a decentralised processing model reflected heightened public concern about data privacy and security, and underscored the interplay between government actions and societal attitudes (Parnell and Plant, 2024).

The adoption of a multidisciplinary sociotechnical perspective that interweaves ANT, Systems Theory, and Structuration Theory is beneficial for several reasons. Primarily, it provides a comprehensive understanding of complex interactions because it captures the intricate relationships among technology, public health, and societal behaviours (Polojärvi et al., 2023). Unlike Sociomateriality, which often prioritises the technical aspects of technology, the use of a sociotechnical lens offers a structured way to analyse health adoption by encompassing a variety of dimensions such as policymaking, governance, user behaviour, and the adaptability of technology (Patorniti et al., 2018). Additionally, this approach is responsive to the dynamic nature of public attitudes and institutional adaptations, acknowledging that tools such as the NHS COVID-19 app are continually shaped by society's evolving demands and expectations (Balloni and Targowski, 2015). Finally, the integration of these theories enriches the study's analytical

framework by mapping relational dynamics and system-wide interconnections while accounting for the fluid interaction between human agency and institutional structures over time (Da Bernardo et al., 2021).

Despite its merits, the employment of a sociotechnical approach has limitations. For example, the broad viewpoint of Systems Theory on interactions risks over-generalisation (Heaton et al., 2024). Furthermore, the application of ANT may introduce methodological complexities, as its use requires a detailed mapping of interconnected actor relationships, and this poses challenges for studies that rely primarily on document-based data (Frimpong et al., 2022). Structuration Theory's focus on dynamics and its use of normative norms and agency necessitates a nuanced understanding of regulatory decisions and their sociotechnical implications, which may not be gleaned easily through historical exploration (Polojärvi et al., 2023). To address these complexities, this study adopts a focused approach that employs ANT selectively to illuminate actor relationships, Systems Theory to evaluate interdependencies, and Structural Theory to examine the use of institutional frameworks and agency interactions within the COVID-19 context.

Use of this sociotechnical perspective offers a salient analytical approach through which to assess rigorously the adoption, governance, and societal impacts of the NHS COVID-19 app. Such an investigation should yield valuable insights into the critical role of digital health technologies in crisis management. By aligning the theoretical framework with the study's document analysis, a precise understanding emerges of the interconnectedness of technology and social elements in shaping public health outcomes.

1.6.2 Establishment of a Theoretical Foundation that Integrates Social and Technological Perspectives

Examination of the domain of digital health technology, particularly the NHS's COVID-19 application, necessitates integration of social and technological perspectives. The application of a sociotechnical framework enables an in-depth exploration of the complex interactions among various stakeholders and the socio-institutional structures that impact the development and utilisation of these technologies (Balloni and Targowski, 2015) This approach transcends a focus on material aspects alone and illuminates the reciprocal influences between technology and society through the application of the three comprehensive theoretical frameworks.

Within the ANT framework, insights from theorists such as Latour and Callon explain how technological systems evolve and the complex connections among both individuals

and objects. In the NHS COVID-19 app, this framework underscores the dynamic interactions that occurred among government and public health officials, technologists, and end-users, each of whom contributed to the app's trajectory from development to deployment and its subsequent integration into daily life.

The app's development necessitated extensive collaboration and negotiation among all stakeholders, who significantly influenced its design and the acceptance of its use across heterogeneous communities (Sharma et al., 2024). Moreover, during its use, the app was acknowledged as an active participant in broad healthcare strategies and played an important role in the healthcare ecosystem. Research conducted by (Huang et al., 2022) highlights that the app's privacy features were shaped primarily by public apprehensions regarding data security, suggesting that societal perceptions, rather than solely technical considerations, were instrumental in the evolution of these features (Walrave et al., 2020).

Complementing ANT, Systems Theory (Checkland, 1981; Leavitt, 1965) offers a holistic framework for understanding how the NHS COVID-19 app functioned within a more extensive public health system. It can be used to explain the operational dynamics within a country-specific context across the entire healthcare value chain. Analysis of how the system functions is best achieved by observing various components' interactions and contributions and their resultant effects. Checkland (1981) advocates that although components may operate independently, their collaborative efforts are directed toward the achievement of a common objective. The success of contact tracing services hinges on a harmonious interaction among public sector leadership, technological innovation and user communities, all underpinned by constructive feedback mechanisms that facilitate feature evolution and periodic enhancements based on user insights (Malik et al., 2022). The iterative quality of this process is evident and portrays a progressively evolving healthcare strategy that prioritises the alignment of technology with the needs and behaviours of the populace.

The use of Systems Theory illuminates the complexities of implementation and suggests that it unfolds over time and is influenced by factors that include regulations, human behaviour and operational constraints. The NHS COVID-19 app is a compelling case study as it illustrates how a balance between community well-being and individual privacy can be achieved, primarily through the use of a distributed database system (Sharma et al., 2024).

Structuration Theory adeptly illustrates the interconnected relationship between

individual choices and societal regulatory practices in the context of the NHS COVID-19 app. Giddens' theoretical contributions posit that community norms inform macro-level regulations and therefore guide individual behaviours. Conversely, it is also argued that everyday micro-level actions and practices of individuals significantly contribute to the shaping, development, and transformation of societal norms within a complex and reciprocal framework. Research has examined the links between public health policies and app development and has shown that user adoption or resistance plays a pivotal role in shaping institutional responses (Sharma et al., 2024). Growing concerns over data privacy have prompted changes to apps. Key adjustments include the adoption of localised data management techniques that improve their alignment with public expectations of digital healthcare innovations (Walrave et al., 2020). Since the success of these solutions relies on user acceptance, their technical design is crucial.

The potential to adapt technical solutions to societal values suggests a more significant use of such technology. Utilising a combination of ANT, Systems Theory, and Structuration Theory provides a strong framework by which to evaluate the effectiveness of the NHS COVID-19 app to enhance public health services. The ANT highlights interactions among diverse stakeholders, Systems Theory addresses overarching principles, and Structuration Theory emphasises the continuous interaction between societal practices and technological progress. Together, the application of these theories offers a comprehensive understanding of how future advancements can be tailored to meet the complex demands of a techno-social environment.

Concerns about privacy and safety related to interconnected devices remain significant. Studies indicate that worries over data security can impact user motivation to adopt specific tools. Consideration of public apprehensions about misuse underscores the necessity for structural integrity and transparency in data management practices (Caillaud et al., 2022). Furthermore, design decisions for health applications, such as the NHS COVID-19 app, are shaped by various factors, including legal frameworks, societal viewpoints, and ethical standards. Research by Huang et al. (2022) emphasises that the adoption of a decentralised data model was crucial to address public concerns about surveillance and civil liberties (Walrave et al., 2020). This suggests that technological solutions often mirror broad societal conversations, and this highlights the interplay between technology and its social environment. Long-term studies on user adoption rates have revealed significant links between privacy apprehensions and perceptions of an app’s effectiveness.

The conflicting desires for personal security and effective contact tracing have sparked

ongoing debates around the ethical integration of health technologies (Martin, 2020). Research indicates that the maintenance of user trust hinges on balancing strong safety protocols with user-friendly apps that meet public healthcare needs (Flors-Sidro et al., 2021).

Evidence suggests that consumers are more willing to embrace these tools if there is transparent communication regarding data-use policies and robust protection features (Walrave et al., 2020). Exploring how these factors contribute to effective crisis management could offer valuable insights into the complexities that are inherent in digital health solutions.

The use of research systems such as ANT, systems methodology or Structuration perspectives can deepen our understanding of intricate digital mechanisms that are increasingly adopted. This approach could pave the way for advancements and stimulate community discussions on various issues, from confidentiality and effectiveness to building mutual trust and fostering cooperation—primarily through the use of knowledge-sharing platforms in large-scale public safety and crisis management situations.

1.7 Significance of the Study

1.7.1 Theoretically Informed Understanding of Sociotechnical Theory and Digital Health Technologies

The study contributes to a theoretically informed understanding of sociotechnical theory but is not intended to extend it. It uses a meta-theoretical approach (Allana and Clark, 2018) to examine the interconnected impacts of technology systems, societal constructs, and individual actions that are related to digital health tools such as the NHS COVID-19 app. By employing ANT, Systems Theory, and Structuration Theory, this research emphasises that these technologies are not merely products but are embedded within a network of social and institutional interactions that shape their creation and operation.

According to Latour and Callon, the ANT perspective provides valuable insights into how various stakeholders—such as government bodies, developers, medical professionals, and users—have influenced the adoption rates and functional characteristics of the NHS COVID-19 app(Booth et al., 2016; Latour, 2007). Investigation of the collaborations among these entities reveals significant insights regarding public trust dynamics and privacy concerns that have impacted the app's design and adherence to regulatory standards.

For instance, research shows that there is a negative relationship between civic beliefs about government legitimacy and the usage patterns of contact tracing applications

(Samuel et al., 2021). Additionally, data indicates that there is a strong relationship between rates of user engagement with apps and the effectiveness of outbreak response rollouts, especially when robust privacy protection measures and communication strategies are in place (Dowthwaite et al., 2022, 2021).

Systems Theory provides a framework through which to understand each aspect of digital health software solutions. Its use indicates that an ecosystem-level approach improves the effectiveness of population-wide healthcare initiatives. Checkland and Leavitt suggest that complex, interconnected relationships are established and that these lead to swaying and patterns within policy directives that are influenced by technology and social behaviours. Iterative feedback loops result in the ongoing adaptation of technology, informed by user input, which contributes to critical improvements in usability and user experience (Palmer et al., 2024).

It is essential to recognise that these digital health tools operate as part of a multifaceted public health monitoring and prevention framework rather than as standalone utilities. User feedback, regulatory guidelines, and approved doctrines significantly shape the technology supply chain. Structuration Theory highlights the dual nature of social structures and human agency in shaping behaviour. This theory illustrates how individual practices and macro-level institutional policies interact and evolve in response to one another. The NHS COVID-19 app is a prime example of the evolving relationship between institutions and users. Key principles such as personal data protection and regulatory frameworks have significantly shaped its development. User behaviour, especially in response to concerns about privacy and government oversight, has driven substantial app changes. Early versions faced backlash due to fears of data misuse, which led developers to implement decentralised data structures. This shift ultimately bolstered user trust and engagement (Walrave et al., 2020). It is crucial to incorporate design elements that nurture public trust and comply with legal standards, as these factors enable the app's acceptance within the digital healthcare landscape.

This study highlights the various elements that influence user interactions, societal norms that are endorsed by different groups, and institutional frameworks that set guiding principles—all of which contribute to the effectiveness of health interventions. Strategic communication is key to the fostering of transparency and confidentiality, shaping societal perceptions, and encouraging higher adoption rates, as demonstrated in the literature (Phillips et al., 2021).

Additionally, it is essential to consider the socioeconomic impacts of health interventions that are aimed at entire communities. Research suggests that awareness campaigns and positive media representation can boost the adoption of health practices on both national and global scales (Caillaud et al., 2022).

However, the implementation of such technologies often meets scepticism, particularly concerning government responses to public health crises. These doubts can erode societal trust in healthcare systems and impede user adoption (Palmer et al., 2024). Therefore, the application of ANT and systems thinking within a Structuration framework allows for a more nuanced understanding of the diverse perspectives that influence digital health adoption, as shown by the NHS app.

This analysis underscores the complex interplay of societal, cultural, and organisational factors and technical elements that help to ensure the successful acceptance and integration of digital health solutions. The insights from this study could provide valuable guidance for policymakers as they navigate the changing landscape of digital health initiatives.

1.7.3 Dual Impact: Application of Sociotechnical Theory as an Explanatory Framework and to Inform Practical Decision-Making

This research has two primary objectives.

1. To utilise sociotechnical theories to analyse digital health technology interactions: The theory is applied to investigate the functioning of digital health tools, such as the NHS COVID-19 app, within complex sociotechnical contexts. It examines how social factors such as privacy concerns, trust in government entities, and public health policies interact with the specific characteristics of technology that shape digital healthcare interventions (Leonardi, 2011; Orlikowski, 2007). Drawing on real-world data from a global medical crisis provides insights into how these technologies operate within interconnected societal and technical systems without challenging existing theoretical models.

2. To inform practical decisions in healthcare settings: The research offers practical guidance regarding the design and implementation of digital health solutions based on insights from the NHS COVID-19 app's effectiveness. Key factors that contributed to successful outcomes are identified and presented as part of practical development advice to create integration strategies that align with societal norms and institutional frameworks (Dowthwaite et al., 2021).

The recommendations drawn from this study emphasise the use of strategies for building public trust and transparent communication practices that address concerns about data breaches or misuse of personal information while effectively engaging diverse demographic groups. This is key to the successful implementation of novel digital health technology (Kendall et al., 2023).

This research employs sociotechnical theories to enhance understanding of the interrelationship between technological innovations and social structures. This approach facilitates analytical clarity and provides practical guidance for organisations that seek to advance digital initiatives in the professional landscape.

1.8. Research Methodology Overview

Health technology and society are interconnected, particularly in the context of public health initiatives. The creation of new digital health innovations, such as the NHS COVID-19 app, in a way that ensures that they are acceptable across society and cultures, is a significant study area. This can be analysed through the application of sociotechnical theory, which provides insights into how these technologies can be integrated into societal frameworks and institutions to align with human behaviour. This theory acknowledges the complexity of such integration; scholars such as Cresswell highlight that technological systems are influenced by their social contexts (Cresswell et al., 2010).

The study emphasises the necessity of understanding both the technological components and the social factors that affect the adoption and utilisation of these systems. Researchers such as Leonardi underscore the importance of examining the relationship between technology and society, suggesting that this understanding is vital for tracking their co-evolution (Parthasarathy et al., 2024).

Interactions among public health policy, user engagement, and digital systems are multifaceted. The application of ANT and Structuration Theory facilitates the examination of the intricate relationships between individuals, technology, and institutions (Carey et al., 2014; Mindell et al., 2024; Troshani and Wickramasinghe, 2014). Employment of qualitative research methods enables in-depth analysis of these interactions to reveal how social and technical elements influence the design and implementation of digital health technologies.

Foundational research by Trist and Bamforth on sociotechnical systems highlights the importance of human participation in organisational operations (Mindell et al., 2024; Trist and Bamforth, 1951). Utilisation of ANT facilitates an understanding of how interactions among individuals and non-individual elements contribute to the overarching landscape of public health technology (Troshani and Wickramasinghe, 2014). A comprehensive examination of legislation and promotional documents reveals lawmakers' motivations in addressing disparities between established benchmarks and actual outcomes. Research by Huang et al. emphasises the necessity of such analyses to identify challenges related to the integration of decentralised data structures and the assurance of user privacy within digital healthcare frameworks (Carey et al., 2014; Cresswell et al., 2010). This underscores the critical role of the perceived simplicity within public health records, which can often obscure significant gaps between policy design and implementation.

Guided by the principles of ANT and other sociotechnical theories, this study aims to investigate the factors that influence the development and governance of digital health technologies, taking into account the sociocultural and political contexts that shape healthcare policymaking (Banda, 2017; Carey et al., 2014; Mindell et al., 2024).

The study encourages the promotion of general health programmes by leveraging the communication dynamics among traditional network actors. It aims to identify the relationships that connect individuals to innovative modelling techniques. These relationships are integral to the informing of strategies that support the effectiveness and scaling of breakthrough technologies in public healthcare, and that ensure that these technologies meet the established requirements. The aim is to recognise collaborative efforts and acknowledge the advancements made within established research protocols and practices (Parthasarathy et al., 2024; Troshani and Wickramasinghe, 2014).

1.9. Structure of the thesis

The chapters of the thesis will review and address the goals and objectives outlined above as well as presenting the overall findings of the research. The following is a summary of the content of each chapter.

Chapter 2: Literature Review and Theoretical Framework

Chapter 2 involves two main objectives: a comprehensive review of existing research and an in-depth analysis of the analytical method. The research examines various studies on digital health technologies and public healthcare strategies to identify potential gaps this study seeks to address. Additionally, the study will explore the applicability of sociotechnical theory in understanding significant phenomena, including the influence of various factors on behaviour, such as the NHS COVID-19 app, which is the primary focus. Integrating past research with the theoretical framework chosen for this study can yield valuable insights and contribute to expanding knowledge in this field.

Chapter 3: Research Methodology

Chapter 3 focuses on the research project plan, which collects qualitative data by evaluating policy documents and identifying primary sources. It also discusses the challenges faced during the study and ethical considerations. Discussing these elements is essential for maintaining scientific integrity and establishing trustworthiness. A well-planned research design ensures transparency in the methods used, minimising potential confusion. Additionally, highlighting any limitations or obstacles helps to

anticipate unforeseen issues and instils confidence in the reliability of the results. This approach contributes to a thorough and systematic methodology.

Chapter 4: Analysis of the NHS COVID-19 App's Mobilisation

Chapter 4 explores the development and implementation of the NHS COVID-19 app in attempting to manage the COVID-19 pandemic in England and Wales. It explores the steps taken by various stakeholders for successful implementation and discusses the challenges encountered during the initial phase. Moreover, it assesses the application's effectiveness in ongoing public health endeavours. Examining the processes and dynamics involving stakeholders in rolling out the app aims to provide insights into the challenges and achievements in integrating digital health resources into broader population-wide healthcare programmes.

Chapter 5: Analysis of Promotion and Adoption Strategies

Chapter 5 presents the marketing strategies employed to generate interest in acceptance of the app among users. It examines the effectiveness of these techniques in addressing user concerns and instilling confidence. Analysing public responses to the marketing efforts for the NHS COVID-19 app yields valuable insights into understanding the prerequisites for promoting widespread engagement. Examining the promotional strategies employed offers crucial insights into the factors propelling society's embrace of health-focused digital technologies, which can enhance future medical interventions aimed at public health.

Chapter 6: Impact of the NHS COVID-19 App on Pandemic Management and Digital Healthcare

Chapter 6 examines the impact of the NHS COVID-19 app on public health outcomes: specifically, its role in enhancing contact tracing and curbing the spread of viruses is explored. The app's broader implications for advancing digital healthcare are also investigated. This section evaluates how effectively the NHS COVID-19 application has met its public health objectives, a crucial research focus. Moreover, it delves into the potential repercussions of this technology as a model for the progression of digital healthcare, considering future trends and possible applications.

Chapter 7: Discussion

In Chapter 7, previous analysis and the research objectives are bridged through employment of a sociotechnical theory framework. The aim is to utilise this established model of sociotechnical understanding, which examines the interplay among technology, social structures and organisational norms, to address key questions. In this chapter, I present observations that have implications for real-world applications while summarising the inquiry process. The results are critically examined through the use of sociotechnical theories, focusing on established theories and related queries. The aim of Chapter 7 is to distinguish academic contributions from practical applications, particularly in digital health practices and policymaking, through systematic data-driven exploration.

Chapter 8: Conclusion

The concluding chapter consolidates the study's findings while acknowledging any associated limitations. Additionally, it proposes potential avenues for future research and offers actionable recommendations to improve public health strategies. This section also delves into the potential impact of insights from digital health research on related fields. The main goal is to provide a comprehensive summary, highlighting fundamental discoveries and emphasising their importance. Furthermore, the chapter suggests new areas that warrant future investigation and underscores the practical guidance and scholarly rigour that should underpin these studies, highlighting their educational value and global impact.

1.10. Chapter Conclusion

The introductory chapter has presented crucial themes, focusing on the researched subject's significance, objectives, underlying questions, and theoretical perspectives. It has also emphasised the importance of the NHS COVID-19 app relative to other health technology solutions and public health initiatives.

This study is significant because it contributes to addressing existing research gaps and offers valuable insights with both theoretical and practical implications. The groundwork laid here sets the stage for more detailed analyses in the following chapters, highlighting the significance of the research findings and their expected impact, to be further discussed as the thesis develops.

CHAPTER 2: LITERATURE REVIEW: A CASE STUDY OF MANAGEMENT STRATEGY THROUGH THE NHS COVID-19 APP

2.1 Introduction

As part of this investigation to assess the app's mobilisation during its implementation across England and Wales, from encouraging (promoting) adoption among citizens to how it helped in curbing virus transmission and advancing healthcare technology, the literature review will incorporate insights from sociotechnical theory (Bertalanffy, 1969; Da Bernardo et al., 2021; Patorniti et al., 2018)which examines the interplay between technology and society, to offer a more profound comprehension of the relationship between technology and social practices.

The literature review will cover three principal areas, corresponding to the themes of the research questions. It is structured around the analysis of the app's deployment, promotion and impact, illuminating its technological, societal, and healthcare ramifications in the distinct setting of England and Wales. The review thus intends to provide an in-depth understanding of the role of the NHS COVID-19 app in managing COVID-19 and its consequential shaping of digital healthcare. Concentrating on England and Wales offers an intricate view of the app's incorporation into a specific healthcare system and socio-political framework; hence, the thesis aims to make a significant contribution to knowledge in the field of digital health technology and public health policy. This analysis is informed by sociotechnical theory (Checkland, 1981; Patorniti et al., 2018) and supported by constructs and empirical data from selected documents.

The literature review is structured as follows: The rationale for the study (section 2.1.1) clarifies the purpose of the research, underscoring the significance of examining pandemic management through the app in the context of England and Wales. Section 2.2 provides the background, offering a concise history of previous pandemics and a brief summary of the COVID-19 pandemic, focusing particularly on England and Wales, the context of the study. Section 2.3 covers the theoretical framework, focusing on the key principles of sociotechnical theory relevant to digital technology, such as the NHS COVID-19 app, in social contexts, especially in healthcare and pandemic management. Section 2.4 contains a review of related literature and the literature review selection process; Section 2.5 highlights the areas left unexplored by the existing studies and the consequent gaps in knowledge that the current research aims to address. Section 2.6 considers the practical implications for the research questions. Section 2.7 provides definitions of keywords used in the thesis

Finally, section 2.8 synthesises the key themes and findings from the literature, summarising the critical insights and contributions of the review.

2.1.1 Rationale for the Literature Review

To control the COVID-19 pandemic, England and Wales adopted digital measures such as the NHS COVID-19 app. This kind of technology now plays a major role globally in managing public health crises, and analysing its impact offers insights into technological future. The innovation of these tools is evident – they have introduced new methods for tackling infectious diseases; in particular, Ferretti et al. (2020) suggest that technologies like contact tracing apps are invaluable as they can significantly enhance epidemic control.

Sociotechnical theory advances this observation by asserting that society is deeply intertwined with technological innovations (Leavitt, 1965; Patorniti et al., 2018)Rethought this perspective, it becomes evident that how users interacted with and responded to the NHS COVID-19 app created distinct patterns in personal practices, behavioural trends and institutional developments, a phenomenon recently witnessed on a global scale for the first time.

Exploring the usage, distribution, promotion and impact of these tools becomes more profound when we examine the broader context involving various digital aids – such as telehealth services and contact tracing programmes – as extensively discussed in the literature, for instance by Whitelaw et al. (2020). This in-depth exploration becomes increasingly vital as I consider the serious ethical issues related to policy instruments that have become widespread, especially during times of public crisis. As highlighted by Lucivero et al. (2020), it is essential to ensure that the deployment of a comprehensive healthcare system does not inadvertently infringe upon individual rights.

In a highly specialised healthcare landscape, case studies offer an inside look at how implementation impacts outcomes, greatly benefiting from the unique external factors. The intelligence gathered is rich, providing valuable lessons and experiences that can guide the direction of next-generation intelligent technology integration in the COVID era and subsequent health-focused strategies (Yin, 2014). These investigations significantly contribute to the dialogue on the digitisation of medicine, transforming scientific findings and theories into real-world applications.

2.2. Background Information

Historically, pandemics in the United Kingdom have significantly influenced public health

responses and strategies, with each outbreak contributing to the evolution of control measures and healthcare infrastructure. The Black Death in the 14th century saw primitive quarantining and public space closures as primary responses, due to limited understanding of disease transmission (DeWitte, 2015). In the 1600s, London's Great Plague led to the adoption of measures such as social distancing, quarantine zones and plague pits to slow the spread of disease (Wohlwend et al., 2017). The cholera pandemics of the 19th century marked significant advancements in disease control; for example, John Snow discovered cholera's transmission through water (Hollin et al., 2017). Following the Spanish flu epidemic in 1918, measures like isolating sick persons and promoting better personal hygiene practices became popular as they were understood to reduce transmission (Spinney, 2017).

Historically, the management of epidemics, ranging from basic strategies to advanced public health strategies, has established a clear route for effectively addressing health crises.

2.2.1. Pandemic Management Before COVID-19: Historical Approaches and Strategies

In this section, I examine historical pandemic response strategies; key measures such as disease surveillance, isolation of the sick, public health awareness campaigns, vaccination efforts, treatment protocols, global collaboration and mobility restrictions will be discussed. These measures indicate that specific approaches to managing pandemics have remained consistent but adapted as society and technology progress.

1. Observation and Monitoring

Disease surveillance is a critical aspect of pandemic control. Historically, monitoring the spread of a disease relied on human-based reports from hospitals and local officials. For instance, during the 1918 Spanish Flu, tracking its spread depended on fragmented communication from sources such as health departments and death records (Taubenberger and Morens, 2006). The lack of a centralised system at that period led to slower response times. Similar approaches were used during cholera outbreaks in the 1800s, with surveillance mainly dependent on individual doctors and regional health boards reporting local observations. The absence of national or global alert systems made effective containment challenging once an outbreak was recognised. However, more recently, advancements in digital tools such as the World Health Organisation's

Global Influenza Surveillance Response System have proven valuable in addressing pandemics, as demonstrated during the H1N1 influenza outbreak in 2009 (WHO, 2011). Reflecting on past pandemics before COVID-19 underscores the limitations of older surveillance methods, which struggled to effectively communicate findings across broad areas due to slower technologies.

2. Quarantine and Isolation Measures

Before the development of vaccines or antiviral treatments, quarantine and isolation had been essential strategies in controlling pandemics. The term ‘quarantine’ dates back to medieval times, during the Black Death plague, when Venetian ports imposed 40 days of isolation on incoming ships. This method aimed to contain any diseases on board, although its success varied due to differing practices across cities (Bailey, 2022; Benedictow, 2020).

Moving forward to the Spanish Flu, public health officials enhanced quarantine measures by closing schools and entertainment venues like theatres. Philadelphia's delayed implementation of these rules resulted in tragically high death rates compared to the swift actions of St. Louis (Hatchett et al., 2007). This emphasised the importance of implementing measures promptly and in a coordinated manner.

Quarantine continues to play a crucial role in managing pandemics today, partly due to the lessons learned from past events such as SARS (2003) and the H1N1 pandemic (2009), where isolating those with cases was a game-changer in stopping the spread of viruses (Shieh et al., 2010).

3. Public Health Campaigns and Communication

During pandemics before COVID-19, governments relied on public announcements to inform the public to take necessary actions when required. These campaigns traditionally used newspapers, posters and radio shows to reach people effectively. During the Spanish Flu era, officials used signboards and newsprint to promote hand hygiene, wearing masks, and avoiding crowded spaces. "Coughs and sneezes spread diseases" was a famous catchphrase promoting hygienic habits (Spinney, 2017). Similarly, the global response to the HIV/AIDS pandemic (1980s-present) heavily emphasised public education on safe practices, including the use of prophylactics and awareness of viral transmission methods. This initiative involved active participation from governments, NGOs and advocates, highlighting the importance of coordinated communication (Kaiser

Family Foundation, 2019). While approaches may have evolved with technological advancements, the primary goal of educating the public to reduce transmissions has remained consistent across all pandemics.

4. Vaccination Campaigns

Vaccines administered over the centuries have played an integral role in pandemic control. The development and availability of vaccines varied significantly depending on the specific pandemic. For example, Edward Jenner's creation of the smallpox vaccine in 1796 marked a significant advancement in managing global health crises through vaccination strategies. Widespread immunisation campaigns over many years and sometimes centuries helped to contain and eventually eradicate smallpox by 1980 (Malacrida, 1989). This demonstrates how extensive international efforts towards vaccinations have successfully overcome lethal diseases.

In another example, during the waves of polio epidemics in the 20th century, Jonas Salk's introduction of the vaccine in 1955, along with Albert Sabin's addition in 1961, significantly reduced instances of the disease, ultimately saving many lives and preventing debilitating impairments (Weihl, 1971).

However, a contrasting response was observed when implementing containment strategies specific to the H1N1 influenza that spread globally in 2009 (Amato-Gauci et al., 2011). Although remedies are typically extensively researched before being swiftly developed after identification of the disease, the initial understanding of the H1N1 influenza had been established before the crisis, enabling a survivable solution to be achieved, albeit after the initial waves had already caused a significant impact.

5. Treatment Approaches

During the Spanish Flu pandemic a century ago, medical practitioners had limited means to tackle the virus. The remedies of that period revolved around resting and staying hydrated while alleviating any symptoms present. Due to a lack of antibiotics, individuals often struggled against influenza and subsequent infections (Barry, 2004). However, during later years in the twentieth century, life-saving treatment innovations bolstered our readiness for such health emergencies.

Similarly, the early stages of HIV/AIDS resulted in countless lives lost due to the absence of effective remedies, but this situation was radically transformed with the invention of antiretroviral therapies (ART). This new form of treatment was established by the mid-

1990s, turning an erstwhile lethal disease into a manageable chronic condition (Palella et al., 1998).

Such vital leaps forward embody how crucial technological progression and medical advancements are in combating public health crises; they reduce fatalities from diseases and ameliorate the prospects for patients. Research is thus vitally important as new developments have a huge impact on societal welfare. The potential here is enormous: providing solutions to address the most critical healthcare challenges worldwide and ultimately saving countless human lives.

6. International Cooperation

Past disease outbreaks have influenced the evolution of collaboration in combating global health crises. The 19th-century cholera epidemics led to attempts at forming international cooperation with shared objectives, such as standardising quarantine protocols and establishing effective communication about diseases (Huber, 2006). This initiative gradually evolved into the World Health Organisation (WHO), which continues to facilitate worldwide joint efforts during public health crises. During the SARS outbreak in 2003, the WHO played a pivotal role in encouraging data dissemination and highlighting novel research insights, leading towards enhanced strategies to counter virus spread (Peiris et al., 2003). Similarly, during the H1N1 flu outbreak, following guidelines issued by the WHO significantly curbed further spread of the disease (WHO, 2011).

These experiences underscore the importance of international collaboration against common threats, especially in dealing with challenging situations in today's globally interlinked world. Cooperation on the global front is automatically strengthened when governments are jointly combating major threats to public health, making overcoming challenges more conceivable and essential.

7. Travel Restrictions and Border Controls

Efforts to control the spread of severe diseases have historically involved measures such as travel limitations and border controls. During Europe's Black Death era, strict regulations were implemented to govern trade and movement in many cities, preventing individuals from leaving plague-stricken locations (Bailey, 2022). While these measures somewhat slowed disease proliferation, they were not consistently enforced or initiated early enough to avoid widespread contagion.

International travel restrictions were minimal during the Spanish Flu pandemic, but some municipalities attempted to limit regional movement. However, the transit of soldiers from different countries during the First World War accelerated the spread of the flu (Crosby, 2003).

Similarly, when the H1N1 pandemic hit, countries issued timely travel advice and implemented strict border controls. However, these measures had minimal success in slowing down the rapid worldwide spread of what became a swiftly evolving health crisis (Shieh et al., 2010). While it has some shortcomings, restricting movement continues to be a practised method for reducing the spread of severe diseases.

Drawing on past experiences and well-documented resources has enabled the UK's adaptability and implementation capabilities, reflecting a sophisticated understanding of outbreak response. These historical events and their associated healing efforts have shaped the recent global response, particularly the UK's approach to the recent pandemic, COVID-19. This is evident in the NHS's operational style and its preparedness, which have played a crucial role in managing this particular crisis (Alderwick et al., 2021; Warfield, 2016). Insights from past events, such as the cholera and Spanish flu outbreaks, have been instrumental in informing decision-making for rapid and impactful interventions in the present, primarily involving modern surveillance and community initiatives (Faye and Jaksland, 2021; Senbekov et al., 2020).

The rapid distribution of COVID-19 vaccines highlights Britain's extensive experience with vaccination campaigns. The significant implications also underline the importance of vaccinations in managing infectious diseases (Chen et al., 2021; Klimaszewski, 2023). Furthermore, these lessons are crucial in shaping current and future public health policies. Below is a list of significant milestones and events related to Britain's response to the widespread infection, culminating in the launch of the mobile application (NHS COVID-19 app) in September 2020.

Table 2. Significant events of Britain's response to COVID-19 infection, culminating in the launch of the NHS COVID-19 app.

Date	Event
29th January 2020	The UK confirms its first cases of COVID-19 in York.
11th March 2020	WHO declares COVID-19 a global pandemic.
23rd March 2020	Nationwide lockdown announced, closing non-essential businesses and advising homestay.
2nd April 2020	The UK reports over 500 daily COVID-19 deaths for the first time.
12th April 2020	PM Boris Johnson is discharged from hospital after severe COVID-19 symptoms.
17th April 2020	Lockdown extended for another three weeks.
10th May 2020	Introduction of a COVID-19 alert level system; beginning of lockdown easing.
28th May 2020	NHS Test and Trace service limited launched.
1st June 2020	Phased reopening of schools begins.
15th June 2020	Non-essential retail shops reopen with social distancing.
4th July 2020	Pubs, restaurants, and hairdressers reopen.
24th July 2020	Mandatory face coverings in shops and supermarkets.
14th September 2020	"Rule of six" introduced, limiting gatherings to no more than six people.
24th September 2020	**Launch of the NHS COVID-19 app for contact tracing and exposure notifications in England and Wales.**
5th November 2020	England enters a second national lockdown.
9th November 2020	Pfizer-BioNTech announces vaccine efficacy over 90%.
2nd December 2020	UK authorises Pfizer-BioNTech vaccine for emergency use.
8th December 2020	First Pfizer COVID-19 vaccine administered to Margaret Keenan.
20th December 2020	Identification of a more transmissible COVID-19 variant; restrictions tightened.
4th January 2021	England enters a third national lockdown due to the new variant.
29th January 2021	UK approves AstraZeneca-Oxford vaccine.
22nd February 2021	Government unveils a step-by-step plan to ease lockdown restrictions.
8th March 2021	Schools reopen in the first step of lockdown easing.
17th May 2021	Lifting of most indoor and outdoor social restrictions.
19th July 2021	Most remaining restrictions lifted on "Freedom Day".
24 Sep-21	Continued role of NHS COVID-19 app in contact tracing and exposure notifications.

Source: Author

The table above provides an overview of the UK's key dates and actions in response to the COVID-19 pandemic. It includes developing and deploying the NHS COVID-19 app, illustrating adaptive strategies over time. From the point when the first case was confirmed in the UK on 29th January 2020 in York, the pandemic significantly impacted various sectors, such as healthcare, education and hospitality, with each significant event listed in the table having widespread effects on communities and businesses. The complexity of combating multiple infection waves necessitated the evolution of preventative health policies. The emergence of new variants like Alpha and Delta

introduced further complications, with their impact varying based on factors like vaccination rates and behavioural patterns (Guerrettaz et al., 2021).

The global aftermath has been severe, with many suffering from long-term conditions known as long COVID, affecting millions worldwide, while the UK's death toll attributed directly to the coronavirus has neared two hundred thousand. Additional indirect consequences include increased delayed diagnoses of other illnesses, particularly cancer, and a notable spike in depression levels among Britons (Cleland and MacLeod, 2022). Specific subgroups were more vulnerable to contracting the illness or dying once infected, leading to widespread calls for better financial support for vulnerable residents. However, deeper underlying issues remain unaddressed, as pointed out by (Allan et al., 2024).

Vaccination programmes were crucial in managing the epidemiological situation and keeping it under control, reducing severe symptoms and allowing a semblance of normalcy to return to citizens' daily lives without the need for continued stringent restrictions to prevent the further spread of the virus. Despite these advances, there is still a concerning amount yet to be revealed about the future implications, which are not fully understood, particularly regarding how healthcare professionals perform their jobs and how society at large copes with this new reality. It is essential to maintaining vigilance and addressing disparities in access to medical services for all (Mathiassen et al., 2023).

The Nuffield Trust and the BMA have contributed valuable insights into how the pandemic has reshaped the social and technological aspects of healthcare response. They suggest building a more robust and adaptable system to face such adversities with minimal disruption and to reduce disparities in outcomes. They emphasise the importance of resuming research as usual, to stay ahead, especially in monitoring the long-term effects of COVID-19 on public health and how it will impact the future (BMA, 2024; Nuffield Trust, 2020).

The NHS COVID-19 app, projected as a crucial element of the UK's digital health strategy in managing the pandemic, was widely believed to have served as a significant technological advancement in preventing further spread. Launched on September 24th, 2020, in response to the increasing need for comprehensive contact tracing in England and Wales, the app's efficacy against SARS-CoV-2 was significantly supported by the use of Bluetooth technology on users' devices, as highlighted by (Kendall et al., 2023). This technology played a role in public health's countermeasures against COVID-19 by enhancing contact tracing efforts, notifying individuals of potential virus exposure and

enabling prompt actions to combat the disease.

The app features a function that notifies users if they have been near someone infected with the virus; this feature played a key role in preventing the further spread of the disease (Kendall et al., 2023). Such technology, when integrated into wider digital healthcare strategies aimed at preventing disease dominance during pandemics, complemented the other advancements associated with the NHS COVID-19 app. The confirmation provided through contact tracing gave users virtual alerts when they came into proximity with confirmed cases, directing them towards actions such as self-isolation or testing. By revealing otherwise concealed outbreaks, it facilitated swift containment efforts that harmonised with long-term strategic approaches to curb viral transmission (Kendall et al., 2023).

Beyond the simple reprographics offered elsewhere, the contact tracing facility, by predicting future data and feeding hospital admission facts dealing specifically with coronavirus cases, was outstanding amongst other features of the NHS COVID-19 app (Mellor et al., 2023). This technological aid can serve as an alert system, notifying medical personnel and authorities about a sudden rise in hospitalisations due to the pandemic. It could provide hospitals with crucial insights that enable them to brace for potential surges, ensuring sufficient bed availability and resources to meet all needs with full preparedness (Kendall et al., 2023; Mathiassen et al., 2023).

2.3. Theoretical Framework

A sociotechnical viewpoint offers a broad understanding of how digital health technologies such as the NHS COVID-19 app are integrated. Three sociotechnical theories—ANT, Systems Theory, and Structuration Theory—explain the relationships among technology, societal frameworks, and human actions in public health initiatives. Additionally, the Sociomateriality Theory, which is a practice theory, was applied in this specific case to examine trust in the uptake of the NHS COVID-19 app.

2.3.1 Actor-Network Theory

ANT was propounded by Latour in 2005 and developed by scholars such as (Callon, (1998). As articulated by Latour in Greenhalgh et al.(2017) and Callon in Witarsyah et al. (2017), it provides a framework to analyse how networks of human and non-human actors influence the uptake of technology. This theory challenges traditional analyses that separate technological impacts from human actions by positing that technology, institutions, and individuals interact within a network. In the context of the NHS COVID-19 app, the use of an ANT perspective enables a comprehensive understanding of the

app as a sociotechnical device that was shaped by factors such as government directives, public attitudes toward health during the pandemic, and institutional constraints (Peng and Woodlock, 2009; Sorani, 2012). The app's design and functionality were influenced by institutional imperatives and negotiations regarding data privacy concerns, legal restrictions, and public trust in health authorities (Cucciniello et al., 2015; Garavand et al., 2016).

The interactions among various actors, including developers, policymakers, and the public, illustrate that the COVID-19 app's implementation involved a complex interplay of adaptations and negotiations, which reflected user demands for decentralisation and privacy adjustments (Chau and Hu, 2001; Takian et al., 2012). These interactions emphasise user agency within the network and that users were active participants rather than merely recipients of imposed technologies. The application of ANT indicates that the interactions among these network components can lead to varied responses and behavioural changes among users (Muhammad and Wickramasinghe, 2018). For example, during the pandemic, the app delivered critical alerts about exposure risks. The decision to use the app for this purpose was influenced by expert recommendations, media narratives, and community factors. These alerts contributed to changes in public behaviour (Cresswell et al., 2011, 2012).

Analysis of the relationships within this network shows the dynamic nature of technology adoption and indicates that complexities and subtleties influence whether or not the implementation of digital health solutions will be successful. Ultimately, ANT posits that the NHS COVID-19 app should be understood as part of a broad sociotechnical framework. The theory highlights that the app’s effectiveness was connected to the evolution of regulations and community expectations that facilitated information dissemination and outbreak management (Mabad et al., 2021). This perspective considers the app integral to broad public health management efforts.

2.3.2 Systems Theory

Systems Theory introduces the concept of synergy among parts within a system and their collective impact on overall functionality, as noted by Rauschenberg et al.(2021);and Yu et al. (2022). Use of this theory highlights that the NHS COVID-19 app is not an isolated entity but serves a connective function within a broad public healthcare network, including in terms of policymaking, infrastructure components, and community behaviour patterns (Wienert et al., 2022).

Interconnectivity is a fundamental aspect of Systems Theory. For instance, the

communication among bees demonstrates how changes at any level can have widespread effects throughout the entire hive structure. In this context, the effectiveness of the tracking app relied not only on technological integration but also significantly on public involvement. Trust in the initiative influenced individuals' decision-making processes regarding adoption, thereby potentially enhancing the practical applications of contact tracing technologies, as highlighted by Farnood et al. (2024).

Adaptive learning is critical, especially when addressing real-world challenges. A key principle of Systems Theory is that changes are inevitable and necessitate ongoing adjustments. This perspective is reflected in the positive outcomes that were observed during various phases of the COVID-19 app implementation, which relied on user feedback, as Mason et al.(2022) have analysed.

Additionally, developments during the pandemic, particularly regarding app preparedness, showcased the importance of the effective integration of the app into other healthcare systems. These improvements can enhance the overall efficiency of digital healthcare systems and contribute to better outcomes in social healthcare initiatives(Huang et al., 2020).

2.3.3 Structuration Theory

Structuration Theory, as recorded by Baio Junior and Carrer (2022), explores the interplay between technology evolution and the interactions of organisations and individuals. It challenges the idea that technology is just a tool, as it emphasises the reciprocal relationship between technological advancements and social changes (Nazir and Khan, 2023; Nyachiro et al., 2023).

The importance of this theory is evident in the rollout of the NHS’s COVID-19 app, during which public health guidelines affected usage alongside factors such as trust, functionality, and privacy concerns, which influenced user engagement (Dutta and Mishra, 2024; Suter, 2023). Giddens’ structure-duality concept shows the ways in which societal practices inform software development and reshape dynamics; it highlights the role of public norms in the adoption of healthcare applications.

Environmental factors significantly impact decisions regarding digital tracking design, as national health regulations and authority channels vary by context. User comfort influences the balance between policy and transparency and necessitates tight security measures. Users actively shape technology through feedback, and this situation showcases their evolving role in this landscape.

2.3.4 Integration of the Three Theories into a Sociotechnical Framework

The incorporation of Structuration Theory reveals patterns in adoption rates and highlights the importance of collective efforts to ensure the successful integration of digital health technology. Scenario planning and flexible strategies are vital to transition practices to transformative IT strategies that are characterised by openness and collaboration.

This environment advances innovation through dynamic interdisciplinary perspectives while embracing complexities. Inclusive design processes enhance resilience to challenges, reflecting a shift in consciousness within specialised fields that oversee project lifecycles. This evolution is crucial to the redefinition of knowledge dynamics among stakeholders who are involved in technological transformations.

Actor-Network Theory: Examining Networked Relationships in Digital Adoption

ANT can be applied to analyse thoroughly the relationships that influence digital health technology. According to ANT, technology adoption is not a straightforward process but the result of continuous interactions among human networks and non-human entities. This theory contests conventional views that separate social and technical elements, instead framing them as parts of an interlinked network (Latour, 2007; Troshani and Wickramasinghe, 2014).

When applying ANT to the rollout of the NHS COVID-19 app, a multifaceted environment emerges in which lawmakers, technology specialists, and public health officials interact. Funding initiatives and public communication shape the relationship between policymaking and technological execution, and this relationship influences societal involvement and attitudes toward the app, thereby affecting its adoption or rejection.

Public scepticism can occur frequently in this scenario, as individuals may face information overload and feel apprehensive about surveillance. This phenomenon reflects a post-truth society in which the line between factual information and misinformation can become blurred, and this situation influences people's overall comprehension and interpretation of the data.

Additionally, ANT offers insights into the complex functions of technical applications, including Bluetooth contact tracing and decentralised data storage. It emphasises the importance of regulatory policies and governance frameworks that affect decision-making within the technology realm. Through its focus on a networked perspective, the use of ANT allows for the natural progression of technological solutions, challenging

hierarchical systems that may restrict innovation(Booth et al., 2016; Suter, 2023).

This theoretical perspective indicates that the adoption of a collaborative and interconnected view may lead to more successful digital health interventions, promoting a thorough understanding of the interactions that influence technology adoption and public health results.

Systems Theory: Understanding the NHS COVID-19 App Within a Public Health Ecosystem

ANT highlights the relationships among various components, whereas Systems Theory (Checkland, 1981; Leavitt, 1965) offers a comprehensive view of how digital health tools fit into public health ecosystems. This viewpoint emphasises that the success of these tools depends on their interconnections rather than on the performance of each tool in isolation.

The NHS COVID-19 app exemplifies this concept. It operates not as an isolated solution but as part of a complicated network that involves numerous stakeholders, such as healthcare organisations, policy structures, and community behaviours.

Systems Theory emphasises continuous adaptation and enhancement during the app development phase. Digital health initiatives should not remain unchanged after launch; they require ongoing modifications that are grounded in user input and changing disease trends (Bertalanffy, 1969;Checkland, 1981). For example, the NHS COVID-19 app received updates to address issues that were related to proximity detection algorithms and to bolster its privacy and security protocols, and these changes ultimately led to greater public confidence. Utilisation of Systems Theory is advantageous as it uncovers the operational interactions among the elements within digital health systems. This analytical approach can help policymakers and public officials to implement new digital healthcare technologies effectively, especially during emergencies.

Structuration Theory: Understanding the Role of Human Agency and Institutional Structures

ANT and Systems Theory demonstrate the interconnected nature of relationships and systemic dependencies, whereas Structuration Theory (Giddens, 1984) emphasises the interplay between individual actions and organisational structures that shape technological adoption. This theory transcends deterministic views that assign change exclusively to technology or to human decisions; instead, it indicates that technological systems and human behaviours develop concurrently through continuous interactions.

When applied to the NHS COVID-19 app, this theory highlights how public sentiment, policy development, and user engagement influenced its efficacy. Governmental initiatives that were designed to encourage the app's utilisation were significant, yet adoption rates also relied on societal attitudes towards technology, including concerns about risk and cultural factors related to privacy (Giddens, 1984).

A key element of Structuration Theory is the notion of structural duality, which asserts that organisational practices shape individual behaviours while personal actions modify these practices over time. This dynamic was evident in the debates concerning data management strategies for the NHS COVID-19 app, particularly after resistance from civil liberties organisations prompted a move towards decentralisation and minimal data collection. This demonstrates how citizen involvement can impact the institutional frameworks that support digital health initiatives.

Moreover, the theory underscores the importance of societal contexts in influencing the acceptance of new technologies and innovations. Previous interactions between established healthcare systems and electronic citizen care projects have shaped public trust and perceptions regarding new technologies. Any evaluation of implementation success must consider the historical and social factors that inform the design and execution of technology-driven healthcare solutions. This insight is valuable to navigate the development of technological applications within the context of historical and societal frameworks.

Sociotechnical Integration: A Comprehensive Framework for Digital Health

The integration of ANT, Systems Theory, and Structuration Theory creates a comprehensive framework that examines the relationships among technology, policy, and society in the context of digital health advancements. ANT is used to analyse the interactions among various stakeholders, including government bodies, developer teams, healthcare providers, and users, and how these interactions influence the development of medical technology. Research indicates that these networks significantly shape the design and functionality of health technologies, which can impact user acceptance (Kc et al., 2023; Kendall et al., 2023).

Systems Theory provides insights into how technology is integrated at a macro-level into complex public health systems. It emphasises the intersections of technological solutions with societal organisations and policies. This perspective highlights that the successful implementation of e-health solutions requires an understanding of their context within the broad healthcare delivery framework, which is influenced by

sociopolitical factors (Bachtiger et al., 2020; Garnett et al., 2020; Nebeker et al., 2022). Studies show that there is a direct correlation between community health outcomes, advanced technologies, and local status (Idris et al., 2021; Kc et al., 2023).

Additionally, Structuration Theory emphasises the interplay between individual and group agencies and larger socioeconomic institutions over time. This theory has been influential in explaining the acceptance of modern digital interventions (Samuel and Sims, 2023; Von Wyl et al., 2021). The uptake of technologies, such as the NHS COVID app, reflects the complexities of real-world implementation and the necessity of having user-friendly strategies (Jonker et al., 2020).

This approach facilitates the development of higher-order perspectives that ensure that the timely introduction of innovations is not an isolated event but an integral network component that is influenced by medical, regulatory, and policy frameworks in conjunction with social activities. Understanding this alignment is essential so that the rate of technological innovation can be adjusted to meet societal norms.

The NHS COVID-19 app is a prime example of the complex aspects of the adoption of digital solutions to manage public health emergencies. The creation and implementation of the app highlight the crucial interrelation between technological advancements, government bodies, and the dynamics of public involvement. Applying ANT, Systems Theory, and Structuration Theory offers a structured framework through which to analyse comprehensively the trajectory of digital health interventions, and such an analysis reinforces the notion that future digital health technologies must be designed with an acute awareness of networked relationships and systemic interdependencies. These theoretical insights are essential to shape effective public health strategies and policy planning and to foster sustainable technological innovations in digital health (Harris et al., 2016; Ishimaru et al., 2021; Phillips et al., 2021).

2.3.4 Sociomateriality Perspective

Sociomateriality, as a practice theory, is used selectively in this study to explain the elements influencing mutual agreement and acceptance of technological changes, such as public trust. A sociomateriality perspective, a term originating from science and technology studies (STS) and information systems (IS), offers a compelling viewpoint for grasping the complex interplay between technological devices and social dynamics (Orlikowski and Scott, 2015). It advocates a novel concept: that technological devices, such as smartphones, and social components encompassing our daily routines and linking them to business operations are not separate entities; instead, they are intricately

interwoven. They mutually influence and co-create each other's strategies.

Key aspects of sociomateriality include, firstly, the acknowledgement that what are often considered 'separate' entities are, in fact, inseparable. Secondly, it emphasises the significance of performativity, which is the idea that actions are not merely routine but are influential (Austin, 1975; Butler, 1990). Thirdly, it recognises the importance of relationships, as nothing exists in isolation. Lastly, it introduces ‘agential realism’, which posits that both material and human agencies actively contribute to reality (Orlikowski and Iacono, 2001; Orlikowski, 2010). Sociomateriality theories, such as those by Orlikowski and Scott (2015) and Orlikowski (2010), question conventional perspectives that differentiate technology from human and organisational components. Instead, they propose that these elements are interdependent and co-evolving. The fundamental idea is that technological progress and human behaviour mutually influence each other.

2.4. Review of Related Literature

The NHS COVID-19 app, with all its challenges, yet played an essential role in mitigating the spread of the virus in England and Wales. Research on health applications in mobile telephony, especially those addressing significant health crises like COVID-19, suggests that smartphones can effectively help fight the spread of diseases. These digital solutions are now globally acknowledged for their efficient information distribution, vital contact tracing capabilities, and overall role in managing outbreaks (Davalbhakta et al., 2020). Thorough assessments of various ‘mHealth’ platforms have highlighted features that are beneficial in pandemics, such as real-time case mapping and virtual consultations with healthcare providers (Ming et al., 2020).

The NHS's leading tool against SARS-CoV-2 is notable among these apps. It includes a Bluetooth-based contact tracing system aimed at reducing transmission. However, academic research points out several factors that may negatively affect the adoption of healthcare apps: concerns about privacy, user-friendliness and familiarity are crucial elements that influence their regular use (Dowthwaite et al., 2022). Building trust through user attitudes is increasingly crucial, as it shapes behaviours related to the future use of digital contact tracing programmes (Dowthwaite et al., 2021). Scholars are eager to understand the role of smartphone services in rapid public health responses during global emergencies (Davalbhakta *et al.*, 2020; Kendall *et al.*, 2023).

A significant amount of research has been dedicated to understanding the factors that influence the adoption of mobile contact tracing technologies. Comprehending why

people use specific applications is critical to decoding their behaviour (Park et al., 2021). During the COVID-19 pandemic, online technology became critically important. Health-related applications experienced a surge in use, proving effective for quickly spreading information, identifying potential infections and remotely monitoring cases, playing an essential role in fighting the virus. The rapid development of app-based services to address the challenges of the pandemic has gained considerable academic interest, with studies assessing their impact on global response efforts (Kendall et al., 2023; Wymant et al., 2021).

The relationship between user attitudes towards digital contact tracing apps, like the NHS COVID-19 app, and their trust in these tools is a vital research area, especially within public health strategies in pandemic situations. Research has identified several factors that affect user engagement with health apps, such as privacy concerns, app performance, and knowledge of features (Holdener et al., 2020; Wang et al., 2021). Comprehending this relationship is critical to understanding adoption rates and developing interfaces that boost user interaction with these applications.

Early evaluations of the effects of mobile healthcare applications, particularly the NHS COVID-19 app, have shown significant progress in reducing COVID-19 transmission in England and Wales (Ferretti et al., 2020). This highlights the critical role of technology companies in resolving crises and the promise of digital tools in supporting public health measures during pandemics.

In times of crisis, it is crucial to acknowledge the distinctive difficulties posed by the situation and the necessity for technological innovation. The sense of community, characterised by bravery and selflessness, is a source of optimism and motivation in a major crisis, highlighting the perseverance and fortitude of individuals and communities (Grekousis and Liu, 2021; Idris et al., 2021). As we confront such challenges, acknowledging the necessity for preparedness and flexibility in response to imminent changes is essential (Boin et al., 2016). Seizing the chance to rebuild stronger and redefine control amid chaos is perceived as a shared responsibility that can pave the way to a more prosperous future for everyone (Paton and Johnston, 2001).

The correlations between user attitudes towards digital contact tracing apps, their trust in these applications and the impact of mobile healthcare applications on public health strategies during pandemics are critical areas of study. Understanding these factors and acknowledging the role of technology companies in crisis resolution can inform the development of effective public health interventions and strategies for the future. Reflecting on past events, the effective deployment of digital health tools in crises hinges

on a comprehensive grasp of user behaviour, trust dynamics and technological proficiency (Liu et al., 2023; Mafham et al., 2020). Insights from the adoption and use of the NHS COVID-19 app are poised to inform future public health strategies and initiatives that drive us toward increasingly digital healthcare landscapes.

Examining the contribution of the NHS COVID-19 app to pandemic management through a sociotechnical perspective will enrich our understanding of the interplay between technology and healthcare practices. This approach transcends the notion of technology as merely a tool, proposing that digital solutions such as this app are both influenced by and influential within their social context (Booth et al., 2016; Garavand et al., 2016; Mason et al., 2022). It highlights the adaptability of healthcare practices in emergencies, particularly when eHealth tools are integrated with linked medical records to provide the real-time data crucial for crafting effective responses.

Most COVID-19 cases have similar features on radiographic images, including bilateral, multi-focal, ground-glass opacities with a peripheral or posterior distribution, mainly in the lower lobes in the early stage, and pulmonary consolidation in the late stage (Chowdhury et al., 2020). However, some studies have shown misdiagnosis in early-stage patients of COVID-19 and proposed the combination of CT imaging and clinical findings for better diagnosis, especially in children (Nabavi et al., 2021). The role of health consciousness as a mediator has been recognised in technology adoption models (Mustafa et al., 2022). Confirming pneumonia in patients experiencing severe respiratory symptoms from COVID-19 is critically important. Chest X-rays are essential for diagnosing correctly (Van Der Heyden, 2021). To deal with COVID-19 well, it was necessary to use digital health tools, such as the NHS COVID-19 app, all the time. Knowing what makes people use these tools helps make them work better and can shape health policies. Studies have shown that initial trust, performance expectancy, technology characteristics and task-technology fit positively affected the behavioural intention to adopt m-banking services (Karjaluoto et al., 2019).

Studies such as the work of Timmers et al. (2020) have observed the app's role in supporting public health initiatives during the pandemic. The sociotechnical perspectives, highlighted by Cartmill et al. (2023), provide insights into the interplay between material objects and social processes, offering a viewpoint for understanding technology integration into healthcare practices. A sociotechnical perspective, which emphasizes the interdependence between technological systems, social structures, and human agency, provides a robust framework for examining the integration of the NHS COVID-19 app. This approach recognises that digital health technologies are not

standalone tools but are shaped by institutional policies, user behaviours, and technological infrastructures, highlighting the dynamic interactions that influence their adoption and effectiveness. Furthermore, the importance of recognising this interconnection in order to comprehend the broader implications of technology in healthcare is emphasised by Cartmill et al. (2023) and Doidge et al. (2021). The NHS COVID-19 app's functionalities, including contact tracing, symptom checking, and public health education, are reviewed in recent studies, in addition to how these features are interwoven with social practices. Various scholars' research highlights the app's role in real-time surveillance and public health response (Davies et al., 2021; Kondylakis et al., 2020; Saeidnia et al., 2023). The impact of the app on healthcare practices is underscored by Panchal et al. (2021), Rodriguez-Villa et al. (2021) and Alanzi (2021), who have discussed user engagement, privacy issues and the factors that influence the adoption of and compliance with the app. Empirical studies and qualitative research documenting how the NHS COVID-19 app has been integrated into pandemic management practices are examined in this section; the epidemiological impacts of the app, its adoption and use within the healthcare system, and its effect on healthcare practices and patient care are discussed by many researchers (Davalbhakta et al., 2020; Ming et al., 2020; Dowthwaite et al., 2021; Holl et al., 2022; Kendall et al., 2023).

Despite being a major technological innovation in managing the pandemic, the NHS COVID-19 app faced challenges in its integration. Barriers discussed include technological adoption barriers, organisational factors and the digital divide between demographics. Research by Kendall et al. (2023) and Walrave et al. (2020) sheds light on these issues, highlighting the necessity of strategic approaches to improve the effectiveness of digital health tools, as supported by McDuie-Ra et al. (2024) and Kontopantelis et al. (2020).

This section considers the insights gained from the integration of the NHS COVID-19 app into healthcare practices and its application to future public health emergencies. It discusses findings from studies on telemedicine, remote patient monitoring, and the influence of mobile health applications on healthcare provision and public health initiatives (Basellini et al., 2021; Hazan et al., 2023; Jansen-Kosterink et al., 2021). The example of adopting the NHS COVID-19 app in managing the pandemic in England and Wales highlights the intricate interplay between technology, individuals and organisations in addressing public health emergencies. This literature review examines how digital health technologies can revolutionise healthcare practices when effectively integrated with social practices and organisational structures. The insights provided

emphasise the significance of understanding the interaction between technology and society in order to enhance the implementation of digital health tools for addressing healthcare challenges.

Studies indicate that effective promotional strategies are vital for mHealth application success. Jongerius et al. (2019) discovered that using scientifically supported communication methods significantly improves caregivers' understanding and encourages the pursuit of assistance. Likewise, research by Mahmood et al. (2024) supports the implementation of evidence-based strategies in mHealth system design, offering users a positive perspective on healthcare decisions.

Regarding future design trends and areas of practical application, personalised learning experiences and appealing platforms are recognised as critical elements that engage stakeholders and contribute to enhanced cognitive development. Such elements can foster systemic excellence and peak performance, eliciting favourable reactions from service users, as revealed by Kim et al. (2022). Moreover, participatory design methods are considered appropriate, demonstrating the practical benefits of improved user feedback and underscoring the crucial continuous improvement processes, as affirmed by Dederichs et al. (2022).

Utilising effective communication strategies and choosing suitable interaction methods are essential for promoting mHealth applications and enhancing user engagement. A study by Wang et al. (2021) showed that adding gamification elements increased long-term satisfaction in mHealth app users, enhancing their perceived value of the app. Similarly, Joo et al. (2021) discovered that transparently disclosing marketing intentions and securing informed consent from customers can encourage smartphone users to download health-related apps.

2.4.1 Pandemic management: Research on the effectiveness and challenges of app usage in managing the pandemic.

Mobile apps have been found to help manage COVID-19. They serve various purposes during health emergencies, such as training, sharing information, assessing risks, checking symptoms, contact tracing, monitoring personal health at home and making informed decisions (Kondylakis et al., 2020). These apps have been effective in solving some of the problems caused by the pandemic (Kondylakis et al., 2020). However, when developing apps for contact tracing, it is essential to consider ethical issues, as well as the reliability of the app and its implications for social and political situations (Ranisch et

al., 2021).

The pandemic has shown that we need to improve self-care practices, particularly for people with underlying health conditions, such as Parkinson's disease, who find it challenging to maintain social distancing (Tang et al., 2023). To address this issue, online chat tools like COVO-CHAT were developed to manage information overload and provide virtual doctor visits (Gharebaghi et al., 2022). Contact tracing apps have also helped to control the spread of the virus, highlighting the importance of collective effort in fighting the pandemic (Rohman and Pitaloka, 2023).

However, managing information overload, learning about eHealth, and sharing knowledge accurately have been significant challenges in handling the pandemic (Gharebaghi et al., 2022). The efficacy of contact tracing apps in controlling the pandemic greatly depends on their ability to prevent the rapid spread of COVID-19 (Seberger and Patil, 2021). Notably, health apps, especially those for mental health management, have become more popular as they provide support for the emotional well-being of individuals during the pandemic (Wang et al., 2023).

Mobile sensing apps have been studied for their potential to assist in self-managing mental health during the pandemic (Suruliraj et al., 2021). However, the development of a unified pandemic management architecture faced challenges due to emerging strains that complicated pandemic control efforts (Roy et al., 2022). Studies have shown that trust and changes in app usage patterns have occurred over time, indicating initial novelty effects that decrease as public concern and media coverage of the pandemic decrease (Pepper et al., 2022). The quality and engagement of mobile health services during the pandemic have also been evaluated, revealing a growing market for mHealth in various regions (Gonzales et al., 2023).

2.4.2 Influence on healthcare: Studies on the broader implications in England and Wales.

There have been some studies of how phone health apps change how healthcare professionals look after health, help patients and improve public health plans in England and Wales. These studies show how important it is to mix these apps into healthcare, because they change how healthcare is delivered. One study done by Wang et al. (2022) researched into a phone app for patients who need to monitor their blood thinning treatment, and how easy it was to use for patients, their caregivers and health workers. This study points out how critical it is for health workers and patients to communicate well, especially if patients find technical healthcare terms hard to understand, to help

them take care of themselves to prevent and manage diseases. Another study by Romero-Jimenez et al. (2022) observed how a phone app was made and used to help track medicine for patients with diseases that cause inflammation because of their immune system. Finding new ways, like phone apps, is essential to improve patient care and treatment results for these diseases. Also, Geerling et al. (2023) explored into why patients with bipolar disorder decide to start, keep using, or stop using health apps that help them take care of themselves. Knowing what patients like and dislike about these health apps helps to improve them, so patients want to use them more and stick to their self-care plans. (Alkamel et al. (2020) studied what people working in healthcare think about a phone app that helps to treat heart attack patients faster. Getting treatment quickly is essential in these cases, so this example shows how health apps can make healthcare smoother and help patients to make rapid improvement. Finally, Choi et al.(2023) investigated into a phone app for patients with heart failure to see if it would help them take better care of themselves. This test showed that using technology to help people with long-term health problems is helpful, and it is important to tailor this help to fit each patient's needs. Looking at all these studies show how much phone health apps can improve patient care, encourage people to take better care of themselves, and improve healthcare

2.4.3 Literature Review Selection Process

Systematic Literature Review Approach

This literature was selected for review in an orderly, transparent, and repeatable manner so that the research could be repeated in the future. The literature was chosen according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which are recognised for their effectiveness in ensuring thorough reviews and credible reporting (Kendall et al., 2023; Samuel et al., 2021). The application of this framework was particularly relevant when examining the integration of digital health technologies into healthcare, particularly regarding aspects such as promotion and acceptance, with the NHS's COVID-19 app serving as a case study.

To cover all relevant studies, data was collected extensively across several high-ranking academic databases, including Scopus, known for its interdisciplinary coverage; PubMed, recognised for medical and epidemiological research; Web of Science, which emphasises innovation within the digital health domain; and Google Scholar, which provides access to both scholarly articles and to preprints in various academic fields (Bachtiger et al., 2020; Lee et al., 2023; Park et al., 2021; Phillips et al., 2021). Boolean operators were employed alongside broad search terms related to key areas of interest,

such as "mobilisation" combined with "digital health" and "adoption" paired with "digital contact tracing" (Dowthwaite et al., 2022; Kendall et al., 2023).

A snowballing technique was utilised to expand data collection, incorporating reference lists from key papers to identify foundational works related to digital health adoption theories (Griffin et al., 2022; Urbaczewski and Lee, 2020). Citation tracking through available databases facilitated the identification of pertinent literature (in-text citations previously mentioned).

This systematic review was executed with clear procedures and inclusion criteria to ensure a focused and unbiased selection of relevant literature. Furthermore, it highlighted the importance of examining relationships and connections within digital health literature, emphasising the need for a comprehensive exploration of the evolving landscape of this field. Furthermore, the focus was on studies that had explored governmental and institutional strategies for the integration of digital contact tracing tools within public health systems (Park et al., 2021; Paucar et al., 2022; Tsinaraki et al., 2021). Conversely, studies not available in full text, those lacking empirical evidence, such as opinion pieces, and those concentrating solely on clinical applications, devoid of public health integration, were excluded from the review (Ming et al., 2020; Subica et al., 2023).

The literature was screened in a meticulous three-stage process. The initial search phase yielded over 500 articles across the databases. The titles and abstracts were scrutinised to determine relevance, resulting in a preliminary selection of 170 papers. A detailed full-text review was conducted, during which studies inconsistent with a sociotechnical perspective were discarded; this narrowed the dataset to 85 core studies (Samuel et al., 2021). The quality of these selected studies was appraised through the application of the established frameworks, the Critical Appraisal Skills Programme (CASP) and Grading of Recommendations Assessment, Development, and Evaluations (GRADE) to ensure methodological soundness and impactful research outputs (Khairat et al., 2021; Palmer et al., 2024).

From the final selection of 85 studies, information was robustly extracted and organised according to major thematic areas: the mobilisation of digital health technologies during health crises; factors that affect user engagement; and governmental promotion strategies that impact public trust (Aalto et al., 2022; Alassaf et al., 2021). This thematic analysis was vital to discern the complex sociopolitical landscapes that influence the integration of digital health applications within existing public health systems (Islam et al., 2020; Schmeelk et al., 2022).

The methodological rigour outlined above underscores this study's systematic and structured literature review process. The aim was to ensure that high-quality research underpinned the analysis of digital health adoption and its integration into public health. Integrating direct database searches and snowballing techniques has heightened the review's comprehensiveness and ensured that the foundational and emergent research findings are aptly represented (Alanzi, 2021; Bächtiger et al., 2020). This meticulous methodology enhances transparency and bolsters replicability and academic rigour, thereby establishing a solid basis for examining the implications of the NHS COVID-19 app within a sociotechnical discourse (Wu et al., 2022).

The literature review emphasises the fundamental role that digital health technologies play in public health realms, particularly in pandemic scenarios where rapid mobilisation and public compliance are crucial. The NHS COVID-19 app serves as a pertinent case study as it illustrates both the potential benefits and the challenges that digital contact tracing initiatives face. It underscores the necessity of continuous evaluation and adaptation of these tools in the context of public health policy and community engagement (Behne et al., 2021; Kawakami et al., 2021).

2.5. Identified Gaps in the Literature

While previous studies have looked into the deployment of the NHS COVID-19 app, there is a lack of detailed research on the specific strategies used to mobilise the app in England and Wales to address the pandemic. It is important to conduct a deeper analysis of the strategic methods, and the challenges encountered during the app's mobilisation to improve future pandemic responses. Furthermore, there is a need for a more thorough understanding of the mobilisation strategies utilised by the NHS COVID-19 app during the pandemic. Investigating how sociotechnical impacted the app's deployment and operational tactics could enhance our knowledge of effective pandemic management approaches.

Current research does not adequately address the promotion of the NHS COVID-19 app across England and Wales. There is a need for comprehensive studies to examine the specific promotional strategies employed, the design of communication campaigns, and the elements that successfully engaged the public. By delving into these promotional nuances, effective practices for future public health campaigns could be identified. Additionally, there is a gap in understanding how sociotechnical factors influenced the app's promotion. Further research is required to explore how sociotechnical perspectives

affected the development of promotional strategies, the crafting of campaign messages, and the overall engagement of the public with the app.

Although some research has focused on the general effects of the NHS COVID-19 app on pandemic control, there is still a significant gap in our understanding of how the app specifically influenced pandemic response and digital healthcare delivery in England and Wales. Further investigation is required to explore how the app has shaped the COVID-19 pandemic management and digital healthcare system. These insights could be crucial for enhancing future crisis management strategies. Moreover, the role of sociotechnical systems in shaping these outcomes has not been fully explored. Additional research is needed to investigate how sociotechnical factors influenced the pandemic response.

By focusing on underexplored aspects of the NHS COVID-19 app's deployment, promotion, and impact, future studies can significantly enhance our comprehension of how digital health technologies are utilised in managing public health crises like the COVID-19 pandemic. Identifying these research gaps will help to develop more precise and effective strategies for employing digital health tools. Moreover, investigating the sociotechnical interactions that influenced healthcare outcomes, public behaviour, and overall pandemic management is crucial. Through the framework of sociotechnical theory, this study aims to deepen our understanding of the sociotechnical dynamics that influenced the NHS COVID-19 app's deployment, promotion and impact. This study examines how social, and material factors influence responses to health crises. This will provide a more detailed examination of the role of digital health technologies in managing crises. Such an approach is expected to generate valuable insights, informing the design and implementation of future health interventions.

2.6. Practical Implications

Bringing into play constructs from current sociotechnical theories and insights drawn from relevant literature will help scrutinise how this technology interacts with society during a health crisis.

Research question one (1) explores how the NHS COVID-19 application was mobilised for managing widespread outbreaks of COVID-19 in English and Welsh territories. Systematic reviews revealed previous attempts at mobile apps (Davalbhakta et al., 2020; Kondylakis et al., 2020; Ming et al., 2020). Analyses are set up to examine how various actors from various fields of expertise linked up to develop an app in the critical moments of a pandemic to track the spread and isolate the infected individuals to help prevent the virus from spreading.

Furthermore, using example-based learnings from studies focusing primarily on adoption rates, including compliance faced by similar health technology (Timmers et al., 2020; Jansen-Kosterink et al., 2021). Research question two (2) aims to unfold strategies developed around promotional messages that helped build trust among users while simultaneously pushing traction and maintaining desired engagement levels. Deeper investigations will reveal precisely how promotional campaigns were crafted to encourage the overall number of downloads.

Addressing the last point and calling upon findings compiled together shows how outcomes related to health interventions introduced via popular mHealth applications that were aimed at targeting the coronavirus threat shaped overall digital healthcare (Chidambaram et al., 2020; John Leon Singh et al., 2020).

Finally, RQ3 continues to identify gaps in the literature, showing how digital apps impact COVID-19 contact tracing and digital health practice.

2.6.2 Implications for pandemic management: Implications of findings for future pandemic management and app development

The literature review on the deployment, promotion, and impact of the NHS COVID-19 app in managing the COVID-19 pandemic in England and Wales has revealed important findings which have significant implications for future pandemic management and app development. By analysing the provided references, we can identify critical conclusions and recommendations for utilising digital health technologies in public health crises. For clarity and ease of reference, the table below shows key considerations and recommendations:

Table 3. Key Considerations and Recommendations

Recommendation No.	Key Themes	Insights and Actions	Sources
1	Long-term Implications	Consider the long-term implications of pandemic mitigation technologies beyond the immediate COVID-19 response to inform future preparedness and response strategies.	(Seberger and Patil, 2021)
2	Privacy and Policy Considerations	Prioritise privacy in app development and adhere to robust privacy policies to build user trust and compliance.	(Hendricks-Sturrup, 2022)
3	Media Attention and Public Perception	Address pre-existing deficits in healthcare systems highlighted by increased media attention during the pandemic, focusing on improving care facilities.	(Miller et al., 2021)
4	Patient Empowerment	Develop apps that empower users to take control of their health and well-being, integrating features that promote patient empowerment.	(Vuokko et al., 2020)
5	Quality and Functional Improvements	Ensure continuous monitoring, quality improvements and technical error mitigation in app development to enhance effectiveness in pandemic management.	(Kim et al., 2022)
6	Healthcare Worker Wellness	Support healthcare workers' well-being through mental health support and wellness initiatives, focusing on the stressors and uplifts experienced by frontline staff during the pandemic.	(Reyes, 2020)
7	Patient Engagement and Self-Management	Focus on enhancing patient engagement and self-management capabilities in apps for chronic disease management, emphasising patient education and clinic engagement.	(Holl et al., 2022)
8	Digital Mental Health Tools	Leverage digital tools for mental health support, prioritising features and services that assist individuals in need during the pandemic.	(Suruliraj et al., 2021)
9	Clinical Trials and Telemonitoring	Explore the potential of mHealth clinical trials for chronic disease management using telemonitoring and wearable devices, optimising technologies for remote patient care.	(Indraratna et al., 2021)
10	Healthcare Worker Support	Develop and prioritise digital tools that enhance healthcare workers' well-being and resilience, particularly those that build resilience in healthcare staff during crises.	(Jembai et al., 2022)

Source: Author

This table categorises insights and recommendations derived from the literature review,

linking to the relevant sources on leveraging digital health technologies in public health crises.

2.7 Definition of Keywords used in the Thesis

1. Mobilisation

Mobilisation means the organisation of resources—people, policies, and technology—to achieve significant goals during health emergencies (Harutyunyan, 2021). Digital healthcare involves collaboration among lawmakers, healthcare providers, and technology developers, as seen in initiatives such as the NHS COVID-19 app (Elkhodr et al., 2021; Kendall et al., 2023). Effective mobilisation relies on clear communication to keep all stakeholders informed and to reduce disruption during the implementation of significant projects during challenging times (O'Callaghan et al., 2022; Samuel et al., 2021). The use of a structured approach enhances public trust and the effectiveness of interventions, both of which are vital during crises (Kendall et al., 2023; Samuel et al., 2021).

2. Adoption

Adoption involves individuals and organisations effectively integrating and implementing new technologies, regulations, or systems. In the context of digital health, several factors contribute to this process, including perceived ease of use and usefulness, trust in the technology's features, and the presence of supportive legal frameworks (Rogers, 2003). The case of the NHS COVID-19 app highlights these characteristics: public reliance on the app, user-friendly design, and privacy protections were significant, as was backing from regulatory authorities. These elements collectively facilitate the integration of such technologies into the healthcare landscape (Wexler and Prineas, 2023; Wut et al., 2021).

3. Digital Innovation

Digital innovation means the development of new digital technologies that enhance processes, services, or products. These include telemedicine products, AI diagnostics, and mobile health apps that improve service delivery and patient engagement (Fagerberg and Verspagen, 2021). The NHS COVID-19 app used Bluetooth contact tracing to reduce virus spread while ensuring data privacy (Banskota et al., 2020).

4. Public Health Integration

Public health integration refers to the embedding of digital technologies and strategies into public health systems to improve healthcare delivery, disease prevention, and population health (Hatchett et al., 2007; Wienert et al., 2022). It aligns digital tools with

existing healthcare policies to ensure accessibility and efficiency (Cevasco and Roess, 2023; Kickbusch et al., 2013). The NHS COVID-19 app illustrates this by merging contact tracing with national healthcare databases to enhance pandemic response and risk communication.

5. Contact Tracing

Contact tracing is a way to identify and notify individuals who have been exposed to an infectious disease to prevent further spread (Cevasco and Roess, 2023; Kawakami et al., 2021). While traditionally done manually, digital contact tracing uses mobile apps and Bluetooth technology to streamline the process (Ferretti et al., 2020). The NHS COVID-19 app showed how digital contact tracing can provide effective exposure alerts and self-isolation guidance.

6. Digital Health

Digital health is the use of mobile apps, wearable devices, AI, and electronic health records to enhance health outcomes and patient engagement (WHO, 2019). It combines telehealth, mobile health (mHealth), big data analysis, and electronic records to personalise healthcare and make it more accessible (Farnood et al., 2024). The NHS COVID-19 app was a digital health initiative to improve pandemic response through technology.

7. Promotion

Promotion means the strategic dissemination of information to raise awareness, encourage engagement, and influence behaviours related to a product, service, or initiative (De Santis et al., 2022). Digital health promotion includes public health campaigns and targeted outreach to enhance the visibility and adoption of digital tools such as the NHS COVID-19 app (Matt, 2022). Effective promotion is linked to increased public participation, trust, and compliance with digital health interventions so that their success and societal impact are improved.

8. Shaping or Impacting

Shaping or impacting refers to how technological, social, or policy-driven interventions influence behaviours and systemic outcomes (Giddens, 1984). In a sociotechnical context, shaping occurs as technological developments alter social structures, while social behaviours and policies modify technological implementations (Leonardi, 2011). The use of the NHS COVID-19 app illustrates how digital health tools enhance public health responses and how public perception and regulatory frameworks affect their

effectiveness (Orlikowski and Scott, 2015).

2.8. Conclusion

I tried to capture mobile technology's pivotal roles, particularly in the COVID-19 pandemic. Through the development and implementation of various applications, significant strides have been made in areas such as contact tracing, public awareness, appointment scheduling and telemedicine, as detailed by Kondylakis et al. (2020) and Alanzi (2022). These tools have not only facilitated more robust pandemic control strategies but have also addressed critical aspects of user engagement and healthcare delivery.

The review underscores a crucial understanding of user needs and preferences, which significantly influence the adoption and effectiveness of mobile health technologies. By prioritising personalised services and ensuring the safety and privacy of users, these applications can achieve higher acceptance and utility among diverse populations, including vulnerable groups, as discussed by Vilendrer et al. (2020) and Panchal et al. (2021).

Furthermore, the studies reviewed highlight the variable rates of adoption and trust in these technologies across different demographic groups, revealing a complex landscape of public acceptance and compliance. This variability points to the necessity for targeted communication strategies and trust-building measures to enhance the effectiveness of technological interventions in health crises (Dowthwaite et al., 2021; Pepper et al., 2022).

The impact of such applications on the pandemic response has been profound, not only in managing the spread of the virus but also in shaping healthcare practices and outcomes. Recent studies' findings indicate the potential of mobile health applications in improving healthcare delivery and speeding up public health responses during crises, as evidenced by studies conducted by Alsyouf et al. (2022) and Kendall et al. (2023).

The literature review provides a detailed analysis of the deployment, promotion and impact of the NHS COVID-19 app on the management of the COVID-19 virus in England and Wales. By synthesising existing research, the review highlights significant themes, including the role of mobile technology in controlling pandemics, user preferences and needs, trust and adoption of COVID-19 apps, and the overall effects of these apps on the pandemic response and healthcare outcomes.

Significant gaps have been identified, particularly in mobilisation, promotion, and the

specific impacts of the NHS COVID-19 app. These gaps underscore the need for further research to obtain a more nuanced understanding of these elements. This study addresses these gaps by focusing on the outlined research questions and objectives, enriching our knowledge of the app's mobilisation, promotion, and influence on pandemic management and digital healthcare practices within England and Wales. The next chapter dives into the methodology used in the thesis.

CHAPTER 3: METHODOLOGY-A CASE OF MANAGEMENT STRATEGY THROUGH THE NHS COVID-19 APP

3.1 Introduction

The research methodology adopts a qualitative lens, analysing textual data from multiple authoritative sources. It uses document analysis, facilitating a thorough investigation of written materials to identify thematic elements and understand the underlying implications of the study's goals. Given the public and accessible nature of the data on the NHS COVID-19 app, document analysis is particularly suited to this research. It enables a detailed assessment of how digital health interventions are communicated, perceived and assessed in the real world (Bowen, 2009; Hodder, 2000; Prior, 2003)..

Data for this study were carefully gathered through targeted sampling from key sources vital to public health communication and disseminating information concerning the NHS COVID-19 app covering a period from 28th March 2020 (when the announcement about the app was made) to 26th April 2023 (when the app was closed down). The sources include NHS England and NHS Digital, which were intimately involved in the app's creation, launch and oversight and provide official documents, guidelines and updates. such as BBC News reports and Sky News reports offer pandemic coverage, giving insight into public sentiment, media representation and the societal effects of the NHS COVID-19 app. The Public Health Directorate plays a pivotal role in formulating public health policies and strategies, including incorporating digital tools like the NHS COVID-19 app into broader pandemic management plans.

3.2 Research Design and Methodological Considerations: Abductive Reasoning

The research methodology that is applied in this analysis follows an abductive approach, which focuses on the generation of insights through ongoing interactions between theoretical concepts and empirical data. This method differs from deductive reasoning, which tests established hypotheses, and inductive reasoning, which relies on broad generalisations drawn from observed facts. The uniqueness of the abductive approach lies in the capacity to use it to investigate unexpected findings and to refine theoretical models that are based on empirical observations, as highlighted by Osei-Bryson and Ngwenyama (2011). By employing this methodology, researchers can formulate new theories that are rooted in real-world data and, therefore, support the reliability of their results (Taylor, 2018).

The suitability of the abductive model becomes clear when specifically applied to the

study of the adoption and integration of the NHS COVID-19 app. This approach encourages dynamic exchanges between practical evidence and theoretical frameworks, offering valuable insights into the complexities that are associated with innovations in digital health (Alam et al., 2023). The investigation utilises sociotechnical perspectives seen through the lenses of ANT, Systems Theory, and Structuration Theory to uncover emerging themes methodically from policy documents, media reports, and public health records.

Using an abductive technique promotes a thorough comprehension of the intricate connections between technical systems and the societal needs that are defined by policy frameworks. This comparative approach is advantageous as it illuminates emerging themes and addresses qualitative data that is related to current concerns regarding the NHS COVID-19 app, thus contributing to broad discussions about the evolving landscape of healthcare.

3.2.1 Justification for Use of Abductive Reasoning in Digital Health Research

It is crucial that abductive reasoning be employed in digital health research, because this approach is especially valuable to assess how technologies such as the NHS COVID-19 app are embraced and incorporated.

1. Ongoing Dialogue between Data and Theory

Abductive reasoning encourages an ongoing conversation between theoretical models and real-life data observations. This interplay enables the movement of research findings beyond established beliefs and the provision of flexibility that is informed by case-specific insights (Saragih, 2025). This method improves comprehension of emerging information trends by promoting analytical synthesis and the derivation of intelligence from raw data samples.

2. Addressing Complex Digital Health Systems

The intricate nature of contemporary digital healthcare systems requires adaptive, solution-focused thinking in order to handle interrelated aspects across government agencies, technological frameworks, and public behaviours. As Saragih (2025) observes, the employment of such methods facilitates a thorough examination of technology adoption trends. Bayesian techniques, similar to abductive reasoning, have proven effective in traversing these complexities.

3. Incorporating Various Data Layers

Another benefit of abductive reasoning is its ability to embrace multiple viewpoints, thereby strengthening the validity of findings. The use of this methodology enables researchers to weave together diverse sources of information within empirical frameworks, and this leads to enhanced scientific discovery and research results(Creswell and Poth, 2016; Yin, 2014). The amalgamation of varied datasets aligns with the principle that having more comprehensive information correlates with better outcomes in scientific investigation. Abduction has been used to map patterns of adoption of the NHS COVID-19 app, and this use has improved problem-solving within complex digital healthcare systems and integrated various data streams. These strategies also complement the shifting landscape of digital health, which requires adjustments to societal dynamics and legal frameworks in the context of policy development.

3.2.3 Theoretically Sensitised Explanation Rather Than Theory Extension

The primary objective of this research is not to expand existing theoretical models but to provide an interpretation based on existing theories regarding the influence of social and technical interactions on digital health technologies, such as the NHS COVID-19 app (Allana and Clark, 2018). The study utilises established sociotechnical theories to enhance the understanding of specific cases.

The analysis engages with ANT, Systems Theory, and Structuration Theory to integrate theoretically informed insights with empirical data to evaluate the adoption of digital health resources(Cresswell et al., 2010). This methodology aligns with the principles of abductive research design, which enables the adaptation of established theories based on observations from real-life contexts rather than the strict application of them to collected data.

3.3. Data Sources and Collection Approach

Document analysis is a systematic approach to reviewing or evaluating printed and electronic documents (Prior, 2003; Bowen, 2009). It is a crucial technique in qualitative research, offering a wealth of detailed information across various fields. This method is particularly relevant for research where direct observations or interviews are impractical due to retrospective considerations or issues of access.

Document analysis involves skimming for a superficial examination, reading for an in-depth review and interpreting the material to extract meaning, enhance understanding and build empirical knowledge (Bowen, 2009; Merriam and Tisdell, 2015). The range of documents analysed can be broad, including newspapers, emails, reports, policy

statements, organisational records and diaries. Researchers use this method to track changes and developments, understand organisational and cultural contexts and gather diverse perspectives and sentiments.

3.3.1 The role of document analysis in qualitative research

In qualitative research, document analysis is frequently employed alongside other methods like interviews and observations to triangulate data. This triangulation aids in confirming the research findings from various sources, thus increasing the study's credibility and reliability (Jick, 1979). Documents are vital for gaining historical insights essential to understanding the past and its impact on current events. They are particularly crucial in research to analyse temporal changes or the development of practices, policies and perspectives (Scott, 1990). Documents provide direct access to the language and terminology of the subjects under study, offering authentic insights into their viewpoints and the meanings they attach to their experiences (Prior, 2003).

Document analysis does not require direct interaction with individuals, making it an unobtrusive method that circumvents potential ethical concerns regarding consent and privacy. This makes it advantageous for researching sensitive topics or when participant observation is not feasible (Merriam, 2009).

This procedure involves picking documents relevant to the research query and evaluating their authenticity, reliability, representativeness and importance. Grasping the circumstances surrounding a document's formation is vital for its correct interpretation. This includes knowing why it was created, who it was intended for and understanding the wider societal-political and historical context (Hodder, 2000). Researchers methodically code documents' content and thematic elements, akin to analysing the data. This includes pinpointing patterns, themes and inconsistencies in and across documents to amalgamate insights regarding the RQs (Saldaña, 2016).

Although document analysis is a potent instrument in qualitative research, it poses challenges such as potential bias in document production, the availability and accessibility of documents and the necessity for critical appraisal skills to assess the pertinence and dependability of the sources (Bowen, 2009; Scott, 1990). Researchers must also be aware of an over-reliance on documents and the exclusion of other data sources, which could constrict the scope and depth of their analysis.

In qualitative research, document analysis facilitates a thorough and multi-dimensional examination of intricate phenomena. When judiciously chosen and critically scrutinised, documents can augment research findings, adding richness, context and corroboration

to the study (Prior, 2003; Sköld, 2015). The value of this method in triangulation, historical scrutiny and ethical research practices renders it essential in the toolkit of a qualitative researcher.

3.3.2 Justification for document analysis in the study of the App

Document analysis is essential in qualitative research, particularly in studies aimed at understanding the evolution, implementation and impact of policies or technologies in particular contexts (Prior, 2003; Bowen, 2009). When researching the deployment, promotion and impact of the app during the pandemic, document analysis emerges as a fundamental method for several reasons.

First, it offers insights into the historical development and implementation of the app, encompassing its conceptualisation, design choices and subsequent modifications. This historical context is vital for understanding the app's progression and integration with public health strategies (Scott, 1990).

Official documents, policy briefs and governmental reports provide essential information on the regulatory, ethical and operational frameworks that guide the app's deployment. Analysing these documents clarifies the app's intended role in the broader public health response to COVID-19 (Bowen, 2009).

Media reports, press releases and public commentary offer insights into the app's societal reception. Analysing these documents helps researchers measure public sentiment, concerns and acceptance levels, aiding in understanding factors influencing the app's adoption and use (Prior, 2003).

Internal documents, minutes of meetings and communications from health authorities, tech developers and policymakers provide insights into the discussions and reasoning behind crucial app decisions. These perspectives are essential for grasping the complexities and challenges faced during the app's implementation (Hodder, 2000).

3.3.3 Ethical and non-intrusive methodology

Document scrutiny is an ethically grounded, unobtrusive research approach that avoids direct participant engagement. This method is invaluable when exploring delicate matters or when direct access to stakeholders is limited (Bowen, 2009; Merriam, 2009).

Document analysis strengthens the research's robustness when used alongside other qualitative methods, such as interviews or focus groups. It also allows for triangulation, corroborating findings through converging evidence from various sources (Jick, 1979).

Document analysis has its advantages but also poses challenges that require careful evaluation. Bias and representativeness are concerns, as documents may be biased or serve the agendas of their creators. Researchers should critically examine documents' origin, intent and viewpoint (Saldaña, 2016). Contextualisation and interpretation are also crucial; the socio-political, economic and cultural contexts in which documents were created must be considered for accurate interpretation (Hodder, 2000). I found the document analysis a legitimate and valuable method for investigating the app's deployment and impact. It provides access to a rich array of historical, contextual and stakeholder information, thoroughly understanding the app's role in managing the pandemic.

3.3.4. Data collection and analysis

Qualitative research typically requires thoroughly examining, evaluating and interpreting documents to collect knowledge and insights pertinent to RQs (Merriam, 2009; Prior, 2003). In studying the app, analysing a range of documents is crucial for gathering data that sheds light on its development process, promotional launch strategies and its role in managing pandemic scenarios or affecting healthcare services.

To understand the broader COVID-19 containment strategy, I reviewed public health guidelines and policy documents from England and Wales.

I examined the marketing strategy by reviewing press releases and social media campaigns, which were complemented by public service announcements to raise public awareness.

Various news reports offered additional viewpoints, enabling me to gauge public sentiment and emerging concerns and initiate discussions about the application.

2. Confirming document authenticity and relevance

The study employed a verification system to ensure that all documents originated from authorised, reliable and credible sources, cross-checking the reported information for utmost precision (Bowen, 2009).

In assessing the document's relevance to research queries, particularly concerning the development, promotion and influence of the application in the surveyed category, preference was given to documents that provided direct access to interpretable, helpful information or other pertinent facts.

3. Steps used in organising and coding

Documents were organised systematically by source type, publication date and relevance to specific aspects of the RQs. NVivo and Excel were used for efficient cataloguing and retrieval. Document cataloguing in qualitative research involves systematically organising and classifying documents to ensure efficient retrieval, analysis and reference throughout the research process. This practice is particularly important when researchers deal with a vast array of documents, as is often the case in studies incorporating document analysis as a primary method. Effective document cataloguing aids in managing the wealth of information collected, ensuring that researchers can easily access, analyse and cite documents relevant to their RQs (Gibbs et al., 2002; Paulus et al., 2014).

Thematic analysis distils critical themes, patterns and narratives from the coded data. This entails interpreting data in the broader context of the pandemic response, technological adoption and healthcare practices. When we explore qualitative research, we encounter thematic analysis. Simply put, it is a technique for identifying and reporting patterns in data (Silverman, 2014, 2011). It naturally fits qualitative research's exploratory and interpretive nature; this method becomes a flexible gatekeeper for dissecting text-based information. Thematic analysis is particularly valued for its ability to explain participants' experiences, meanings and reality. It is a fitting choice for studies that delve into complex phenomena, such as the deployment and impact of health interventions like the app. Thematic analysis is methodologically flexible, applicable to various frameworks and can be used with multiple qualitative data types, including interview transcripts, field notes and documents (Braun and Clarke, 2006; Silverman, 2014). It facilitates a rich, detailed, yet complex account of data, allowing researchers to describe their data set and interpret various aspects of the research topic (Silverman, 2014). The process involves the identification of patterns or themes across a data set that are important or interesting and the assembling of data linked to each theme to conduct a detailed analysis (Braun and Clarke, 2006).

3.3.5. Process of thematic analysis

The first critical step in thematic analysis and other qualitative research methods is becoming acquainted with the data. This stage involves profoundly engaging with the collected data to gain an initial understanding, which is essential for discerning patterns, central concepts and emerging themes.

It is engaging with the data through repeated readings or listening to audio recordings, aiming to absorb the content thoroughly and noting initial impressions (Braun and Clarke, 2006). This involves jotting down observations, thoughts and reflections that emerge

during the initial engagement with the data, laying the groundwork for deeper analysis (Riessman, 2008). Reflecting on how the initial data immersion aligns or diverges from research objectives and theoretical frameworks guides the subsequent phases of analysis (Finlay, 2002). Thorough familiarity with the data is vital for effective coding, ensuring that codes are grounded in the actual data and not influenced by pre-existing theories or biases (Braun and Clarke, 2006). Initial data immersion helps recognise early themes which can direct more focused analysis and data collection in the later stages (Braun and Clarke, 2006). Deep engagement with the data from the outset enhances the analytical depth, ensuring that interpretations are substantiated by the data (Patton, 2015, 2002).

The challenge of information overload, particularly with voluminous data sets, requires strategic approaches for effective management. This may involve an initially selective focus on representative data segments or employing qualitative data analysis software to organise and annotate data for more straightforward navigation (Paulus et al., 2014). Familiarisation with the data is indispensable for qualitative analysis, serving as the foundation for a rigorous, insightful exploration of the subject matter. Through this initial immersion, researchers set the stage for a nuanced and well-grounded analysis that genuinely reflects the complexity and depth of the qualitative data.

Generating initial codes is a crucial early step in qualitative data analysis, particularly in thematic analysis. This stage follows the initial familiarisation with the data, where researchers systematically break down the data into meaningful information units. Coding involves labelling data segments (phrases, sentences or more extended text sections) with short names that simultaneously summarise and account for each piece of data (Braun and Clarke, 2006). These codes then serve as the foundation for identifying patterns and themes across the dataset.

Researchers meticulously sift through datasets, identifying and marking text segments or other data forms significant to their RQs or objectives (Saldaña, 2015). Each segment is assigned a code – a word or short phrase summarising its essence. Codes may be descriptive, inferential or both, depending on the data and the researcher's analytical approach (Saldaña, 2015).

The coding process must be systematic to ensure all data are scrutinised and consistently coded, enhancing the reliability of data analysis (Gibbs, 2007). Initial coding is iterative; researchers may refine, merge, add new or discard irrelevant codes. This adaptability is a strength of qualitative analysis, allowing coding to evolve with the researcher's deepening understanding of the data (Braun and Clarke, 2006).

Coding organises data, aiding in pattern and theme identification. It turns raw data into a structured format for more accessible analysis and interpretation (Saldaña, 2015). Coding also deeply engages researchers in analytical content examination, which is essential for developing a nuanced understanding of datasets (Braun and Clarke, 2006). A systematic and transparent coding approach bolsters the rigour of qualitative research. It creates a clear audit trail from raw data to the final themes, thus enhancing the credibility of the results (Gibbs, 2007).

3.3.6. Challenges in generating initial codes

The large volume of documents can overwhelm researchers during the coding process. Starting iteratively with a manageable data subset and expanding as necessary can alleviate this issue.

Coding consistency can be difficult to maintain across large datasets or multiple researchers. A detailed codebook and regular coding meetings can ensure consistency (Saldaña, 2015).

Initial codes are crucial in qualitative data analysis, allowing theme identification and meaningful data interpretation. This method demands a meticulous, systematic process, yet remains flexible enough to evolve codes as data understanding deepens. This highlights qualitative research's iterative and reflective essence, greatly enriching the analysis's depth and rigour.

The search for themes is a crucial step in thematic analysis. Its purpose is to uncover patterns or themes in the dataset that describe the phenomenon significantly and are directly linked to the RQs. This stage advances beyond the initial coding to sort codes into potential themes that capture critical elements of the data related to the research aims.

A theme encapsulates something significant about the data about the RQs and denotes a patterned response or meaning in the dataset. Themes are typically more comprehensive than the codes they originate from, offering a narrative that connects the specific observations (codes) to the broader RQs. Start by revisiting the codes created during the initial coding phase, scrutinising each code, the data it covers and the relationships between codes.

Then, begin to cluster related codes together. These clusters are formed around a familiar concept or idea that binds them, laying the groundwork for possible themes. Identify potential themes by evaluating how they connect to the RQs. A theme should

mirror a pattern in the data that addresses the research inquiry and sheds light on the phenomenon under investigation. Verify these potential themes against the dataset to confirm the data supports them. This may require returning to the dataset and the initial codes to ensure the themes accurately reflect essential patterns in the data.

3.3.7. Application to the app's case-study

In studying the app, theme searching involved identifying patterns that reveal themes regarding user engagement with the app have surfaced, encompassing its ease of use, privacy issues and perceived efficacy in enhancing individual and public health safety. Themes related to the app's marketing and public reception, including the effectiveness of communication strategies and public sentiment towards the app, have also been identified. Additionally, themes may arise concerning the app's role in the broader context of pandemic management, such as contact tracing, case management and dissemination of pandemic information.

Achieving a balance between the scope and depth of themes is crucial. Researchers must acknowledge biases in subjective data analysis when identifying themes. The themes should accurately represent the data, not the researchers' preconceived notions. They should be broad enough to capture the complexity of the data yet narrow enough to offer valuable insights that correspond to the RQs. It is possible for themes to intersect, and data may align with multiple themes. Researchers must clearly define themes and justify data categorisation for reliable results using systematic coding and validation methods such as triangulation or member checks. The search for themes is a crucial stage in thematic analysis that bridges the gap between detailed data coding and overarching RQs. This step in the app study allows researchers to connect individual experiences and observations to broader patterns and trends, revealing insights about the app's design, deployment and influence. Researchers ensure their findings are relevant to their research objectives by meticulously identifying and validating themes from the data. Document analysis provides a systematic and comprehensive approach to collecting and analysing data for a study on the app. By carefully selecting, evaluating and interpreting relevant documents, researchers can comprehensively understand the app's development, promotional efforts and impact in the complex pandemic management and healthcare delivery ecosystem. This method allows for an in-depth exploration of both the explicit content of documents and the underlying meanings, providing valuable insights into the multifaceted role of digital health technologies in public health crises.

3.3.8 Selection Process for Case Study Documents to Ensure Replicability and

Transparency

In qualitative research, methodological rigour supports the study's integrity and trustworthiness. This rigour is achieved through the judicious selection of sources and commitment to systematic research methods. It ensures the research is conducted transparently and consistently, and as far as possible in qualitative paradigms, is replicable (Denzin and Lincoln, 2012; Lincoln and Guba, 1985). This discussion explores the chosen sources for qualitative research and details the strategies employed to sustain methodological rigour throughout the study.

Researchers obtain information from various places for qualitative research (books, official reports, news reports, interviews, studying artefacts) (Braun and Clarke, 2006). The key aim is to pick sources that matter for their questions and help show different views (Bowen, 2009). The quality of the document is essential to ensure that the research is robust. Researchers should consider each source carefully and should not overlook how the data was gathered and the writer's perspective (Corbin and Strauss, 2015). Researchers often mix and match sources to make their research even more robust. This technique, called triangulation, helps them be sure about their findings. It shows whether things match up or not, giving a fuller picture of what they are studying (Denzin, 1978). Being clear and keeping track of how sources are picked, analysed to draw conclusion is crucial. This openness allows for other researchers to follow the research process and understand the results (Lincoln and Guba, 1985).

It is relevant for the researcher to be honest and not to introduce their views into the data to help avoid biases. This is called reflexivity, simply a notion about avoiding bias in gathering data to make the research findings reflect a true-to-life experience as possible (Malterud, 2001).

Documents used in this study were analysed systematically to maintain a thorough, transparent, reproducible selection process. The use of this strategy was intended to capture various viewpoints concerning the development, implementation, and societal effects of the NHS COVID-19 app.

The Document Analysis Method

Document analysis, which is a qualitative research technique, was chosen because it is well-suited to the examination of publicly accessible reports, policies, media coverage, and institutional guidelines. The use of this method enabled a detailed assessment of textual data to identify common themes, policy ramifications, and public attitudes towards the NHS COVID-19 app (Bowen, 2009; Merriam, 2009).

Selection Criteria for Documents

A systematic and focused sampling approach was utilised to guarantee that the chosen documents were credible, relevant, and representative of the effects of the COVID-19 app (Andersen, 2018; Bauer and Aarts, 2000; Price, 2022). The criteria for inclusion and exclusion were as follows:

Table 4 A table containing both Inclusion and Exclusion Criteria for document selection

Criteria Category	Criterion	Description
Inclusion Criteria	**Timeframe**	Documents published between March 28, 2020 (app announcement) and April 26, 2023 (app closure), encompassing the lifecycle of the NHS COVID-19 app.
	Official Sources	Official documents from authoritative bodies, including NHS England Digital, NHS Test and Trace, and Public Health England, which provide direct insights into policy, technical implementation, and integration of the app.
	News Reports & Media Analysis	Articles from reputable media organisations (BBC News, Sky News, Med-Tech News) that evaluate public perception, societal discourse, media representation, and the impact of media narratives on adoption.
	Policy & Legal Documents	Official policy papers, parliamentary committee reports, and regulatory documents (UK Health Security Agency, Parliament Joint Committee on Human Rights, European Data Protection Board) addressing ethical, regulatory, and governance considerations.
	Cybersecurity & Data Governance	Publications that address privacy and cybersecurity frameworks, particularly from authoritative sources such as the National Cyber Security Centre (NCSC), and that focus on privacy protection, security measures, and compliance.
	Local Government & Public Health Policies	Documents from local/regional authorities (Digital Health and Care Wales, Northeast Lincolnshire Council) that highlight regional implementation, integration with local health services, and community-specific challenges.
Exclusion Criteria	**Duplicate Reports**	Duplicate documents or submissions from the same source unless they provide substantially new insights, updated content, or critical revisions.
	Non-Empirical Content	Opinion pieces, editorials, or general commentaries that lack empirical evidence, analytical rigour, or original data-driven insights.
	Irrelevant Documents	Documents unrelated to digital health adoption, specifically those that discuss general COVID-19 topics without explicitly addressing contact tracing, digital interventions, or public health technologies.
	Outdated Sources	Documents published before 2020, unless they are foundational to the understanding of core digital health adoption and policy frameworks essential to the research.

Source: Author

Data Sources and Document Breakdown

To ensure a diverse and comprehensive dataset was formed, documents were gathered from the following authoritative sources:

Table 5. Data Sources

No.	Source	Count by Source
1	BBC News Reports	31
2	Department of Health and Social Care (DHSC)	21
3	European Data Protection Board	3
4	Legal Action Group	7
5	Med-Tech News	9
6	NHS England Digital	37
7	NHS Test and Trace	42
8	NHS Transformation Directorate	14
9	National Cyber Security Centre	4
10	Northeast Lincolnshire Council	2
11	Parliament Joint Committee- Human Rights	9
12	Public Health England	26
13	Sky News	17
14	UK Health Security Agency	11
15	Digital Health and Care Wales	12
16	GOV.UK	4
17	Open Rights Group	1
18	NHS COVID-19 App Support Group	15
19	The Isle of Wight evaluation report	1
20	UK's Parliament Post	1
21	The Telegraph	9
22	NHS COVID-19 app explainer pack	19
23	Information Commissioner's Office (ICO)	1
24	Welsh Government announcement	1
25	Royal College of General Practitioners	2

Source: Author

3.3.9 Document Search, Retrieval, and Analysis Process

Documents were collected and examined methodically in several distinct stages. In the first stage, databases and repositories were searched thoroughly (Andersen, 2018; Price, 2022). This involved reviewing credible sources such as verified NHS websites, governmental records, and respected news sources such as BBC News and Sky News. This step was crucial for gathering authentic original materials that reflected genuine

viewpoints and public understanding.

Next, a specialised keyword-based search was undertaken to locate literature relevant to the research goals. Significant search phrases included terms such as "NHS COVID-19 app AND public health harmony," "Digital footpath tracing AND uptake," "COVID-19 tech advances AND government policy," and "Privacy anxiety AND NHS data rights". The careful choice of particular keywords enabled effective filtering of information pertinent to the adoption of digital health, administrative initiatives, and public feedback.

These initial results then underwent thorough cross-corroboration checks. The information obtained from these records was compared with that from other trustworthy sources to ensure accuracy and maintain uniformity. This step bolstered credibility and minimised dependence on potentially misleading narratives.

Iterative snowball sampling then enriched the discovery process by referencing previously gathered materials and uncovering additional essential content. This method provided insight into the influences of policies and subsequent studies that may not have emerged through keyword searches alone.

The research aim was to examine the influence of technology integration within health services, especially during the COVID-19 pandemic. After coherent study materials had been compiled, a categorisation process was conducted to identify themes. Software NVivo was employed to organise patterns, highlight significant points, and illustrate recurring themes. The process was concentrated on government-led initiatives in the digital health domain, societal trust perceptions, and the legal and ethical considerations surrounding privacy and security in integrated technology. This structured investigation sought to evaluate the public's engagement and participation in a digitally oriented environment.

The selection method for case study documents was developed to ensure replicability, transparency, and academic rigour. By utilising multiple authoritative sources, applying systematic inclusion/exclusion criteria, and incorporating snowballing techniques, this study ensures that the analysis of the NHS COVID-19 app is grounded in a comprehensive and methodologically robust dataset. This organised approach strengthens the validity and reliability of the findings and offers a solid basis for future digital health research.

3.4 Research approach and methodology

The methodology chapter is structured around the three central research questions (RQs), which form the basis of my investigation into the incorporation of digital health interventions. The qualitative approach, grounded in constructivist and interpretivist paradigms, provides a perspective for this investigation, embracing the app's deployment and societal acceptance's depth and complexity.

The first research question delves into the strategic implementation and operationalisation of the NHS COVID-19 app as a pandemic management instrument. This exploration requires understanding the app's integration with existing public health strategies, its technological and functional features aimed at halting the virus's spread and the logistical and administrative hurdles faced during its introduction. The qualitative method allows for a detailed analysis of the strategic decision-making processes, stakeholder participation and adjustments to changing pandemic conditions. The study seeks to piece together a detailed account of the app's deployment efforts, emphasising the cooperation and conflicts in technology-centric public health initiatives.

The second research question focuses on the promotional strategies that encourage the widespread adoption and regular use of the NHS COVID-19 app. It examines the communication channels, message content and engagement strategies that build public trust and app use. The research approach will uncover the core themes in the app's promotion, such as calls to collective responsibility, assurances of privacy and its depiction as an essential tool in managing the pandemic.

The third research question expands the examination to evaluate the effects of the NHS COVID-19 app on the pandemic management and the healthcare system in England and Wales. It prompts an investigation into how the app uses Bluetooth technology for contact tracing and case detection, merging medical science with digital technology to enhance healthcare delivery during the pandemic. It delves into the socio-political and ethical considerations of implementing digital surveillance tools in public health. A qualitative analysis integrates data from various sources to investigate the app's features that contributed to curbing the spread of COVID-19 and the subsequent effect on digital health policy and patient care models due to its incorporation into healthcare practices.

3.4.1 Research Design Considerations

The study focuses on adopting digital tools for health during health emergencies. This

type of research is centred on interpreting and understanding how society was arranged for people to navigate their lives during the COVID-19 crisis and how societal factors shape their interactions with others (Denzin and Lincoln, 2011). The study adheres to several fundamental principles, including the belief that one's understanding and perception of the world stem from personal experiences and interactions. By studying the pandemic accounts captured in official reports, the research aims to better understand the situation (Creswell and Poth, 2016). Additionally, it pays close attention to the context in which events occur, recognising the significance of the setting, including the historical period (Maxwell, 2012), in shaping the use of the NHS COVID-19 app during the pandemic.

Flexibility is vital when studying complex subjects keenly, such as the NHS COVID-19 app and its impact during the pandemic. Being open to new information is crucial for a comprehensive understanding. Document analysis involves scrutinising written materials, including official reports, news articles and health advisories. This approach aided in understanding the discussions surrounding the NHS COVID-19 app and its significance in pandemic management (Bowen, 2009). Thematic analysis focuses on identifying and discussing significant themes in the collected data. It is instrumental in distilling numerous details into patterns that address the overarching questions (Braun and Clarke, 2006). Examining the broader context and underlying meanings enhances our grasp of how such technology integrates into public health strategies during significant events like pandemics.

3.4.2. Case Study Methodology

The case study methodology is grounded in the concept that social interactions and interpretations shape our understanding of reality, supported by scholars like (Stake (1995) and Yin (2018). It is particularly fit for the study's goal to understand the perspectives of the NHS COVID-19 app by policymakers, health professionals and the broader community. There are three key parts of the case study method.

This method highlights the significance of the environment, examining how the immediate surroundings, societal norms and historical context influence the subject under study. This is particularly pertinent when discussing the NHS COVID-19 app against the backdrop of the COVID-19 pandemic and public health policies (Flyvbjerg, 2006).

Case studies typically collect data from a variety of sources to construct a comprehensive view of the subject. In this study, data from NHS England and NHS

Digital, media outlets such as the BBC and Sky News and Public Health Directorate are crucial sources that provide diverse perspectives on the app's role in pandemic management (Yin, 2018).

Case studies enhance our understanding by examining and contrasting various types of information. This approach is particularly beneficial when determining the deployment strategy and assessing the effect of initiatives such as the NHS COVID-19 app (Denzin and Lincoln, 2011).

By examining a variety of documents, researchers can understand the app's development, deployment and impact on public health and healthcare systems. This study method is very useful as it provides extensive information and illustrates the interplay of a variety of factors. However, findings from a single case may not universally apply, and it may be difficult to determine if the same principles apply elsewhere. Nonetheless, case studies are invaluable for learning, particularly regarding health science research during significant health crises (Baxter and Jack, 2015). Through meticulous analysis of a variety of documents and perspectives, this study explores how digital health tools like the app can significantly aid during health emergencies.

3.4.3. In-depth Exploration

Qualitative research is essential when delving into complex subjects. It enables an in-depth examination of the NHS COVID-19 app's origins, development and community perceptions, considering the social, political and technological factors influencing its deployment and use (Maxwell, 2012).

In-depth exploration is a rigorous examination technique in its natural setting, employed in qualitative studies to reveal underlying stories or patterns that define an event (Creswell and Poth, 2016) In contrast to wide-ranging quantitative analyses focusing on data aggregation and general conclusions, qualitative research seeks depth by concentrating on a smaller number of samples or items, yielding detailed views that uncover unique aspects usually not considered (Patton, 2015).

The benefits of such detailed investigative methods used by researchers include:

- **Understanding complexity**. The subtleties of complex phenomena, especially those related to societal constructs formed by human interactions, cannot be fully grasped through superficial examination. In-depth exploration enables researchers to understand human experiences intertwined with sociocultural constructs beyond superficiality (Maxwell, 2012).

- **Revealing hidden meanings**. Qualitative researchers delve into the subject matter to reveal hidden meanings and implicit knowledge that may elude participants, particularly vital in cultural, psychological or symbolic studies (Geertz, 1993).
- **Grasping context**. The context is pivotal in moulding phenomena. Thorough investigation ensures findings are contextualised against the social, historical and environmental factors affecting the phenomenon, leading to a fuller understanding (Flyvbjerg, 2006).
- **Promoting empathy and connection**. Deep engagement with participant experiences allows researchers to cultivate empathy and a true connection, enabling a more respectful and genuine understanding of the perspectives studied (Denzin and Lincoln, 2011).

Qualitative research employs various techniques for profound exploration, such as:

- **In-depth interviews**. These interviews, whether semi-structured or unstructured, prompt participants to convey their narratives, experiences and viewpoints in their language, yielding rich, detailed information (Kvale, 1998).
- **Participant observation**. Researchers surround themselves with the participants' setting, observing and at times partaking in daily activities to gain insights into social dynamics and cultural settings (Emerson et al., 2011).
- **Document analysis**. Scrutinising pertinent documents like reports, media pieces and personal accounts helps researchers create a holistic picture of the phenomenon, including its historical and cultural foundations (Bowen, 2009).
- **Thematic Analysis**. Identifying patterns and themes through data analysis helps researchers craft a nuanced and intricate interpretation of the subject being examined (Braun and Clarke, 2006).

While in-depth exploration can provide essential knowledge and insight, it can also lead to problems such as the chance of the researcher's views affecting the study, needing a lot of time and resources and having to think carefully about how to treat people being studied. Researchers must keep checking their thoughts and how they might influence the study (Malterud, 2001).

3.4.5. Flexibility and being able to change

Qualitative research is flexible. This means a study can change when new things are

found out. This flexibility helps study something complicated like the NHS COVID-19 app. It lets the person doing the research change how they collect and look at their information based on new things they find out. This helps ensure the study stays up-to-date and gets into the situation's details (Merriam and Tisdell, 2015). Having the ability to be flexible and change is what makes qualitative research different from more fixed quantitative research methods. These qualities let researchers dig into complicated social topics in a way that other methods cannot. Being able to adapt and change is essential for understanding the many sides and new information about the issues being studied, especially in research areas that are complex and constantly changing, as is the case here (Morse, 1999; Braun and Clarke, 2006; Patton, 2015).

By embracing the need to adjust and remain flexible, researchers can explore complex topics profoundly and keep their work relevant and honest. This careful, thoughtful approach keeps research honest and respects everyone involved (Charmaz, 2014; Lincoln and Guba, 1985; Saldaña, 2016).

3.4.6. Contextual sensitivity

The qualitative approach emphasises the importance of context. This study focuses on the details of the app's deployment, promotion and impact on pandemic management and healthcare. Seeing how vital the backdrop of the environment, society and politics are, helps us understand why the app matters for public health in England and Wales and shows how the app fits into the bigger picture of fighting the pandemic (Flyvbjerg, 2006; Yin, 2018). Being sensitive to the context is important in studies that dive deep into topics of this nature. This means that researchers need to look at things by themselves and as parts of the more extensive surroundings that shape them. This way of looking at things allows that people's actions and the culture, environment, history and immediate situations around them are closely connected. By paying attention to these factors, researchers can get a more complex view of their study topic than just looking at numbers or facts alone. In studies that focus intensely on topics, being aware of the setting is about the researcher's ability to notice the small but important details that affect their study (Flyvbjerg, 2006). It means seeing how the setting shapes research, from creating questions to collecting, analysing and making sense of information. This awareness of the setting ensures that the study's conclusions are deeply connected to people's real challenges and experiences, offering insights that truly matter.

The importance of context in qualitative research and implementation strategies

- Enhancing depth of understanding: When researchers look at the broader picture, they can find deeper meanings they might not see at first. This helps them understand people's actions and societal events (Maxwell, 2012).
- Improving validity: Paying attention to the big picture ensures the research results truly reflect what is going on with the people and places being studied. This helps determine why people behave the way they do, leading to results you can rely on (Lincoln and Guba, 1985).
- Facilitating ethical research: Considering how research affects the people and places involved is essential. This means being respectful and careful, especially about cultural differences. Doing research this way is the right thing to do and respects everyone involved (Guillemin and Gillam, 2004).
- Conducting thorough background research**:** Before starting their actual research, experts suggest reading a lot, understanding history and culture and knowing about the social and political issues related to the topic. This preparation work helps researchers fully understand their topic and how to study it correctly (Creswell and Poth, 2016).
- Practising reflexivity: Researchers should always think about how their own experiences and ideas might influence their work. This helps them understand how the big picture affects what they are studying and their findings (Malterud, 2001).

3.5. Overview of the case

The NHS COVID-19 app was launched on 24 September 2020, by the NHS in England and Wales (Pepper et al., 2022; Wymant et al., 2021). It was a vital part of the pandemic response and part of the UK's plan to control the spread of the virus. As a part of the more extensive NHS Test and Trace effort, it uses technology to help reduce how much the virus is passed on, warn users if they might have been near someone who tested positive and make it easier to get tested. The app has many features to combat COVID-19: It anonymously tracks contacts through a Bluetooth technology to alert contacts that have come into close proximity with affected person. The app quickly informs the individuals involved and suggesting they stay home and get tested if needed. It updates the virus threat level in your area with advice for those conditions. The app lets people report if they are sick with COVID-19 symptoms and find out what to do next. Locations are given QR codes that the app can scan, helping to keep track of places where people might have been exposed to the virus.

Getting the app ready required much technology work, tests and teamwork between health groups, technology companies and others. Efforts to build trust and get as many people to use the app as possible were crucial to its success. This meant clear messages about how people's privacy was protected.

Proponents of the app argue that it was crucial in the UK's handling of the COVID-19 pandemic, aiding in detecting and isolating cases and gathering essential data on the virus's transmission. Nonetheless, its effectiveness faced obstacles such as privacy issues, digital disparities and initial public adoption rates. Addressing these issues necessitated continuous improvements to the app's functionality, resolving user concerns and ensuring it effectively augmented other public health strategies.

The creation and implementation of the app illustrate the promise of digital health technologies in aiding public health efforts. Its provision of prompt exposure alerts and area-specific risk details showcases the potential for technology in monitoring and managing diseases. Yet, it also emphasises the need to fully consider ethical, privacy and access issues to leverage such technologies for societal benefit. The app's development, deployment and influence demonstrate the opportunities and obstacles in incorporating digital solutions into public health plans. The insights gained from the app's use will shape future digital health response.

This case study delves into the complex task of organizing technological resources and expertise to rapidly develop the app alongside strategic promotional activities to boost its adoption. It looks at the cooperation among health officials, tech specialists and policymakers to overcome the app's technological, ethical and logistical hurdles. The study also considers the communication strategies and public outreach efforts to foster trust, address privacy and security concerns and underscore the app's importance in managing the pandemic.

Mobilising the app and making people use it was necessary to handle the pandemic. Everything that goes into this including making the app and getting people to understand how technology can help with health crisis management. The app was tested, first in some places and then throughout the country. Tests were crucial for improving the app, ensuring it worked well and keeping people's information safe. Mechanisms were in place to ensure that data was decentralised and used anonymous IDs to ensure that privacy was protected. This was necessary to make sure people trusted the app. Various avenues such as the traditional and social media were used to promote the app by the authorities.

3.5.1. Access to the NHS COVID-19 app

I chose this app for the case study as it provided a suitable means to gather comprehensive empirical data for my research on the interaction between humans and technology in combating a pandemic. Also, it was the UK's inaugural digital contact tracing app, representing an innovative approach to public health management. The research could thus explore the integration of digital health tools with various entities in addressing a significant crisis. Being a novel initiative, the app also attracted extensive media coverage, offering abundant data that is readily available.

3.6. Choice and Justification of Research Methods

Choosing a specific way to do a research study depends a lot on what the study aims to find out, the kind of questions it seeks to answer, and the main ideas guiding the study. It is imperative to pick a suitable method because it ensures the study can dive deep into what it is trying to learn about (Yin, 2018). In this discussion, I articulate the reasoning for choosing a qualitative research design, focusing on how the app was used to help with pandemic management in England and Wales. The main reason for selecting the case study method for research is that it fits well with what the study is trying to achieve and the questions it seeks to answer. It is all about getting into the details and understanding the complex parts of using new tech in healthcare, the NHS COVID-19 app. The study aims to understand the efforts made to mobilise, promote the app and how it played a role in public health and healthcare. In research that seeks to explore into details, a method that aligns well with the study's aims and questions must be chosen (Lincoln and Guba, 1985; Yin, 2018) When the technique matches the goals, the study can explore its questions and learn more about the research object. For instance, if I want to look at how the app was mobilised, promoted and impacted the pandemic management, the research should be able to capture the details of digital health interventions in the political and social setting.

1. Fundamental aspects of alignment and achieving alignment

The research design aimed to be thorough enough to cover all aspects of the RQs. For example, a study of the app should include a design that addresses technological, behavioural and policy-related questions (Yin, 2018). Considering the dynamic nature of the pandemic and its interaction with the rapid advancements in digital health technologies, the research design also needs to be adaptable to accommodate discoveries (Morse, 1999).

The selected methodology should enable a detailed exploration of the phenomenon,

allowing the researcher to uncover and interpret the app's meanings, experiences, and consequences for different stakeholders (Patton, 2015). It also allows researchers to scrutinise the app against new developments, shedding light on its role in public health strategies (Stake, 1995).

The study's RQs are crafted to delve into the app's mobilisation, promotion and overall influence. Each question calls for an in-depth investigation to grasp the underlying motivations, strategies, challenges and results linked to the app's rollout. Exploring the app's mobilisation involves looking into its planning, development and operational hurdles, which aligns with a qualitative case study design that includes document analysis for a holistic view (Creswell and Poth, 2016). It is necessary to analyse various communication methods to understand promotional strategies. Assessing the app's effect on COVID-19 trends and healthcare outcomes necessitates a detailed review of policy documents. Qualitative research excels at capturing the stories and discussions around health initiatives, thus fitting this inquiry (Geertz, 1993).

Congruence between the research design and the study's aims and questions is vital to ensure the research is significant and methodologically robust. By thoughtfully selecting a qualitative case study design, this study aims to yield detailed, context-sensitive insights into digital health interventions during the pandemic. This promotes a nuanced understanding attuned to the details of the phenomenon under consideration (the NHS COVID-19 app).

2. Complex phenomena in context

Qualitative research, especially case studies, is well suited to understanding complex phenomena in their usual settings (Yin, 2018). Researchers can notice small details and changes that number-based studies may overlook (Stake, 1995). This method is essential for investigating how the app was crucial during the global health emergency.

Investigating complex phenomena in their natural settings is fundamental to qualitative research and is ideal for studies probing the complexities of human behaviour, societal structures and technological interventions. This method is crucial for deconstructing the layered nature of phenomena such as the deployment and impact of digital health technologies, as seen with the app during the pandemic. Grasping these complex phenomena demands a methodological approach that captures the breadth, variety and dynamism of the experiences and processes involved (Stake, 1995; Creswell and Poth, 2016).

Complex phenomena are marked by numerous interacting elements, non-linear

connections and emergent properties that are not fully comprehensible in isolation or through simplistic methods. For the app, this complexity stems from the interaction among technological innovation, healthcare practices, public health policies and societal reactions. These phenomena are entrenched in and shaped by their socio-political, cultural and historical settings, requiring a research approach considering these layers of complexity (Morçöl, 2005).

The justification for focusing on complexity and context in qualitative research design arises from the essence of qualitative inquiry, which aims to understand and interpret the rich, detailed fabric of human experience and social phenomena. When examining topics like the deployment and impact of health interventions in particular settings, such as the app during the pandemic, it is imperative to employ research designs that can navigate and illuminate the intricate interplay of factors influencing the phenomena under study.

Complexity in research means examining all the different parts and how they relate to what is being studied (Patton, 2015; Creswell and Poth, 2016). It shows that social realities are not linear or simplistic but are shaped by cultural rules, how people act, and how institutions work in the larger societal and political context. Considering the NHS COVID-19 app in such a context requires a research plan that can capture how the app influenced society during a pandemic and vice versa.

3. Emphasising Contextuality in research design

Understanding the context is vital in research examining how a product or a tool works in real life. This means knowing what is happening where, when and why. One must dive into its specific situation to understand what something means, its use and its effects (Corbin and Strauss, 2015; Merriam and Tisdell, 2015). With the app, things like public health rules and how people feel about technology and privacy are essential in shaping how the app was made, how people adopted it and how well it works. Research plans that focus on context help get into the details of the situation around what is being studied. This involves a surface-level description and critically examining how context influences the phenomenon. These studies also realise that what is being studied has the context's temporal and spatial dimensions, acknowledging that phenomena are historically situated and geographically bounded. Awareness of this makes the research findings richer and more meaningful (Massey, 2005).

The justification for a qualitative research design that focuses on complexity and context is dual. First, such a design ensures a nuanced and comprehensive understanding by

embracing the complex nature of phenomena and their context-specificity. This is crucial for health interventions, where outcomes are closely linked to human behaviour and social structures. Second, insights from this design carry practical significance, shaping decision-making and policy formulation. Grasping the complexity and context of phenomena can lead to more effective deployment, promotion and integration of public health measures.

The emphasis on complexity and context in qualitative research design highlights a dedication to an in-depth and subtle examination of social phenomena. This is vital for research on health interventions during a pandemic, like the app, capturing the essence of phenomena in their complexity and ensuring that results are substantial, meaningful and actionable.

Qualitative research methods, especially case study designs, excel at delving into complex phenomena in their natural settings (Yin, 2018). These methods enable researchers to capture rich descriptive data that mirror the real experiences of individuals and groups, offering insights into their interactions with, perceptions of and the effects they receive from the studied phenomenon (Stake, 1995). It also allows the researcher to understand contextual influences. By anchoring the research in particular contexts, qualitative researchers discern the contextual elements that influence the phenomenon, including environmental, cultural, institutional and historical factors (Yin, 2018). It also uncovers emergent themes and patterns, providing a profound understanding of a phenomenon's intricacies. It delves beyond mere observations to examine the foundational mechanisms and significances (Saldaña, 2016).

4. Exploratory nature of the qualitative research design

Qualitative research design is fundamentally exploratory. Its goal is to understand the full scope and intricacies of human experiences, behaviours and societal phenomena. Its exploratory characteristic is especially fitting for studies that seek to reveal new insights, grasp complex processes and interpret meanings in particular contexts (Miles and Huberman, 1994; Silverman, 2014). For instance, in examining complex issues like the use and impact of the app during the pandemic, an exploratory qualitative research design provides a versatile and thorough method for grasping the subtle dynamics and viewpoints.

Exploratory research is intended to probe areas where knowledge is scant or to shed light on the unknown facets of a thoroughly examined field. Its purpose is not to offer conclusive answers but to identify patterns, themes and hypotheses for subsequent

investigation. This approach is founded on several fundamental principles. Qualitative research flourishes with open-ended questions that do not assume specific outcomes, aiming to delve into participants' experiences and perspectives (Stebbins, 2001). It permits researchers to pursue new directions and modify their inquiries as initial results emerge. This flexibility is vital for investigating complex and dynamic phenomena (Patton, 2015). Finally, exploratory research typically employs inductive reasoning, where specific observations inform the creation of broader generalisations or theories. This ground-up strategy is essential for context-specific understanding of phenomena (Thomas, 2006).

5. Exploratory nature of studying the App

An exploratory qualitative research design is particularly suitable for studying the app for several reasons. It looks at how the app was deployed and promoted to the population, including healthcare workers, policymakers and users of smartphones (Greenhalgh et al., 2004). The flexible nature of this research also lets it keep up with fast changes and new uses in digital health tech, allowing researchers to adjust their focus as new information comes out.

6. Methodological Considerations

This kind of research uses many ways to collect information, including detailed interviews, observation and documents analysis to fully understand the topic. The process usually involves identifying themes, storytelling or building theories from the data collected, which helps in spotting trends and getting a complete picture of the insights gathered.

Analysing data in exploratory research typically involves thematic analysis, narrative analysis or grounded theory techniques, helping in the identification of patterns and the formation of a detailed understanding of the data (Miles and Huberman, 1994; Braun and Clarke, 2006). This research method is beneficial for looking into new or complex issues by following an iterative form of inquiry for the study. It aims to create a deep understanding through a broad and flexible inquiry, laying the base for more research and informed decision-making.

7. Exploratory nature of the qualitative research design

The app's launch marks an innovative public health crisis management strategy by combining technology with established epidemiological practices. With this intervention's innovative and emergent nature, the research field is filled with uncertainties and

variables that are not yet fully understood or recorded. Qualitative research's exploratory nature excels in managing this ambiguity, offering a versatile framework for uncovering new knowledge and grasping complex phenomena from diverse viewpoints (Miles and Huberman, 1994; Patton, 2015). This exploratory method recognises and accepts the intricacies of the app's deployment and promotional efforts and its role in shaping the pandemic and healthcare delivery in England and Wales. It permits researchers to investigate the intricacies of the collaboration among experts who came together to develop and launch a health app during a critical time without the limitations of searching for definitive answers or forcing the narrative into pre-established categories. Such openness is vital for grasping the app's complex nature.

Exploratory qualitative research is marked by methodological flexibility, enabling researchers to modify their approaches as fresh insights arise (Braun and Clarke, 2006; Merriam, 2009). This adaptability is essential when examining the app, as the pandemic's context, technological standards and public health policies are rapidly changing.

As research advances, the qualitative exploratory approach allows for refining RQs, adjusting data collection methods and re-evaluating analytical frameworks to align better with emerging data and insights (Corbin and Strauss, 2015). The exploratory nature of qualitative research encourages deeper stakeholder engagement by prioritising their voices, experiences and interpretations in the investigation. The qualitative research design's exploratory aspect is crucial for understanding the complexities of the app's deployment and its public health management implications. This approach deepens our understanding of digital health interventions during unprecedented times, fostering the emergence of new insights, methodological adaptability and profound engagement with stakeholders' experiences. It thus establishes a groundwork for future research, policymaking and the development of public health technologies.

The qualitative research design's exploratory nature is vital for the app's study, following qualitative methodologies' flexibility and depth to address digital health interventions. This approach allows researchers to get into the details and understand the challenges of digital health tools. Stebbins (2001) discusses the principles and importance of exploratory research in social sciences. He emphasises the necessity of an exploratory approach when encountering new or complex phenomena, emphasising its capacity to produce rich, contextualised insights into social realities. His exposition on exploratory research's flexible and open-ended character highlights its appropriateness for examining innovations like the app.

Table 6. Stebbins' framework for exploratory research, including the study of the NHS COVID-19 app.

Key Principle	Description	Application to NHS COVID-19 app Study
Emphasis on New Discoveries	It investigates areas with little prior research to identify new phenomena, concepts and connections.	Explore the aspects of the app's mobilisation, promotion and potential unforeseen impacts on the COVID-19 pandemic and healthcare.
Flexibility in Research Design	Adaptable research designs that can evolve in response to emerging data, allowing for changes in focus based on preliminary findings.	Employ a research design that adapts to new insights about the app's mobilisation and promotion, constructing the COVID-19 pandemic/healthcare as data is collected and analysed.
Use of Qualitative Methods	Uses in-depth interviews, participant observation and document analysis to gather detailed data, prioritising understanding of individual and group perspectives.	Analyse documents to gain rich insights into the app's mobilisation, promotion and construction of the COVID-19 pandemic and healthcare.
Abductive approach	Employs an abductive reasoning approach, where theoretical explanations and hypotheses are iteratively generated from the analysis of collected data, enabling a continuous dialogue between observed phenomena and theoretical insights rather than strictly testing pre-established theories.	Use sociotechnical theory to gain insights about the app's mobilisation, promotion and construction of the COVID-19 pandemic/healthcare.
Iterative Process of Data Collection and Analysis	It involves a cyclical process of collecting, analysing and using findings to inform further data collection, enabling deeper understanding over time.	Continuously refine the research focus and questions as new data about the app's mobilisation, promotion and construction of the COVID-19 pandemic/healthcare are collected and analysed.
Emphasis on Contextual Understanding	Stresses the importance of understanding phenomena in their social, cultural and historical contexts to uncover how these contexts influence the phenomena.	Understand the app in the broader context of pandemic management, considering various demographics towards technology and policy changes.
Openness to Serendipitous Findings	Acknowledges the value of unexpected findings that may arise, encouraging researchers to remain open to serendipity and incorporate such findings into analyses.	Remain open to and incorporate unexpected insights into the research findings about the app's mobilisation, promotion and construction of the COVID-19 pandemic/healthcare.

Source: Author

Stebbins' framework endorses the use of exploratory qualitative research by offering a methodological rationale for examining digital health interventions' intricate and evolving aspects during a global health crisis. Such an approach enables a more insightful understanding of the app's influence and possibilities, setting the stage for subsequent research and policymaking in digital public health initiatives. The table captures the core of Stebbins' framework for exploratory research, underscoring its significance in an exhaustive study of the app. Using these principles, researchers can deftly explore the intricacies of this digital public health initiative, gaining detailed insights crucial for guiding future technological advancements, policymaking and strategies for pandemic response.

The justification for emphasising interpretive depth in qualitative research stems from the primary aim of qualitative research: to grasp the subtle meanings and intricate realities of human experiences and societal phenomena (Finlay, 2002). This is especially vital in fields like health studies, where grasping individuals' subjective experiences, the intricate details of health interventions such as the app and the broader social and cultural contexts are crucial to providing valuable insights for theoretical and practical applications. Interpretive depth allows researchers to depict phenomena and understand the reasons and mechanisms behind them, yielding a comprehensive, multi-dimensional, enlightening and practical understanding.

Fully grasping the concept behind a phenomenon requires researchers to examine all its components critically. This includes the interplay of individual agency, social structures and cultural norms (Geertz, 1993). Achieving interpretive depth necessitates a focus on contextual richness. Attention to detail, such as the connection between people's actions and thoughts and their specific time and place, allows researchers to uncover subtleties and complexities that standardised quantitative research might overlook (Flyvbjerg, 2006). Awareness that personal perspectives influence experiences, and our understanding of the research subject is crucial. Thinking and reflecting on our biases and how they shape our interpretations can help us understand the proper view of the situation (Finlay, 2002).

Investigating complex issues such as mobilising and deploying a health app requires a deep dive into its significance to users and its impact on them. This depth of understanding can contribute to the app's wider acceptance and influence policy surrounding it. Interpretive depth provides detailed insights that can inform more effective deployment, engagement strategies and policy development, helping to place the narrative in the larger societal context (Riessman, 2008). The interpretive depth in

qualitative research yields context-sensitive insights vital for shaping informed policies and practices.

To get a broader view, researchers use many methods of gathering information, such as talking to people (in-depth interviews), focus-group discussions, observation and document analysis. This makes it easier to understand things in more detail because it involves many different views and types of data.

Researchers use unique methods such as thematic analysis, discourse analysis or grounded theory to analyse data in a manner that emphasises interpretive depth, concentrating on the identification of underlying themes, narratives and discourse, like looking for themes, studying conversations or building theories from the ground up to dig deep into the data. They focus on finding hidden themes and stories (Braun and Clarke, 2006). Achieving interpretive depth presents challenges, including the risk of researcher bias, the complexities of expressing complex facts and the necessity for extensive, careful analysis. However, the advantages of this approach, especially regarding the richness, relevance and practical insights, warrant its application in qualitative research designs. Its detailed approach helps make research rich, relevant and valuable, especially in studies about people and society.

3.7. Philosophical underpinnings

The philosophical foundations of a research role shape its methodological approach, affecting the framing of questions, the collection and analysis of data, and the interpretation of results. This session will explore critical philosophical viewpoints on the study of the app's deployment, promotion, and influence on managing the pandemic.

3.7.1 Constructivism

Constructivism argues that reality and knowledge are constructs of social interactions and experiences (Crotty, 2020; Lincoln and Guba, 1985). Constructivism holds that individuals create subjective meanings based on their experiences directed toward specific objects or entities. These diverse meanings are plentiful, prompting researchers to seek various perspectives rather than reducing them to a limited set of categories or ideas. Constructivism is especially pertinent in qualitative research, prioritising understanding individuals' nuanced, subjective experiences in their contexts.

Constructivism stresses that knowledge and truths are subjective, emerging from the interaction between researchers and participants. It challenges the notion that reality can be observed objectively, proposing that individuals construct their realities through engagement with their surroundings (Crotty, 2020). Constructivist research endorses a

co-constructive process between researchers and participants involving dialogue and reflection that allows both to contribute to the evolving understanding (Berger and Luckmann, 2016). Constructivism recognises that truths are relative and context-dependent, permitting the coexistence of multiple, equally valid realities that mirror the variety of human experiences (Schwandt, 1994).

It is essential to understand how different individuals, such as those implementing policies and those who developed the app, are involved. This way of thinking, known as constructivism, believes that exploring different views and how people interact with the app helps understand their reality. In the app, researchers are encouraged to dive deep into how everyone involved – users, healthcare workers and policymakers – form their views and thoughts about the app. For example, looking at the app, especially privacy and how it changes user's actions, can say much about how it would be accepted. It is also important to determine how healthcare professionals and those making policies see the app's role in public health. This involves checking out what they expect, the challenges benefits of the app. How the app was promoted, and the media also helps in influencing public opinion about the app's uptake. Constructivism suit well with research methods that focus on detail understanding context and personal perspectives. Techniques like detailed interviews, group discussions and documents analysis are suitable approaches to learning complex realities (Denzin and Lincoln, 2011). Researchers need to think about their influence on the research. They should consider how their views and interactions might shape what they discover (Finlay, 2002). Adopting constructivism views in the research helps in getting a thick and personal view of the complex and varied realities people experience. Studying the app with this approach lets researchers understand people's views, giving a richer picture of its effects and what it means to people. Constructivism enhances research by focusing on personal views, how things are interpreted and working together to create knowledge. This helps researchers understand how digital health tools like the app impact people's lives.

Constructivism and its application to RQs on the App

Examining the app using a constructivist approach, especially about specific RQs, facilitates an in-depth investigation of personal experiences, perceptions and interpretations of the app's implementation, use and influence. This section explores how constructivism guides the study of the app according to the proposed RQs.

In the constructivist framework, the initial research question investigates the collaborative mobilisation of the app for pandemic management. It examines the symbiotic relationship between technology firms, health management entities like the

NHS and other social dynamics contributing to the app's creation. Through thorough document analysis, researchers can discover diverse approaches of the phenomenon (Prior, 2003; Bowen, 2009), such as app development.

The second research question examines the app's promotional strategies and their reception, interpreting them through a constructivist perspective as a process of meaning construction by both the promoters (the government and NHS – and the audience – the public). Constructivism enables researchers to scrutinise how promotional narratives affect specific population segments critical to the app's success. Studying promotional content, social media conversations and public responses offer insight into the communicative strategies influencing public sentiment regarding the app (Berger and Luckmann, 2016)

In the third question, constructivism helps to decipher the intricate relationship between the app and broader public health strategies through the lens of healthcare professionals, policymakers and users. Researchers employing a constructivist lens investigate how these groups perceive and define the app's function and influence in the healthcare system, encompassing its obstacles, advantages and assimilation into established protocols. This includes examining policy documents related to the app's deployment in pandemic management and its effects on healthcare provision (Schwandt, 1994).

3.7.2 Interpretivism

Interpretivism, a philosophical approach emphasising the nuanced and subjective meanings individuals and groups ascribe to their experiences, offers a valuable lens for examining the app's impact on healthcare. It is useful in qualitative studies involving document analysis as it aims to uncover the complex layers of meaning in texts associated with this health-centric application (Schwandt, 1998, 1994).

Integrating the app into healthcare encompasses its development and launch phases and initial engagement with potential users. This process can be analytically examined by delving into policy papers, project development logs and public health communications disseminated through official channels.

The interpretive perspective enables researchers to discover broader aspects of the app's intended objectives and the pronounced strategies for its launch and adoption. It facilitates an in-depth examination that goes beyond basic knowledge, revealing the biases and expectations of key stakeholders, including policymakers and technology developers (Yanow and Schwartz-Shea, 2015).

How this application was presented to the general public and medical professionals is profoundly insightful as it conveys implicit messages and perceptions that are carefully crafted to encourage adoption and increase use, thereby leveraging power dynamics. An interpretive understanding is essential when evaluating the narrative intensity of health-related communications and the various underlying narratives, especially those centred on societal responsibilities towards collective well-being – critical elements in the widespread adoption of emerging technologies (Hsieh and Shannon, 2005). The promotional campaign is crucial to engage essential segments of society, shaping the potential for achieving widespread acceptance and, consequently, the app's effectiveness (Lupton, 2016, 2014). Analysing media coverage can reveal the public's perception of an app, revealing diverse opinions and critiques from professionals and everyday users. The interpretive, analytical perspective helps understand societal interactions with the app, including fears, hopes and scepticism (Couldry, 2012).

The NHS COVID-19 tracking software's impact on healthcare delivery and public health was complex. It guides patient behaviour in various ways while modifying case management procedures and strategies to curb the virus's spread. An interpretive approach allows the researcher to explore how this digital tool is integrated into medical policies and clinical practices and its role in the broader context of e-health technologies (Greenhalgh et al., 2005).

Examining policy documents related to Bluetooth functionality offers insights into these applications' user alert and self-isolation support features. Interpretive analytics allow one to delve beyond the surface to uncover deeper meanings directly related to delivery and patient management experiences during the pandemic (Morse et al., 2002). Using interpretive methods to analyse documents on deployment, promotion and impact strategies is beneficial for understanding the rationale behind actions taken in the fight against COVID-19, exemplified by the NHS smartphone technology.

This study formulates a complex relationship among medical fields, public perception and theoretical technological advancements. It focuses on collectively deriving subjective interpretations from sociocultural cognition, recognised in conjunction with individual contextual understanding. This culminates in reports that lay the groundwork for further improvements.

A philosophical framework underpins all qualitative research routes. This is particularly evident when examining specific cases such as the NHS COVID-19 app, where the focus extends from constructivist aspects to extracting meanings assigned by stakeholder groups, contrasting the tangible outcomes of strategic implementations.

Analysing media coverage can illuminate the public's perception of an app, revealing diverse opinions and critiques from professionals and everyday users. The interpretive, analytical perspective helps understand societal interactions with the app, including fears, hopes and scepticism (Couldry, 2012).

Take the NHS COVID-19 tracking software as an example – its impact on healthcare delivery and public health is complex. It guides patient behaviour in various ways while modifying case management procedures and strategies to curb the virus's spread. An interpretive approach allows researchers to explore how this digital tool is integrated into medical policies and clinical practices and its role in the broader context of e-health technologies (Greenhalgh et al., 2005).

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3.7.3 Epistemic Considerations

Epistemic considerations in qualitative research are about the nature and justification of knowledge, focusing on our understanding and validation of truths about the world (Bryman et al., 2021; Miles and Huberman, 1994). They explain the fundamental assumptions influencing research choices. These considerations guided my selection, interpretation and understanding of documents as knowledge sources in analysing the app's mobilisation, promotion and healthcare impact through document analysis.

Epistemology in qualitative research addresses knowledge construction, including its definition, generation, and validation in the research process. It interrogates the origins of knowledge, the methods for its acquisition, and the standards for its evaluation (Denzin and Lincoln, 2011; Crotty, 2020). In my study of the app via document analysis, epistemic considerations shaped how I assessed documents and used them to understand its implementation.

This entails evaluating the authenticity, credibility and representativeness of documents concerning the app, including government reports, policy documents, promotional materials and media coverage (Scott, 1990; Prior, 2003). Considering the constructed nature of documents – created by entities with particular intents and viewpoints –

epistemic rigour in the interpretive analysis involves recognising and critically scrutinising the biases and presuppositions in these texts. Researchers must traverse these biases to forge a nuanced understanding of the app's development, deployment and reception (Altheide and Schneider, 2013).

Triangulation involves verifying findings from multiple sources to enhance epistemic validity. This method validates constructed knowledge by comparing and contrasting various information sources (Denzin, 1978). Understanding the epistemic foundations of policies and strategies is crucial when examining documents from the app's development and deployment phases. Researchers must consider the knowledge claims in these documents, analyse how the app is presented as a solution to public health needs and examine the evidence supporting these claims.

Epistemic considerations include examining the strategies used to persuade the public and healthcare professionals in documents promoting the app. The analysis should explore health behaviour, technology adoption and public trust assumptions. Focusing on the app's impact, document analysis involves scrutinising reports, health data and professional feedback. Researchers must assess the methodologies and metrics in these documents, questioning how they construct knowledge about the app's adoption and healthcare implications.

Epistemic considerations are crucial in qualitatively studying the app through document analysis. They guide the researcher to critically assess how knowledge about the app was constructed, presented and validated across documents. applying epistemic rigour allows the researcher to navigate the complexities of constructed knowledge, ensuring a comprehensive and critically informed understanding of the app's mobilisation, promotion and impact on healthcare.

3.8. Ethical Considerations

Ethical considerations are important in qualitative research, especially document analysis studies. Ethical document acquisition and use ensure respect for individuals' and institutions' rights, the research process's integrity and the results' trustworthiness. This section addresses the principal ethical considerations and methods for acquiring and using documents responsibly in this study.

Publicly accessible documents might contain sensitive data about people or organisations. Researchers must handle personal information with the highest level of confidentiality and anonymise any potentially identifying details when sharing findings (Mauthner et al., 2012).

Informed consent for public documents may not always be necessary, but it is imperative when dealing with private or confidential materials. Researchers ought to obtain permission from the documents' owners or custodians, clearly articulating the research's purpose and the papers' intended use (Saunders et al., 2015).

Honouring copyright laws and intellectual property rights is important. This includes appropriately citing sources and securing permission to use copyrighted content in the research (SPJ, 2024).

Researchers must consider the possible harm resulting from document misuse, such as misrepresenting the creators' intentions or inflicting reputational harm. Meticulous and respectful analysis and reporting can help reduce these risks (Guillemin and Gillam, 2004).

Public documents are generally considered fair use for research, though ethical considerations still apply. For private documents, explicit permission and consideration of privacy concerns are paramount. Maintain transparency about how documents were obtained, the criteria for their selection and the analysis methods. This transparency supports the ethical integrity and accountability of the research process.

Researchers should de-identify data in documents containing sensitive or personal information to protect individual privacy. This may involve redacting names, locations or other identifying details (BPS, 2021). They should also approach the analysis and reporting phases with an ethical mindset, ensuring that interpretations and conclusions do not misrepresent the data or harm the document creators or subjects represented in the documents (Iphofen, 2011).

This research was centred on publicly accessible documents concerning the app and presented distinct ethical considerations, especially during a worldwide health emergency. Given their relevance to public health policy, individual privacy concerns and the potential sensitivity of the information, these materials' respectful and responsible use is paramount.

Before initiating this research, the Aston University Research Ethics Committee gave ethical approval, affirming the study's commitment to the ethical standards required for scholarly research. This approval process ensured that the research design adhered to the moral principles and guidelines for conducting research with integrity and respect for all involved parties.

Given the public domain status of the documents analysed, special attention was

directed towards ensuring the confidentiality and anonymity of any potentially identifying information, even though the primary focus is public health strategies and outcomes. This approach aligns with ethical guidelines that advocate for protecting individual privacy, even in analysing publicly available data (Mauthner et al., 2012). All documents and sources cited, including publication dates, adhere to strict copyright laws and intellectual property rights, respect the creators' rights and contribute to the research's credibility (SPJ, 2024).

The documents' selection, procurement and analytical methodologies were transparently documented and conducted ethically. Ensuring transparency is crucial in managing the COVID-19 pandemic through technological means, such as the app, due to the public interest and the sensitive nature of the situation. Maintaining ethical integrity in analysis ensures that the results are reported truthfully. This will help avoid misrepresentation or damage to the reputation of the involved parties or individuals (BPS, 2021).

The analysis examined the broader effects of the app on healthcare systems and pandemic management in England and Wales, with a conscious regard for the ethical implications of discussing public health strategies and outcomes. It also considered the ethical risks arising from document misuse, such as misrepresentation or causing reputational harm, particularly during a public health crisis (Guillemin and Gillam, 2004).

In conclusion, this thesis on managing the COVID-19 pandemic via the app in England and Wales is committed to rigorous ethical standards, reflecting the topic's seriousness and delicacy. With ethical clearance from the Aston University Research Ethics Committee and strict adherence to privacy, copyright laws and intellectual property rights, this research offers significant insights into the role of digital technology in managing pandemics and maintains the utmost ethical research protocols.

CHAPTER 4: THE MOBILISATION OF NHS COVID-19 APP THROUGH SOCIOTECHNICAL LENS

4.1. Introduction

The outbreak, which began in late 2019 in Wuhan, China, quickly spread worldwide, leading to widespread illness, numerous deaths, and disruptions to business and daily life. The World Health Organisation reported nearly 760 million cases and 6.9 million deaths globally due to the COVID-19 pandemic as of 9th August 2023 (WHO, 2023)). This crisis underscored the need for stronger local community care systems to better prepare for future threats.

Healthcare systems, unprepared for such an unprecedented event, were thrust into the rapid spread of COVID-19, with essential resources becoming scarce - hospital beds were inadequate, and frontline workers were overwhelmed. The scale of these disruptions required significant actions: implementing lockdown protocols and social distancing measures and restricting travel to curb further spread while trying to minimise the negative impact where possible, which provided some control over the situation (BMA, 2024) This crisis highlighted the need for innovative solutions to strengthen healthcare systems in the face of future threats.

However, the physical toll of the illness on humanity also brought repercussions such as economic downturns, a surge in job losses, upheaval in the education sector, and mental health suffering due to extended periods of isolation and uncertainty, exacerbating pre-existing issues significantly. The development of vaccines was a breakthrough during these difficult times; however, it was not without challenges - vaccine hesitancy arose during immunisation campaigns, distribution issues emerged, and new virus variants complicated the situation further (ONS, 2021).

Despite scepticism, vaccines paved the way toward herd immunity, representing a crucial step in restoring normalcy, proving more essential than ever. International medical organisations have adopted cutting-edge technological solutions to address these health challenges. Among these, were the contact tracing apps, designed to empower smartphone users with early warning updates should they be at risk of exposure of the virus. The NHS COVID App, a product of the United Kingdom's National Health Service, explicitly targets the regions of England and Wales as a frontline effort to curb the further spread of infection. The effort to develop and deploy such a significant tool in the fight against the virus's transmission is indeed an understatement of its complexity.

The research question that guides this chapter is (RQ1): **How was the NHS COVID-19 app mobilised to manage the COVID-19 pandemic in England and Wales?** This study examines the collaborative efforts, technological advancements, and strategic decisions that shaped the app's development.

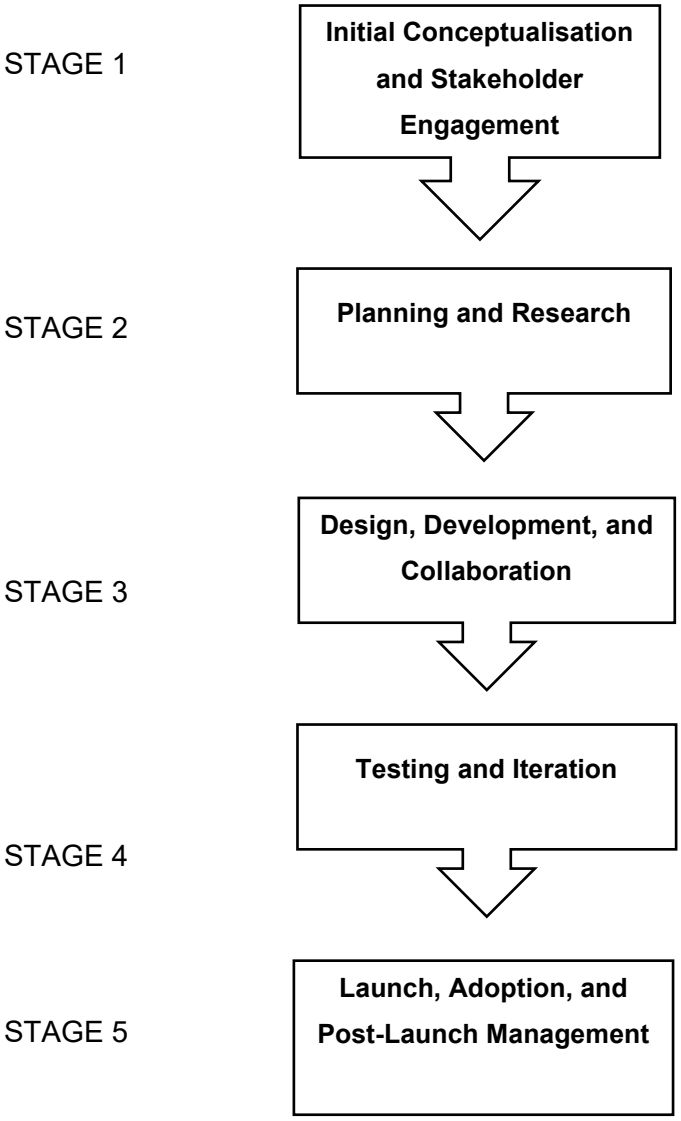
The research is informed by the sociotechnical theory, which considers the interplay between social and technical elements in technology's creation and use (Balloni and Targowski, 2015; Da Bernardo et al., 2021). The core idea is that technological components and societal practices mutually shape each other, forming a network of interdependent elements. For instance, developing the NHS's COVID-19 app highlights the complex journey from development to deployment that can be analysed under this theory.

This theoretical perspective reveals a complex web in which public health officials intersect with technology developers and government entities engaging with end-users, all interacting through the mobile application's pivotal technological artefact.

Investigating these connections is crucial for several reasons. First, tracing the entire course of the NHS COVID-19 app from its conception to its launch provides insights into how to integrate traditional preventive measures with technology to contain pandemics more effectively, revealing the intricate, multilayered dynamics within sociotechnical systems to help illustrate the critical factors and dependencies for the success of digital healthcare solutions. Second, developing such applications raises significant privacy and security concerns that must be addressed before these digital tools are widely adopted. This examination deepens the understanding of maintaining confidentiality and building trust with potential users. Third, the insights gained from analysing these critical factors can inform strategic decisions for future innovations in smartphone applications that support epidemic and pandemic management, potentially enhancing preventive care outcomes on a population-wide scale.

Analysing the details and refining the deployable, high-impact NHS COVID-19 app presents a roadmap with multiple nuanced steps.

Figure 1: Five main stages of the NHS COVID-19 App development



Source: Author

The above steps form the themes of chapter 4 and are presented in more detail in the table below. I then follow sociotechnical theory to examine the app's journey from conceptualisation to its launch, and post-launching management. Sociotechnical theory offers a valuable framework for analysing the development and deployment of the NHS COVID-19 app by emphasising the inseparable connection between technology and social practices. Applying this theory involves examining several vital elements, including the interplay between social dynamics and technology, the intertwining of social and

technical elements, the causal impacts, the influence of technology, and the practices in real time. The creation and dissemination of the app represent a complex interweaving of human and non-human agents, including health experts, developers, Bluetooth technology, and privacy regulations, all intricately interconnected and mutually constituted. Sociotechnical theory posits that the social and technical realms are perpetually interlinked. Regarding the NHS COVID-19 app, applying the theory necessitates exploring how public health objectives, user privacy concerns, and technological capabilities mutually influence one another. Sociotechnical habits are influential; they shape certain realities. The launch of the app was more than a tool for contact tracing; it influenced public perceptions of digital health devices and their role in pandemic management. Such tools are significant; they can initiate action and drive change. The NHS COVID-19 app, through its design and workflow, influenced user behaviours, health strategies, and policy decisions. Exposure alerts from the app encouraged users to self-isolate, impacting the virus's transmission. Sociotechnical theory examines the practices that animate the social and technical worlds. Therefore, it was essential to observe the app's routine usage, to integrate it into public health procedures, and to incorporate it into users' daily lives.

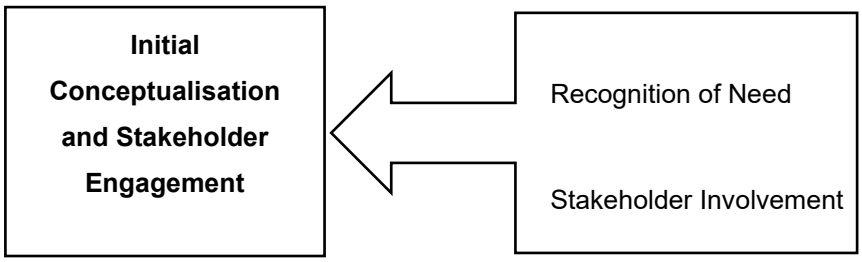
Table 7. Themes, Codes, and Description of the Identified Codes

Themes	Codes	Description
Initial Conceptualisation and Stakeholder Engagement	Recognition of Need	Identifying the necessity for a digital solution to manage COVID-19.
	Stakeholder Involvement	Engaging with the NHS, government bodies, public health experts, and partners.
Planning and Research	Feasibility Study	Assessing the technical feasibility, potential impact, and challenges.
	Benchmarking	Learning from similar solutions in other countries.
Design, Development, and Collaboration	Technical Architecture	Defining the app's architecture, including centralised vs. decentralised models.
	Privacy and Security	Ensuring robust data protection, user privacy, and regulatory compliance.
	User Experience (UX) Design	Creating a user-friendly interface to ensure ease of use and accessibility.
	Partnership with Apple and Google	Using the Apple-Google Exposure Notification API to enhance functionality.
	Development Teams	Collaboration with organisations such as Alan Turing Institute, Oxford University, Zuhlke Engineering and NHS Digital.
Testing and Iteration	Beta Testing	Conducting pilot trials in selected regions to gather user feedback.
	User Feedback	Collecting and analysing feedback to improve the app.
	Bug Fixes and Updates	Addressing technical issues, bugs, and performance improvements.
	Enhanced Features	Adding new features based on user needs and feedback.
Launch, Adoption, and Post-Launch Management	Marketing and Outreach	Promoting the app through various channels to encourage adoption.
	User Support	Providing support for installation and usage to assist users.
	Ongoing Monitoring	Continuously monitoring app performance and user feedback.
	Regular Updates	Rolling out updates and new features to enhance functionality.

Source: Author

4.2. Initial Conceptualisation and Stakeholder Engagement

Figure 2. Thematic map 1:



4.2.1. Recognition of Need

The COVID-19 pandemic presented significant challenges and myriad issues. However, innovative strategies to combat and mitigate the virus's impact were devised. Nevertheless, the rapid transmission of the virus and the limitations of traditional health measures have emphasised the need for technological solutions. The swift global spread of the virus rapidly revealed that traditional contact tracing was insufficient for managing the pandemic. The high number of cases and contacts overwhelmed health systems, complicating the process of tracing and notifying potentially exposed individuals. This situation emphasised the scale of the pandemic, and the shortcomings of traditional methods, leading to a shift towards innovative approaches acknowledged to be the fastest way to deal with the virus, as indicated by the excerpt below:

> *The NHS COVID-19 app is the fastest way to keep yourself and other people safe from Coronavirus. [NHS Test and Trace, 24 September 2020]*

The rapid spread of the virus necessitated swift action, with the potential for technology to provide solutions. This marked a pivotal moment in the battle against COVID-19, driven by the crisis and the gradual realisation of the virus's rapid transmission. The initial steps focused on identifying the significant challenges posed by the pandemic and exploring technological interventions. The NHS COVID-19 app was based on the idea that technology could improve the speed of contact tracing. Traditional contact tracing involved laborious efforts to identify and communicate with anyone exposed to a confirmed case, a process too slow for the virus's rapid spread. Digital solutions, especially those involving smartphones, promised to expedite this process and reduce manual labour. Using Bluetooth, smartphones could detect proximity to other devices and log encounters automatically, bypassing manual recall or action. As noted by the

extract below, this innovation promised to make contact tracing quicker and more precise, a critical advantage in containing the virus.

> *The NHS COVID-19 app uses the latest Google and Apple technology to identify an individual's exposure risk. The app achieves "excellent" performance in accordance with international definitions. [NHS Test and Trace, 24 September 2020]*

This quote highlights the expected rapid and precise improvements from this technological fix in computing. The following sections outline the main reasons for the necessity of a digital solution: the vast reach of the virus, the sluggish nature of traditional contact tracing, and the opportunity technology presents for a quicker and more accurate alternative. Moreover, there was a clear need for scalability. Traditional contact tracing methods are resource-intensive and difficult to scale up. In contrast, digital solutions can be rapidly deployed on a large scale, making them ideal for handling an outbreak of this magnitude. The unique challenges posed by COVID-19, including the extent of the pandemic, its rapid transmission, and the inadequacies of conventional strategies, called for a new direction, culminating in the creation of the NHS COVID-19 app.

4.2.2. Stakeholder Involvement

The creation of the NHS COVID-19 app was a collaborative effort involving key players, such as the NHS, major government entities, public health experts, and technology specialists. Their combined expertise, intelligence, and resources ensured the project's success. Each individual's unique contributions enriched the app development process, adding various elements:

> *The NHS Test and Trace team behind the app has worked closely with major tech companies, including Google and Apple, scientists within the Alan Turing Institute and Oxford University, Zuhlke Engineering, medical experts, privacy groups, at-risk communities and teams in countries across the world using similar apps – such as Germany, to develop an app that is safe, simple and secure. The app has been through successful trials in the Isle of Wight, Newham and among NHS volunteer responders. Lessons learned have informed the final version that is launching today. [Department of Health and Social Care, 24 September 2020]*

This quote highlights the broad consensus among stakeholders on the necessity of a digital approach, which involved experts and selected geographical trials to produce an app that worked for England and Wales.

Involving the right people was crucial. Initially, it ensured the app aligned with health objectives and could address the challenges posed by the pandemic. Involving key individuals was essential for acquiring technical expertise and infrastructure, and it fostered trust and acceptance, which is vital for widespread app adoption. The NHS played a significant role in developing the app, being the primary healthcare entity in the UK. The NHS's experience with health crises and reputation greatly influenced the app's development and implementation. Government involvement guaranteed compliance with national health policies and facilitated the acquisition of the resources needed for the app's creation and launch. Experts contributed critical insights into disease management, ensuring the app was equipped to handle COVID-19, including features such as symptom checking and exposure notifications. Collaboration with tech giants, notably Apple and Google, was instrumental for the technological aspects, leveraging their prowess in mobile technology and developing the Exposure Notification API, which was integral to the app's functionality.

4.2.3 Analysis of Sociotechnical Interactions

Analysing the NHS COVID-19 app using sociotechnical theory examined the interplay between people and technology. This perspective helps to understand how various groups and the app's technology came together in its creation. The app's interconnected health-centric objectives and technological framework exemplify sociotechnical entanglement. Thanks to the expertise of the NHS, the app included features such as exposure notifications and symptom checkers, making it a trustworthy source for reliable information and safety.

> *The app has a range of features including risk alerts by postcode district and a symptom checker. The app has been rigorously tested and we have worked closely with Google and Apple; scientists within the Alan Turing Institute and Oxford University; medical experts; privacy groups; at-risk communities, and teams in countries across the world, who are using similar apps, to bring a state-of-the-art contact tracing product to market that is safe, simple to use and secure. [NHS transformation directorate, 2020]*

The NHS's guidance significantly influenced the app's development, highlighting the healthcare system's crucial role in public health initiatives. Regulatory bodies ensured the application aligned with national policies, integrating policy-driven social considerations with the functional elements of tech-support tools. The government's involvement in providing essential support and resources was vital in developing this software tool.

> *UK government Health and Social Care Secretary Matt Hancock said:*
>
> *We are at a tipping point in our efforts to control the spread of this virus. With infection rates rising we must use every tool at our disposal to prevent transmission, including the latest technology.*
>
> *We have worked extensively with tech companies, international partners, and privacy and medical experts – and learned from the trials – to develop an app that is secure, simple to use and will help keep our country safe.*
>
> *[Department of Health and Social Care, 24 September 2020]*

When government officials became involved, they ensured alignment with the national health objectives. Collaborating with tech giants such as Apple and Google provided the necessary technical foundation. This highlights the government's crucial role in shaping policy and managing resources. Additionally, with their understanding of diseases, numerous health experts contributed to the app's design and functionality. This collaboration exemplifies the synergy between social expertise and technological innovation .

> *In a joint statement, Apple and Google said: We built the exposure notifications system to enable public health authorities in their efforts to develop apps to help reduce the spread of the virus while ensuring people can trust in the privacy-preserving design. We are committed to supporting the government's effort to launch an app based on this technology. [GOV.UK, 2020]*

Public health experts offered insights into epidemiological needs, ensuring the app was designed to meet real-world challenges, emphasising the importance of expert knowledge in shaping the app's features.

The collaboration with technology companies provided the technical foundation for the app, illustrating how social interactions (collaboration) and technological aspects co-construct each other. The use of the Exposure Notification API resulted directly from this sociotechnical interaction. Wales's Health and Social Services Minister, Vaughan Gething, said:

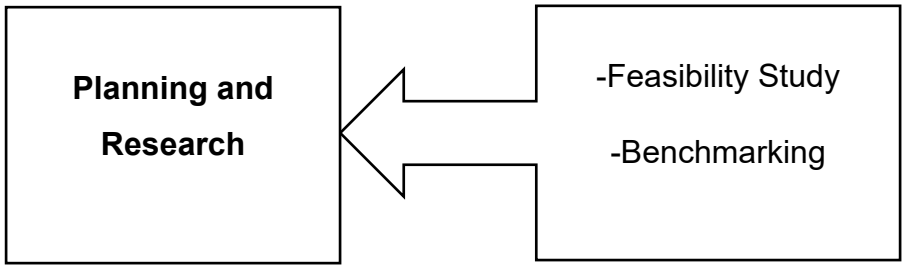
> *We have worked closely with the app development team to ensure it works seamlessly across England and Wales, providing people with the right advice based on where they live. In Wales, the app will complement our existing contact*

> *tracing and testing services and will further support our co-ordinated response to COVID-19 at both a local and national level. [GOV.UK, 2020]*

Collaborating with technology giants such as Apple and Google was a significant aspect of app development. These companies created the Exposure Notification API, which was integrated into the app, enabling it to function across various phone models and enhancing its utility. This aspect emphasises the critical importance of technological partnerships in establishing the app's technical foundation. Involving everyone in creating the NHS COVID-19 app was a complex task that involved gathering diverse perspectives, specialised knowledge, and the resources to construct a substantial, effective digital solution. Examining the interplay between human and material components offers valuable insights into their collective contribution to the app's development. These interactions emphasise such endeavours' dynamic and interdependent nature, illustrating the importance of comprehensive collaboration in developing meaningful digital health solutions.

4.3. Planning and Research

Figure 3.Thematic Map 2:



4.3.1. Feasibility Study of the NHS COVID-19 App

Conducting a trial of the NHS COVID-19 app was a significant move. The trial evaluated the app's functionality, usefulness, and potential challenges and gauged public reaction, as it needed to be effective and well-received. The technical aspects, notably Bluetooth Low Energy (BLE) technology, were crucial. BLE is advantageous as it conserves battery life while detecting proximity between devices. Selecting BLE was vital; the app required efficient proximity detection without draining batteries. However, signal interference and varying performance across different phone models posed challenges. Compatibility with various platforms necessitated collaboration with Apple and Google to integrate their exposure notification systems.

Adapting the app to diverse devices and operating systems presented obstacles, including variable Bluetooth usage and privacy concerns. With health data involved, prioritising privacy and security was paramount. Therefore, it was decided to store data on individual devices rather than a centralised server, a departure from the initial plan. This approach aimed to minimise data exposure risks and enhance user trust. The app's potential benefits were measured according to its ability to expedite contact tracing, with the primary objective of making this process quicker and more automated. By informing users immediately about possible exposure to the virus, it was hoped the app could decelerate the spread by prompting quicker isolation and testing than was the case previously. An additional benefit was that the collected and anonymised app data could provide insights into the virus's transmission patterns. This information enabled health authorities to identify hotspots and allocate resources efficiently. However, widespread adoption of the app was crucial for its effectiveness. Therefore, earning user trust and ensuring the app's ease of use were vital for its success. The pilot phase highlighted some concerns, particularly regarding data privacy and fears of surveillance. Ensuring that users were confident in the app's data security was essential for its widespread acceptance.

The project encountered various technical challenges, including unreliable Bluetooth connections, potential signal disruptions, and different quirks of smartphone hardware. These issues presented significant obstacles. Obtaining reliable, consistent performance across various devices necessitated significant tweaking and adjustments. Persuading people to download and continually use the app was also a formidable task. Clear communications were required, as well as possibly offering incentives to encourage regular use. The documentation created during the app's development is filled with valuable insights. The document serves as a comprehensive manual that outlines the various challenges encountered and the solutions implemented to ensure the proper functioning of the app.

> *When two devices running the app are close to each other, they exchange Bluetooth "handshakes" to determine the distance and duration, measured in sessions lasting five minutes. The measurements are not always accurate – and work continues to improve them – but the logs are used to create a cumulative points score for the set of interactions between two people over the course of a day. [BBC, 24 September 2020]*

Ensuring accurate distance estimation and consistent performance across different devices posed significant challenges. The importance of addressing privacy concerns to

build public trust is emphasised in the following quote:

> *But Michael Veale, a University College London academic who was involved in proposing a decentralised model even before Apple and Google came up with their system, says the NHS app team has gone even further than needed in protecting privacy: "Some of the design choices that the NHS Covid app made were more conservative than the Apple-Google API is." [BBC, 30 October 2020]*

Privacy concerns drove the choice of a decentralised data system, emphasising the necessity of aligning technical specifics with public preferences. Collaborating with major players, such as Apple and Google, was crucial to resolving technical issues, and integrating their exposure notification APIs was imperative for the app's functionality.

Sociomateriality theory examines the interplay between organisational operations' social and material aspects, which is particularly relevant when considering the trust-building element of the NHS COVID-19 app planning study. The theory emphasises the intricate connection between technology and social elements, influencing each other reciprocally. For instance, public trust, a social aspect, was deeply intertwined with the material aspect of data privacy. Opting for a non-centralised data model directly responded to societal concerns about privacy. This interplay demonstrates how societal sentiments (the social aspect) shaped the app's technical framework and vice versa.

Additionally, compliance with data protection regulations, such as GDPR, was a social imperative that affected the app's technical construction. Ensuring that the data collection and management adhered to legal standards influenced the selection of encryption techniques and data storage protocols. Anticipating user-device interactions (social) informed the design of the user interface and notifications (technological). For example, minimising battery consumption was crucial to prevent users from disabling Bluetooth, which is essential for the app's functionality. However, balancing the social and material considerations was challenging. Maintaining privacy while ensuring the app's effectiveness required a delicate equilibrium. Overemphasis on privacy could have hindered the app's contact tracing ability, and insufficient focus could have provoked public discontent. Public perception of the app's efficacy and privacy safeguards was critical; effective communication strategies were essential to highlight the app's advantages and alleviate concerns regarding data security.

Moreover, the app needed to be compatible with various technological aspects, including the capabilities of different devices and user preferences. Ensuring compatibility and

optimal functionality across various devices required extensive testing and multiple enhancements. The preparatory study for the NHS COVID-19 app examined the feasibility of the technology, its potential impact, and the anticipated challenges through a sociotechnical lens. This perspective emphasised the interdependence of social and material components and the importance of their careful alignment to ensure the app's success.

4.3.2. Benchmarking in the Development of the NHS COVID-19 App

Benchmarking is the process of evaluating performance against industry leaders (Invernizzi et al., 2018) and it played a crucial role in developing the NHS COVID-19 app. Observing and learning from the strategies of other countries guided the crafting of the app. Other nations' use of digital technology to track COVID-19 contacts provided valuable insights. During the app development process, several countries had already implemented their systems, providing a comparative advantage. Additionally, various effective strategies and potential pitfalls were identified. For instance, Singapore's TraceTogether app, launched on 20 March 2020, was an early model that utilised Bluetooth for proximity detection, serving as a blueprint for the NHS COVID-19 app's development. Despite concerns about Bluetooth's reliability and data privacy, the app's development proceeded, highlighting the necessity to gain public trust, which required transparent communication about the personal data needed and its protection. The Singapore government's enthusiastic support and active promotion of their app provided valuable insights into user engagement.

Similarly, Germany's Corona-Warn-App, released on 16 June 2020, provided another valuable reference point. That app stored all user data on their devices, similar to the NHS COVID-19 App. This approach conveys to users that they have control over their information, which fosters trust. The app's code was also made public, allowing anyone to review and propose enhancements. Germany's existing health systems integrated seamlessly with the new system, emphasising the importance of interoperability. On 11 February 2020, South Korea implemented a comprehensive digital strategy to combat COVID-19. This approach included a combination of application-based tracing, extensive testing, and robust public health measures not limited to a contact tracing app. This approach demonstrated the necessity of a well-organised strategy. However, the South Korean government faced criticism regarding the extent of personal data scrutiny, emphasising the delicate balance between public health and privacy. From this benchmarking exercise, Singapore, the first country to deploy a similar app, provided lessons for countries that deploy them later.

> *Singapore was the first country to deploy a national coronavirus-tracing app. The local authorities say 2.1 million people have downloaded the software, representing about 35% of the population. It is voluntary for everyone except migrant workers living in dorms, who account for the majority of Singapore's 44,000-plus infections. [BBC, 5 July 2020]*

Bluetooth's effectiveness in tracking meetups and safeguarding personal information was significant. Establishing and maintaining trust by being transparent about data usage and ensuring privacy protection was important:

> *Ministers point out the devices don't log GPS location data or connect to mobile networks, so can't be used for surveillance of a person's movements.*
>
> *Mr Cross agrees that from what he was shown, the dongles cannot be used as location-trackers.*
>
> *But he adds that the scheme is still less privacy-centric than a model promoted by Apple and Google, which is being widely adopted elsewhere. [BBC, 5 July 2020]*

Additionally, the significance of government involvement and effective communication in driving public acceptance also highlighted its shortfalls:

> *The government agency which developed the devices acknowledges that the Tokens – and technology in general – aren't "a silver bullet", but should augment human contact tracers' efforts. [BBC, 5 July 2020]*

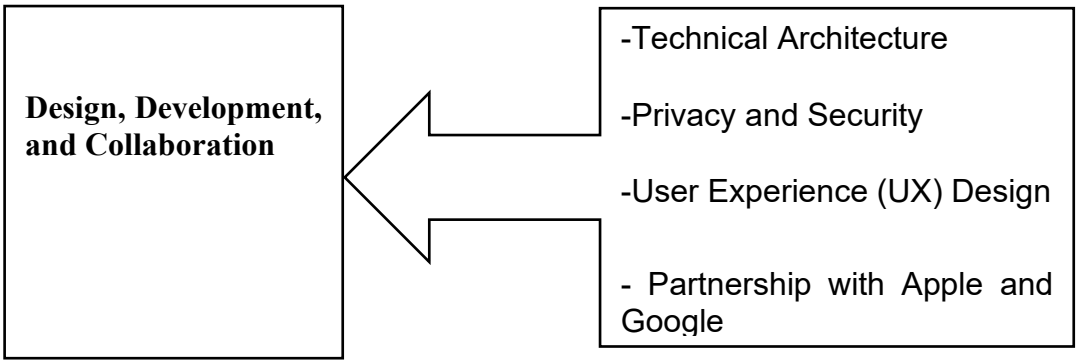
The strength of government support and clear communication significantly influenced public adoption. Based on experiences with similar initiatives, these observations played a vital role in developing the NHS COVID-19 app. The lessons learned from observing comparable solutions informed the strategy and construction of the app.

Examining similar aspects in various settings provided a straightforward method for developing the NHS COVID-19 app. Factors such as public trust and governmental directives played significant roles. Technical elements and data security were also crucial. This understanding was instrumental in the planning process. Trust and transparency were paramount. Lessons were drawn from the challenges faced by Singapore's app: the developers of the NHS COVID-19 app aimed for clarity in data usage and security. Inspired by Germany's app, they opted for an open-source approach to enhance trust. The combination of societal trust and transparency was vital for public acceptance of the app. Privacy was not overlooked; emulating Germany's app, data

centralisation was avoided, which ensured contact matching occurred on individual devices, reducing the likelihood of data breaches and alleviating privacy concerns. The NHS app team considered the balance between privacy and health needs, taking inspiration from South Korea's approach. The team chose technology that respected privacy while effectively tracking contacts. Learning from other countries made government support and public engagement much more accessible. Experiences from Singapore and Germany highlighted the necessity of government backing to launch the app successfully. The NHS app developers understood the importance of strong government support and clear communication to encourage public usage. Drawing on lessons from abroad, the developers recognised the need for public participation, so they focused on transparency, user education, and addressing concerns. Technologically, the developers borrowed elements such as Bluetooth proximity tracking from Singapore and compatibility with existing health systems from Germany, influencing their app's design. This blend ensured the app's functionality aligned with the health objectives. Observing international strategies greatly informed the development of the NHS COVID-19 app, emphasising the significance of both social and technical aspects in its design and implementation.

4.4. Design, Development, and Collaboration

Figure 4.Thematic Map 3:



4.4.1 Technical Architecture

The NHS COVID-19 app's technical infrastructure played a crucial role in its effectiveness. Critical decisions, particularly about data management (centralised or

decentralised), were necessary during its development. When developing the NHS COVID-19 app, a significant decision was required regarding data management. The options were to adopt a centralised or decentralised approach. Each method had advantages and disadvantages, significantly influencing the app's technical aspects and public perception. In a centralised model, all data gathered by the app, such as contact events, are transmitted to a central server. These data were then analysed to identify potential exposure events and notify affected individuals. The centralised model offers considerable benefits, such as simplified data analysis. With all information in one location, health authorities can swiftly examine contact patterns and track the virus's spread, enabling quicker and more co-ordinated responses. However, this model raises substantial privacy and security concerns. Concentrating sensitive health data in one centralised location makes the system prone to a significant risk of cyber-attacks.

Conversely, in a decentralised model, data processing occurs on individual phones.

Each device independently logs encounters, and when a user tests positive, only pertinent data – typically stripped of personal identifiers – are shared with a central server. The decentralised approach offers improved privacy and greater control over data for users, and it has the potential to enhance trust and usage. Additionally, this method reduces the likelihood of widespread data breaches by eliminating a central data repository. Nevertheless, the decentralised model adds complexity to data analysis and the coordination of public health initiatives, as information is spread across various devices. The development of the NHS COVID-19 app offers valuable insights. A section of the document mentions reasons individuals may have concerns about their personal information:

> *In a huge win for digital privacy, in June 2020 the UK government scrapped plans to use a centralised model for its Covid-19 tracker app, opting for the decentralised model long advocated by Open Rights Group (ORG).*
>
> *Vital funding from members and supporters enabled ORG to deliver key legal demands that helped convince the government their centralised model was a privacy disaster.*
>
> *The UK has averted the creation of a massive database of sensitive personal data that could be handed over to American Big Data companies vying for NHS patients' data. [Open Rights Group, March 2020]*

The decision to adopt a decentralised data model was influenced by social concerns about privacy (as demonstrated by social groups such as ORG), emphasising the

importance of addressing public concerns in technical decision-making. Another significant point discusses the technical challenges:

> *The measurements are not always accurate – and work continues to improve them – but the logs are used to create a cumulative points score for the set of interactions between two people over the course of a day [BBC, 24 Sept 2020]*

Ensuring the app's consistent functionality across different devices posed a significant challenge, requiring diligent efforts to achieve seamless operation on diverse device types. The main challenge lay in optimising the app for various gadgets.

Choosing between centralised and decentralised plans highlights the trade-offs between technical considerations and broader objectives. Health initiatives require swift and straightforward contact tracing and data management, which a centralised approach can provide quickly. However, personal privacy and data security concerns led to a preference for a decentralised method. This tension illustrates how societal factors, such as public trust and privacy concerns, technical capabilities and data protection, shape the architecture of an application. Viewed through a lens that combines social and technical aspects, the interplay between these elements is significant. The shift to a decentralised approach was not solely a technical choice but was also influenced by societal values and concerns. Public trust, for instance, is crucial and can affect an app's adoption rate. If people felt the app infringed on their privacy, they might have opted not to use it, rendering it ineffective.

Consequently, the decentralised method was chosen, as it was deemed more publicly acceptable, promoting broader usage and efficacy. The technological framework of the health app had to balance these diverse requirements. The app's developers needed to ensure it was robust and capable of effectively tracing contacts and alerting individuals to potential exposure from an infected person. The development team had to create a system prioritising user privacy and security to build trust and promote app adoption. Balancing technical effectiveness and user privacy was essential for the app's development. Bluetooth technology for proximity detection was chosen because it provided accurate distance measurements without compromising individual privacy.

Additionally, choosing a decentralised data approach presented numerous technical hurdles. Each device had to perform complex calculations to assess exposure risk, typically handled by a centralised server. This process required ingenious solutions and optimisations to ensure the app functioned efficiently across various devices without

draining the battery or impeding performance.

4.4.2. Privacy and Security

The quotation below notes that, for the app to comply with stringent data protection regulations, privacy experts were consulted:

> *We have been discussing the app with the Information Commissioner and Members of the National Data Guardian's Panel as well as a wide range of privacy experts…*
> *The NHS COVID-19 app has been developed with a commitment to transparency, ethics and the law.*
> *We have also used the advice provided by the Ethics Advisory Group for the app, chaired by Professor Sir Jonathan Montgomery from University College London, during the development of the app. This group was formed and met in the spring of 2020 and ceased to meet in July. It identified key ethical issues and a trust matrix for the development of contact tracing apps and these were a reference point throughout the app's development. [NHS Covid-19 App Support Group, 24 September 2020]*

The above quote provides an indication of the significance of complying with regulations to protect individuals' data security. The quote also emphasises the importance of transparency and honesty in building trust with application users. Clearly communicating how data are used and maintaining confidentiality are essential in promoting user engagement.

The development of the NHS COVID-19 app prioritised robust data safety and strict rule compliance. The app had to navigate complex privacy laws while ensuring user confidence through transparent, secure practices. The development team employed several vital strategies to protect user information and prevent stringent regulation breaches, such as GDPR.

Advanced security measures were embedded in the app's design to prevent unauthorised access and protect user identities from being compromised. All data transferred between devices and servers were encrypted with high-level encryption to defend against potential breaches. Personal identifiers were anonymised or replaced with pseudonyms, making it challenging to trace data back to individuals – a critical step in preserving privacy.

During the design phase, the focus was on collecting the minimum data necessary,

reducing risks and adhering closely to GDPR's data handling requirements with strict precision. By collecting only essential information, the developers aimed to minimise external threats while adhering to data protection policies established by design.

To comply with GDPR, the system incorporated features that enabled individuals to manage their information, including access to their data, the ability to correct errors, and the option to delete records, empowering users to control their personal details. The team leading the app's development emphasised the importance of clear and transparent communication regarding data collection, storage, and accountability. Building public trust was essential for the app's widespread acceptance.

A critical assessment, evaluating the pros and cons of data protection courses, termed DPIA, has become an indispensable part of contextualising successful analytics. Identifying and addressing bottlenecks before they impact the end-user workflow is easy, and these are not just a mere display of obedience to laid-down schemes but undoubtedly reinforce the commitment to deliver unmatched assurance.

The development of the NHS COVID-19 app's privacy features demonstrates the intricate interaction between social and technical elements. Public privacy concerns heavily influenced technical decisions, such as implementing encryption to conceal data and anonymise identities. Conversely, the technical capabilities shaped the app's privacy policies and user communication. The app's ability to earn public trust hinged on adherence to privacy regulations. Frameworks such as GDPR provided the basis for privacy protocols, whereas public perception and confidence influenced their implementation. This dynamic between regulatory standards (technical elements) and public trust (social elements) highlights how digital health apps' privacy features are intertwined with social and technical considerations. The privacy aspects of the app's creation were not solely about addressing technical challenges but navigating a complex network of social and technical factors. For instance, the decision to adopt a decentralised approach was driven by privacy concerns and the desire to safeguard data:

> *Apple and Google's "decentralised" approach carries out the matches on the handsets themselves, on the grounds that this better protects users' privacy. [BBC, 11 Jun 2020]*

Therefore, they opted for a decentralised data model due to privacy concerns. This option required the technical team to address complex issues, such as accurate distance

estimation and consistent device performance. The team committed to minimal data collection, employing advanced encryption and anonymisation techniques. This approach highlights the intersection of social and technical considerations. Technical measures were necessary to preserve user privacy, a highly valued aspect. Implementing encryption and anonymisation was central to the app's privacy policies. In this manner, the team ensured the protection of user data according to both societal expectations and legal requirements. Adherence to privacy regulations and trust were closely linked to the app's development. Strict compliance with GDPR provided a robust framework for privacy. However, public trust, equally crucial, influenced the practical application and communication of these measures. By adopting a transparent approach to data handling and implementing exceptional privacy features, the team earned and maintained public trust. The importance of public trust is further emphasised in the following quote:

> *The app has been designed with user privacy in mind, so it tracks the virus not people, and uses the latest in data security technology to protect privacy.*
>
> *"The app will only notify users who are at-risk if they have been near to an individual that has tested positive for Covid-19 and provides advice on what actions to take next." [BBC, 30 October 2020]*

The app's success was significantly influenced by gaining user trust through data usage and privacy transparency. Clarity and honesty played a crucial role in the app's triumph. The app developers aimed to foster trust and encourage widespread adoption by ensuring that users were informed about the use and protection of their information. However, developing the NHS COVID-19 app was far from straightforward; it demanded robust privacy and security measures, balancing safeguarding user data, complying with regulations, and gaining public confidence.

4.4.3 User Experience (UX) Design

The development team's focus on user engagement is emphasised by the following quote, which highlights the effort to encourage consistent app usage:

> *Once the app has been downloaded, you'll need to switch on Bluetooth so that contact tracing can work.*
>
> 1. *Go to your phone's home screen. Find 'Settings' and tap on it to open.*

> 2. *Scroll down in 'Settings' until you find 'Connected devices' or 'Connections' and tap on it to open.*
> 3. *Find 'Bluetooth' and tap on it. You may need to open 'Connected preferences' to find Bluetooth, depending on your phone model.*
> 4. *Tap the slider button next to Bluetooth to switch it on. It should change colour once Bluetooth is on.*
> 5. *Your phone may ask you to select a nearby Bluetooth device. This is not needed for contact tracing to work so you can close this screen if it appears.*
>
> *[UK Health Security Agency, 13 May 2020]*

The above quote emphasises the significance of creating a user-friendly and engaging interface that allows users to navigate independently.

The development of the NHS COVID-19 app prioritised user-friendliness. The screen was designed to be intuitive, inclusive, and enjoyable to encourage widespread downloading and usage. This approach involved integrating design principles with technical aspects informed by user feedback and testing outcomes. The team's goal was to create an app that was straightforward, universally accessible, and captivating. The team strived for a self-explanatory minimalist design, enabling users to navigate without a manual. Using distinctive icons, minimal text, and clear instructions ensured the app was used correctly. Simplicity was vital to prevent any barriers to usage.

Furthermore, the quote below emphasises the app's dedication to accessibility for diverse user groups:

> *It will be available to those aged 16 and over in multiple languages. It forms a central part of the NHS Test and Trace service in England and the NHS Wales Test, Trace, Protect programme – identifying contacts of those who have tested positive for coronavirus. [Department of Health and Social Care, 24 September 2020]*

The app was developed with features to target those aged 16 and over in multiple languages, demonstrating an inclusive approach to enhance usability.

User input was a top priority and based on how individuals used their devices, which is evident in the app's design. Features were added to enhance accessibility, because the goal was to ensure the app's usability for everyone. This approach responded to societal needs, exemplifying the concept of sociotechnical systems, in which social requirements and design features evolve in tandem. Engaging users was a challenging task that required continuous attention to this social–technical interplay. Notifications and

reminders were crafted to prompt the necessary user actions. However, the effectiveness of these prompts depended on user perceptions and responses, creating a dynamic exchange between design elements and societal behaviour. This process became a cycle of designing, testing, and iterating, embodying the essence of social technical, in which user experiences continually shape and are shaped by the app's design features.

Apple and Google were critical players in developing the NHS COVID-19 app, particularly through integrating the Apple-Google Exposure Notification API. This collaboration ensured the app functioned correctly. The following quote emphasises this technical integration:

> *The NHS Test and Trace team behind the app has worked closely with major tech companies, including Google and Apple…*
>
> *[Department of Health and Social Care, 24 September 2020]*

Collaborating with Apple and Google was crucial for the app's functionality. Integrating their exposure notification system was a pivotal move. The collaboration between Apple and Google exemplifies the teamwork and technological expertise of the project. The two tech giants united their experts to create the exposure notification API. This alliance ensured the API was robust, safeguarded user privacy, and accessible to a broad audience.

4.4.4. Development Teams

The NHS COVID-19 app was a project involving enormous activity and collaboration. Other partners contributed to various aspects of the app, such as data security, user experience, and regulatory compliance. Addressing all facets of creating a user-friendly app that adhered to data protection laws was crucial. The collaborative effort ensured that the app was reliable and intuitive, which was vital for gaining public trust and widespread adoption. The importance of team collaboration is emphasised in the development process:

> *The NHS Test and Trace team behind the app has worked closely with major tech companies, including Google and Apple, scientists within the Alan Turing Institute and Oxford University, Zuhlke*

> *Engineering…to develop an app that is safe, simple and secure. [Department of Health Social Care, 24 September 2020]*

The app's development involved collaboration with various organisations, including the Alan Turing Institute, NHS Digital, Oxford University, and others. This highlights the project's multidisciplinary nature and the importance of collaborative efforts in achieving its objectives. Furthermore, the project noted the value of technical expertise:

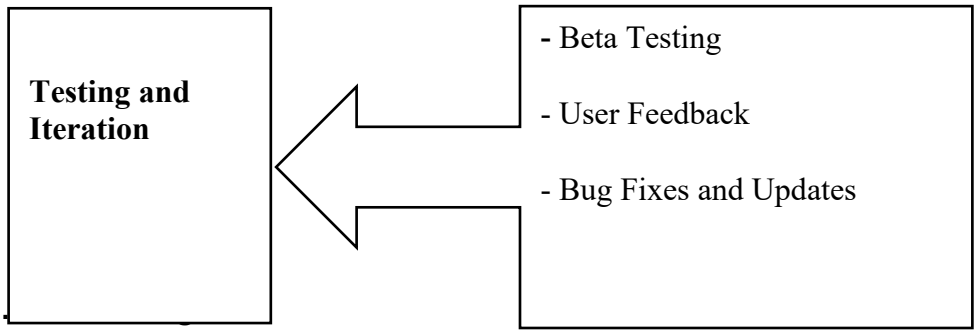
> *The NHS COVID-19 app has the UK Conformity Assessed (UKCA) mark and shows that a medical device is fit for its intended purpose and meets the necessary safety requirements. [UK Health Security Agency, 13 May 2020]*

The Alan Turing Institute specialises in software development and project management, and it helped the application to be completed on time and function without any issues, highlighting the importance of technical expertise in the successful execution of the project.

The app development teams comprised individuals with expertise in various fields, such as coding, wellness, and data security. This blend of significant expertise created a rich mix of knowledge, ensuring the app achieved vital health objectives. For example, the NHS ensured compatibility with the existing health infrastructure, and the UKCA mark indicated regulatory compliance. Such a teamwork is a demonstration of the sociomateriality framework of material and social activities mutually influencing each other in creating an app.

4.5. Testing and Iteration

Figure 5.Thematic Map 4:



4.5.1.

Studying how users interact with a new app, commonly known as the "beta testing

phase". Beta testing is crucial in-app development, as it bridges conceptualising an idea and launching a fully functional application. The NHS COVID-19 app underwent several trial runs in specific locations to identify and resolve issues before its public release. This process included real-world testing with a limited users to evaluate the app's performance, ease of use, and effectiveness. The beta testing began in particular areas, such as the Isle of Wight, which was chosen for its manageable population size, facilitating close monitoring and control of the trial. This strategic choice enabled an in-depth assessment of the app's real-world operation. This phase focused on the app's technical performance, user accessibility, and user feedback. The accuracy of Bluetooth contact tracing and data transmission consistency were critical aspects of the testing. Ensuring the app was user-friendly across diverse demographics was also a priority. User feedback was essential to determine the app's usability, value, and any encountered issues. Beta testing involved daily app usage by residents of the selected areas, integrating it into their routine to observe natural usage patterns. Surveys and feedback forms were distributed regularly to capture user experiences and suggestions for improvement. This comprehensive approach enabled the developers to identify and rectify problems before the app's wider release. User engagement was a critical aspect of beta testing explained by Simon Thompson, Managing Director of the NHS COVID-19 App:

> *We have worked tirelessly to develop the new NHS COVID-19 app and we are incredibly grateful to all residents of the Isle of Wight, London borough of Newham, and NHS volunteer responders, the learnings and insight have made the app what it is today. We are now ready to roll-out the app across England and Wales. [Department of Health and Social Care, 24 September 2020]*

The participants from the Isle of Wight were given the app and advised to use it as part of their daily routines, emphasising the relevance of real-world testing in gaining insights into user interaction with the app. Certain technical issues were uncovered during the beta testing phase reported by the media:

> *However, the BBC has discovered that one of the main reasons the initiative is running behind schedule is that developers are having problems using Bluetooth as a means to estimate distance. [BBC, 11 June 2020]*

Preliminary tests identified issues with Bluetooth signal stability and data transfer, highlighting technical obstacles that needed to be overcome to guarantee the app's

dependability and efficiency.

This cycle of feedback and refinement is integral to the intertwined nature of social and technical elements, in which user experiences and app features continuously influence each other. Swiftly reacting and adapting are essential in developing quality software. The changes implemented based on user feedback were instrumental in enhancing the app. The development team made improvements such as improving Bluetooth connectivity for better signal detection and revamping the app's interface for ease of use. The dynamic interplay between social aspects (user experiences and feedback) and technical elements (app design and functionality) highlights the importance of the development team's adaptability and ability to modify features based on user input, which was a critical factor in the success of the app.

4.5.2. User Feedback in the Development of the NHS COVID-19 App

The technology team utilised various methods to collect user feedback, including distributing surveys to test users to gather data on usability, reliability, and satisfaction. In addition to the quantitative data, direct conversations with users provided valuable insights beyond what the numerical data revealed. The app also included features enabling users to report issues and share thoughts in real time, helping the team to identify and address problems quickly to align better with users' needs. Initial trials of the app uncovered both glitches and aspects appreciated by users. The feedback collected during the beta testing phase highlighted several common issues and positive aspects of the app:

> *The most commonly cited reason was not having the appropriate equipment. Many did not have the correct operating system or were using phones that they did not think would be compatible with the app. Additionally, those who did not have mobile data or were on pay-as-you-go contracts were not keen to download the app or did not think it would be useful. Another commonly cited problem was not having enough space on the phone to be able to download the app. Some respondents were casual phone users, who either do not take their phones out with them or who use their phones only for emergencies so they did not feel that they would benefit from the app, given their current habits. [Department of Health and Social Care, 8 April 2021]*

Based on the feedback, mobile data issues and gadget malfunctions were reported. These issues needed to be addressed before the app was launched nationwide. The input provided clear and direct points, highlighting the need for immediate attention to improve the app's performance and user satisfaction. However, the Isle of Wight

evaluation report also mentions positive feedback:

> *Most users found the app easy to use: 82% of people found the app very easy to download and 84% found it very easy to enter their details. Additionally, 84% of people rated their support for rolling out the app across the UK as being 4 or 5 out of 5. [8 April 2021]*

Many users appreciated the app's simplicity and its clear guidance on when to avoid contact with others or get tested. This feedback highlighted the app's strengths and the most beneficial features to its users. User input was instrumental in enhancing the app at every stage. For instance, issues with Bluetooth connectivity prompted technical improvements to improve signal detection and reduce disconnections. Addressing real-world problems led to a more reliable and effective app.

Conversely, negative feedback, such as reports of the app malfunctioning, was invaluable for identifying and resolving problems that could have impacted the app's performance. This swift action on user feedback fostered trust and ensured the app remained effective in its purpose.

This interplay of feedback and app development emphasises the value of openness and adaptability in-app creation. The significance of dialogue and adaptation cannot be overstated. The NHS COVID-19 app was improved and remained relevant throughout its life by heeding and responding to feedback. It is not enough for a health app to be merely functional; it must also earn the trust and engagement of users. Prioritising user-friendliness and adaptability were vital for creating compelling, reliable, and user-endorsed health tools in the digital era.

4.5.3. Bug Fixes and Updates

Addressing technical glitches and enhancing functionality are essential for maintaining an app's reliability and performance. The fixes and updates for the NHS COVID-19 app were identified through user feedback and testing. A primary objective of improvements was to enhance Bluetooth functionality, particularly for accurate contact tracing. The optimisation of algorithms for distance calculation and reducing signal interference was crucial for the app to detect and record user interactions accurately. Updates were implemented to improve data security, including enhanced encryption methods to protect user information and ensure compliance with evolving privacy regulations. The development team faced significant technical challenges, particularly in optimising Bluetooth functionality as mentioned previously. This problem highlights the complexity of the task, and the technical expertise required to address such issues effectively. User

feedback was instrumental in guiding these efforts:

> *Some respondents were concerned, or actually forgot, about turning the contact tracing toggle back on after pausing it. The NHS COVID-19 app now has a timer function to reactivate contact tracing. [DHSC, 8 April 2021]*

Feedback from users played a crucial role in identifying and prioritising performance improvements, highlighting the significance of user input in shaping the development process and ensuring the app addressed the most pressing issues.

This process involved various social and technical elements that shaped the app and its usage. Modifications were made based on user feedback, creating a feedback loop that altered user interaction with the app. This demonstrates the intertwined technological and social aspects, each influencing the other. For instance, improving the app's Bluetooth functionality stemmed from the necessity for dependable contact tracing.

4.5.4. Enhanced Features

The app was continually improved by heeding these user-driven adjustments, aligning with user preferences and desires. Beyond user suggestions, new features also responded to dynamic public health demands. For instance, integrating test centre locations and QR venue check-in information became essential as the pandemic evolved. This adaptability demonstrated the app's capacity to address changing health requirements and provide timely, relevant information. Introducing new features entailed development and testing. The updates were customised to meet individual user requirements and health goals and were reviewed to guarantee smooth integration with the current app. The development process was influenced by user feedback, as evidenced by the report of the DHSC addressing a “ghost exposure notification” feedback from users:

> *By removing these unnecessary ‘ghost’ exposure notifications, it will be clearer to app users they only need to self-isolate when instructed to do so by the app. The new update will be available immediately on all eligible Android phones, and iPhones running on operating system iOS 3.7 or above. [29 October 2020]*

The app was updated to include more detailed exposure notifications and additional language support, addressing user requests, demonstrating how user feedback influenced the development of new features. The app was adapted to changing health

requirements:

> *Features of the app include contact tracing using Bluetooth, risk alerts based on postcode district, QR check-in at venues, symptom checker and test booking – with user privacy and data security at its heart. [DHSC, 24 September 2020]*

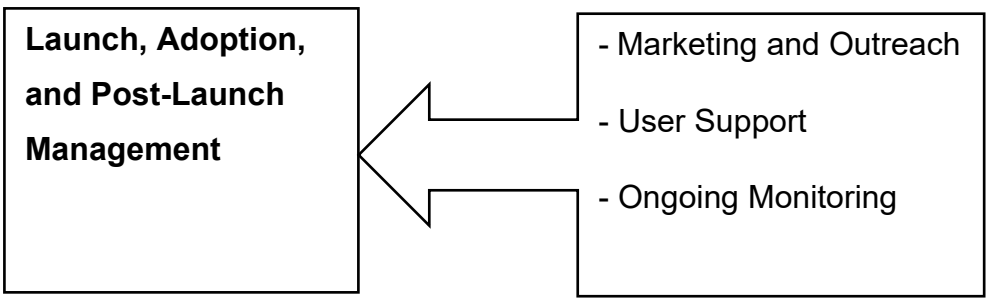
Working with testing centres and the QR check-in feature for locations was implemented in response to evolving health requirements, demonstrating the app's ability to adapt swiftly to public feedback and health authorities' needs. These updates ensured the app remained useful and performed its functions effectively.

Continuously incorporating user input kept the app relevant and enjoyable. Regarding adaptability to new health requirements, the app's ability to adjust quickly was crucial. User feedback (the social aspect) guided the integration of new features (the technological aspect), influencing subsequent user interactions and perceptions. This ongoing cycle highlights the interplay between social and technological considerations in the development of health applications. The iterative process helped maintain the app's effectiveness by adapting to user preferences and technological advances. Viewing this stage through a sociotechnical lens reveals a dynamic interaction between social elements (such as user feedback and public trust) and technological components (such as features and data security), influencing the app's evolution. This process emphasises the significance of integrating user experiences into development, creating a digital tool capable of responsiveness and adaptability.

4.6. Launch, Adoption, and Post-Launch Management

This theme covers various promotional strategies that helped in the launch, adoption, and post-launch management of the app in England and Wales. I have provided a concise discussion at this stage due to this theme's overlap with research question 2, which discusses promotional strategies in chapter 5.

Figure 6.Thematic Map 5:



The journey of the NHS COVID-19 app encompasses its launch, widespread adoption, and subsequent management. These milestones in the app's history involved innovation and decisive action to ensure its effectiveness in controlling COVID-19. The development involved strategic planning and execution to meet the objectives related to managing the COVID-19 pandemic. The analysis explores these stages, examining them through a sociomaterial lens.

The following quote from a BBC report reveals extensive public awareness and government efforts in supporting the app's promotion:

> *The social media posts were part of a wider campaign to inform the public about the programme. "Our use of social media influencers has meant over 7 million people have been reached," said a spokesman for the government.*
> *"As a responsible government, we will use every means possible to keep the public informed during the pandemic and raise awareness of NHS Test and Trace. "This is just one part of a wider campaign utilising TV, radio, social, print, and other advertisements to ensure the public has the information it needs." The government said that all costs involved in the campaign would be published in due course as part of the regular transparency reports on gov.uk.*
> *Dozens of Instagram influencers including former Love Island contestants Shaughna Phillips, Chris Hughes and Josh Denzel made paid Instagram posts marked as ads, with the hashtags "#gettested" and "letsgetback". (BBC, 31 August 2020).*

Extensive public awareness campaigns informed the public about the app's benefits and encouraged downloads, demonstrating the use of comprehensive outreach strategies. In addition, high-profile endorsements from government officials and public health authorities were utilised to build trust and credibility.

> *Health Secretary Matt Hancock said the app "helps us to find more people who are at risk of having the virus" that human contact tracers are unable to find.*
> *"Everybody who downloads the app will be helping to protect themselves, helping to protect their loved ones, helping to protect their community because the more people who download it, the more effective it will be," he told BBC Radio 4's Today programme.*
> *The app keeps secret who receives a self-isolation alert.*
> *And there was some confusion about whether users could ignore a notification telling them to stay at home.*
> *Mr Hancock told BBC Breakfast: "That self-isolation is voluntary, unlike the mandatory self-isolation if you are called by NHS Test and Trace." (BBC, 24 September 2020)*

The above extract highlights the crucial importance of government endorsement in

cultivating public trust and encouraging widespread adoption.

Promoting the NHS COVID-19 app was not easy; it involved a complex blend of human and technical elements. Transparency with the public was a crucial part of the strategy. By highlighting the app's benefits and addressing privacy concerns, the creators aimed to reassure the public. This effort to align the app's functionality with public trust illustrates the necessity of synergy between technology and people. Engaging with the community was vital. By enlisting community leaders and groups, the strategy leveraged existing social networks to increase the app's visibility. Utilising existing relationships and trust to boost a technological tool's adoption was central to the campaign. Support from recognisable figures reinforced the message. Monitoring and adjusting the communication strategy was also essential. For instance, messages that did not resonate were refined to connect better with the public and emphasise the app's advantages. This dynamic illustrates the interplay between societal perceptions and the tactical approach. Flexibility in response to public feedback was crucial to sustain the app's momentum. Promoting the COVID-19 app involved a comprehensive strategy that included advertising efforts, government backing, and collaborative community programmes. The NHS COVID-19 app aimed to build confidence and increase usage by highlighting its advantages and addressing privacy worries. It is impressive how this campaign emphasises the significance of considering human elements (such as trust and community engagement) alongside technical aspects (such as privacy and functionality). Achieving this equilibrium was crucial in devising a campaign that could adapt and rise to the challenge of widespread app adoption. This dynamic strategy of monitoring public response and adjusting ensured the campaign consistently met its targets. The strategy enabled the campaign to evolve based on public feedback, maintaining its effectiveness.

The promotional campaign for the NHS COVID-19 app demonstrates the importance of considering various perspectives, encompassing people and processes. The campaign's success relied on gaining public trust, securing government support, and involving the community, leading to increased app usage. This experience highlights the need for continuous adaptation, especially when promoting the adoption of digital health tools, and it sets a higher standard than previously for future public health initiatives, emphasising the importance of flexibility and trust-building. (Chapter 5 provides a compressive promotional strategies of the NHS COVID-19 app)

4.7. Analysis Through Sociotechnical Lenses

Exploration of technological frameworks, social conventions, and personal actions offers

valuable insights into the development history of the NHS COVID-19 app. The effectiveness of this digital tool was shaped by careful planning, collaboration among stakeholders, and technological flexibility, which collectively influenced its features and the levels of public adoption. Conventional health strategies fell short in addressing the scaling hurdles of the unpredictable COVID-19 crisis, and this failure prompted the search for advanced solutions, as exemplified by the NHS COVID-19 app.

Systems Approach: A Unified Health Response Strategy

From the perspective of Systems Theory, the NHS COVID-19 app can be viewed as an element of a larger framework that was designed to improve public health standards. The transition toward the use of technology was a reaction to the extensive utilisation of digital devices in modern society and sought to speed up results to tackle the heightened virus transmission rate. This approach, centred around smartphones, was aimed to address the limitations of traditional manual methods and to enhance the pandemic response with real-time update capabilities.

The key collaborators for the app comprised the NHS management, government bodies, healthcare professionals, and reputable software development companies. This team exemplified a cross-sector effort to leverage collective knowledge and ensure compliance with technical and legal standards(Davies et al., 2021; Harris et al., 2016) The NHS provided clinical content, while regulatory agencies guaranteed adherence to legal obligations, even amid challenges posed by multinational technology firms. The blend of social factors with technological components mirrored a rising trend in the use of public health initiatives.

Furthermore, designers considered international model criteria to guide policy adjustments. An example was Germany's decentralised framework, which supports global knowledge sharing and influences national policymaking. Structural theories helped planners to recognise patterns that could be customised to address specific British requirements and, therefore, to guarantee alignment with shifting health standards and legal regulations(Fagerberg and Verspagen, 2021; Leavitt, 1965; Shaw and Glover, 2023).

An In-Depth Look at Actor-Network Theory

Analysis of the development of the NHS COVID-19 app from the perspective of ANT demonstrates that external influences such as governmental agencies, healthcare organisations, technology firms, and individual users significantly contributed to the process. These stakeholders illustrate that technologies do not arise from isolated

initiatives but through continuous negotiations among interconnected entities(Troshani and Wickramasinghe, 2014).

The significance of public trust, privacy standards, and adherence to international guidelines were highlighted as critical elements in the construction of a decentralised data framework. The development journey involved a focus on technical accuracy, on conformity with General Data Protection Regulation (GDPR) requirements, and public discourse surrounding these matters. It showcases a fundamental principle of ANT: technology design is shaped by social interactions, which, in turn, are transformed by technological progress(Booth et al., 2016; Latour, 2007).

Reliable relationships are pivotal to this process. The establishment of credibility regarding the app necessitated transparency in information management, which was achieved through a streamlined approach to data gathering, evident in the utilisation of Data Protection Impact Assessments (DPIAs). Adherence to this strategy aimed to strike a balance between user preferences and the advancement of technological capabilities within digital healthcare management. The engagements involved a wide range of participants, which underscored the importance of making continual adjustments based on real-time feedback to seek to close gaps and promote inclusive policymaking.

Sociomateriality: Trust and Digital Health Governance

Sociotechnical theories offer insights into broad dynamics, while Sociomateriality theory helps to explain the detailed elements that affect mutual agreement and acceptance of technological changes(Garbutt and Van Den Berg, 2022). This is pertinent given the role in everyday life of health technology devices and the public's perceptions of them. The successful implementation of these technologies necessitates manoeuvring through a complicated landscape that is shaped by regulatory factors and consumer expectations. In the case of the COVID-19 app, the ultimate focus was on the tracking and control of an infectious disease.

Independent evaluations and rigorous security protocols strengthen the precision of these technological solutions. The use of these services and frameworks is vital to foster trust and satisfy societal demands in digital healthcare governance. Their use results in a complex interplay of roles that becomes increasingly significant from a Sociomateriality viewpoint.

4.7.1 Design Focused on User Experience and Ongoing Enhancements

A design strategy that combines social and technical elements underscores the

significance of user participation and feedback systems to maintain public engagement with digital tools. This approach was strengthened by the partnership between Apple and Google, which enabled cross-compatibility among mobile platforms. This link highlighted the need for technological adaptability to advance public health.

Objective testing of the app, mainly conducted on the Isle of Wight, provided valuable insights into its real-world functionality and led to iterative updates informed by user feedback. This method aligns with System Theory's focus on adaptation and illustrates the necessity for ongoing improvements in digital healthcare solutions as user interactions and policies evolve (Cevasco and Roess, 2023).

In addition to technical updates, initiatives to raise awareness, such as endorsements from prominent figures, were implemented. These contributed to increased download figures (Between January 2019 and May 2021, there were 8,524,882 NHS App downloads and 4,449,869 registrations, with a 4-fold increase in App downloads when the COVID Pass feature was introduced) (Kc et al., 2023). Strategies aimed at informing the broad community about the app concentrated on establishing trust regarding its security and additional benefits. An emphasis on community involvement and the nurturing of proactive relationships illustrated that excelling in technology alone was not enough; to implement any digital healthcare project successfully, a well-rounded integration of medical accuracy and efficient communication systems is vital.

4.7.2 Constant Checks Alongside Adaptability Ensure Sustained Relevancy

An essential insight gained from the creation of NHS COVID-19-related apps is the need to keep the focus and a dedication to flexibility to improve user experiences over time.

The software underwent systematic updates that were driven by planned circular information flows, which included data from external influences that impacted decision-making, such as changing political regulations and new medical directives. Furthermore, technological enhancements were adopted to facilitate health issue resolutions by utilising available resources.

For instance, the introduction of timely notifications that were supported by the availability of integrated testing centres in various regions showcased the effectiveness of merging social and technical aspects, thus promoting continuous interaction, even when systems surpassed previously established performance standards (KC et al.,2033). The emphasis was not merely on regular software updates but on fostering multi-level dedication to the creation of responsive systems that met healthcare demands through interconnected digital frameworks.

4.8. Chapter Conclusion

In this chapter, the deployment of the NHS COVID-19 app has been analysed from a sociotechnical viewpoint. The examination centred on how technology was designed to interact with social practices in order to control the spread of the coronavirus in England and Wales. Key takeaways were that effective digital health initiatives relied on the harmonisation of technical design with stakeholders' collaboration to build public trust.

Five primary phases were recognised in the deployment process: the initial idea and engagement of stakeholders; strategic planning combined with research efforts; the design and development stages; assessment and modifications; and, ultimately, the launch and ongoing post-release management. Each phase emphasised that the interaction between technological infrastructure and human elements was vital to the achievement of favourable outcomes. The involvement of pertinent stakeholders, such as government bodies, healthcare providers and tech companies, was crucial to ensure consistency between public health goals and the app's technical functionalities.

Employment of a sociotechnical framework enabled a thorough understanding of how societal anticipations—especially regarding data privacy and software security—profoundly impact technological choices during the development phase. For example, a decentralised data storage model was adopted to boost user trust in data security.

The app was improved in various ways one of which was to learn from international standards, which helped to identify effective tactics that other nations utilised. The application of this method assisted in circumventing potential problems and reinforced successful components of communication strategies that were used to reach the public across pertinent channels.

Throughout the testing phases, repeated operations enhanced overall user contentment with the app. Engagement in a feedback loop facilitated constant integration of user recommendations and enabled confirmation that updates adhered to compliance mandates and were centred on individual user preferences. This attentiveness to user issues highlighted the importance of respecting personal space and privacy in technology development.

The promotion and oversight of the app were also critical elements of the process. It was vital to understand comprehensively the intricacies involved in sociotechnical dynamics in order to boost user acceptance of digital health solutions during the pandemic.

Transparency, government backing, and community outreach were essential to the continued engagement of users with the app.

The assessment of the NHS COVID-19 app underscored that the initiation of any digital health endeavour requires a combination of technological capabilities and societal endorsement. Adherence to regulatory standards plays a vital role in establishing user trust. These conclusions offer insights for the future management of similar situations; vital factors are collaboration among stakeholders and having an adaptable strategy to meet the changing needs of digital healthcare services.

CHAPTER 5: THE PROMOTION STRATEGY OF THE NHS COVID-19 APP THROUGH THE LENS OF SOCIOTECHNICAL THEORY

5.1 Introduction

On April 5, 2020, Queen Elizabeth II made a speech to the British public:

> *A time of disruption in the life of our country: a disruption that has brought grief to some, financial difficulties to many, and enormous changes to the daily lives of us all. I want to thank everyone on the NHS frontline, as well as care workers and those carrying out essential roles, who selflessly continue their day-to-day duties outside the home in support of us all. I am sure the nation will join me in assuring you that what you do is appreciated and every hour of your hard work brings us closer to a return to more normal times. I also want to thank those of you who are staying at home, thereby helping to protect the vulnerable and sparing many families the pain already felt by those who have lost loved ones. Together we are tackling this disease, and I want to reassure you that if we remain united and resolute, then we will overcome it.*
>
> *I hope in the years to come everyone will be able to take pride in how they responded to this challenge. And those who come after us will say the Britons of this generation were as strong as any. That the attributes of self-discipline, of quiet good-humoured resolve and of fellow-feeling still characterise this country. The pride in who we are is not a part of our past, it defines our present and our future. The moments when the United Kingdom has come together to applaud its care and essential workers will be remembered as an expression of our national spirit; and its symbol will be the rainbows drawn by children.*
>
> *Across the Commonwealth and around the world, we have seen heart-warming stories of people coming together to help others, be it through delivering food parcels and medicines, checking on neighbours, or converting businesses to help the relief effort.*
>
> *And though self-isolating may at times be hard, many people of all faiths, and of none, are discovering that it presents an opportunity to slow down, pause and reflect, in prayer or meditation.*
>
> *It reminds me of the very first broadcast I made, in 1940, helped by my sister.*
>
> *We, as children, spoke from here at Windsor to children who had been evacuated from their homes and sent away for their own safety. Today, once again, many will feel a painful sense of separation from their loved ones. But now, as then, we know, deep down, that it is the right thing to do. While we have faced challenges before, this one is different.*
>
> *This time we join with all nations across the globe in a common endeavour, using the great advances of science and our instinctive compassion to heal. We will succeed - and that*

> *success will belong to every one of us.*
>
> *We should take comfort that while we may have more still to endure, better days will return: we will be with our friends again; we will be with our families again; we will meet again.*
>
> *But for now, I send my thanks and warmest good wishes to you all.*
>
> *[BBC, 5 April 2020]*

The Queen's speech was generally agreed by many to have united the public and inspired hope during the early challenging days of the COVID-19 pandemic (Yu, 2020). She expressed gratitude and offered encouragement, which seems to have prepared people to embrace new methods of combating the virus, such as the NHS COVID-19 app which was launched in England and Wales six months later. Her Majesty acknowledged the difficulties of the pandemic and expressed appreciation for NHS staff, care workers, and other essential workers for their contributions. Her speech instilled a sense of pride and reminded everyone of their part in the fight against the virus, which may have contributed to the public's readiness to trust and adopt new health tools. The Queen emphasised unity and the importance of staying home to safeguard the most vulnerable. Her words motivated everyone to contribute, a sentiment that was crucial for the public adoption of the NHS COVID-19 app. By appealing to collective action, she underscored the shared nature of the struggle and the significance of each individual's efforts. She also addressed the challenges of isolation, drawing on a World War II memory to illustrate that the country had overcome difficult times before, that may reinforce the view of the NHS COVID-19 app and similar technologies as contemporary means of collective perseverance, similar to past experiences.

The Queen's Speech during the pandemic did more than convey messages; it could shape behaviours, illustrating the concept of sociotechnical perspective, which posits that human actions and created technologies mutually influence each other (Patorniti et al., 2018; Polojärvi et al., 2023).Thus, the speech was a significant force in the real world, affecting responses to technological solutions like the NHS COVID-19 app. Understanding the Queen's words through performativity, explain how language and actions within a technological context actively shape social realities and forms. It further suggests that speech acts do not merely describe the world but also perform actions and effect change (Austin, 1975; Butler, 1990). The Queen's expressions of gratitude, calls for unity, and assurances of overcoming the crisis were not just commentary; they actively shaped a reality where collective action and technological adoption in combating

the virus became natural and necessary. The performativity theory furthers this alignment with public health goals, showing that the Queen's Speech was more than a reflection of the times: it fostered trust and morale by commending NHS workers and emphasising the need for a united effort against the virus. This trust was crucial for adopting the NHS COVID-19 app, as people were more inclined to follow guidance from a respected figure during challenging times.

Additionally, the Queen highlighted the significance of personal sacrifices and community solidarity. These themes resonated, fostering a sense of identity and duty among listeners and propelling them towards actions aligned with public health aims. By framing resilience and unity as elements of British identity, the speech promoted a narrative that people were prepared to embrace.

The Queen's mention of ‘using the great advances of science’ in her speech may have significantly impacted the NHS COVID-19 app acceptance as it was a product of science and technology (notwithstanding the app’s imperfections). Her message went beyond mere encouragement; it effectively changed how the app may have been utilised. Designed to halt the spread of COVID-19 by tracking infections, the app somewhat gained traction due to the Queen's portrayal of collective effort. She conveyed that using the app was a communal act of solidarity and hope during a time of adversity. Her April 2020 address did more than uplift spirits; it may have motivated the widespread adoption and use of the NHS COVID-19 app. This chapter tries to answer a question 2: **What strategies were used to promote the NHS COVID-19 app in England and Wales?** In analysing the promotional strategies of the app’s uptake, I focus on the sociotechnical concept, which explores the interplay between social dynamics and tangible entities. It is evident that the Queen's words contributed to transforming the app into a crucial tool in the COVID-19 response, illustrating the profound influence of community and national leadership on the adoption of new technologies.

The primary focus is to understand how these strategies were framed and their implications: studying the promotion of the app underscores the importance of swiftly and efficiently deploying health technology in a manner that gains public trust, particularly during crises. It examines technology's role in healthcare, reviewing the use of advertisements that align with technological capabilities and user needs. It examines the promotion of health apps in their interaction with society, offering insights for advancing future healthcare technology. The central inquiry is the marketing approach for the NHS COVID-19 app in England and Wales, analysing the methods employed to encourage the public to adopt the app. The focus extends beyond marketing strategies,

including public perception and integration into daily routines.

By considering diverse perspectives, the study explores the dynamics of user interaction, societal response, and the impact of technological advertising strategies and user engagement on public health discourse. Sociotechnical provides a perspective on the interplay between social events and technological entities (Bertalanffy, 1969; Trist and Bamforth, 1951). The relevance of sociotechnical theory becomes apparent when examining the dissemination and usage of the NHS COVID-19 app in England and Wales. It aids in analysing not only the technical components of the app but also its interactions with human behaviour, societal norms and legislation.

For instance, this concept illustrates how privacy concerns (a social aspect) can influence the development and functionality of apps (technical aspect) and how public trust and media narratives (social elements) can affect the extent and manner in which people utilise an app (technical outcomes). The table below outlines the key themes discussed that act as pillars for this chapter.

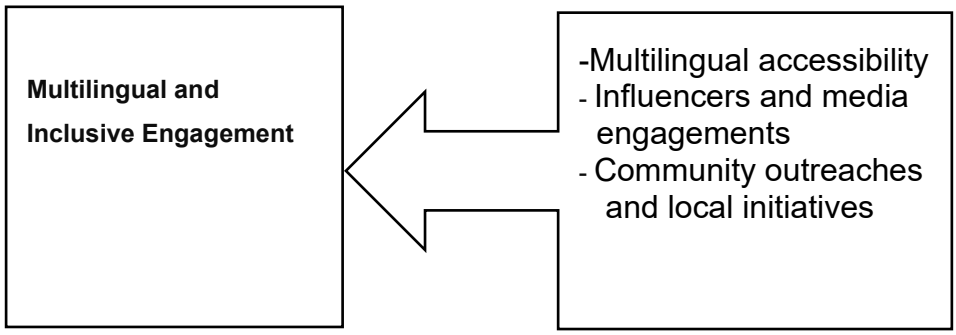
Table 8. Chapter themes and their codes

Theme	Codes
Multilingual and Inclusive Engagement	**-** Multilingual accessibility **-** Influencers and media engagements **-** Community outreaches and local initiatives
Privacy and Security Assurance	- Strong emphasis on privacy - Non-tracking, - Bluetooth-based technology
Integrated Health Functionality	- Health services integration - Booking tests and receiving test results
Technical Accessibility and Support	- Detailed installation and operation guides - Support across major mobile platforms (Android and iOS)
Strategic Partnerships and Compliance	- Data exemption collaboration - Regulatory compliance - Continuous updates

Source: Author

5.2 Multilingual and Inclusive Engagement

Figure 7.Thematic Map 1



5.2. 1 Multilingual accessibility in the Adoption of the app

The multilingual capability of the app could reflect a responsiveness to user needs, leading to the creation of new features that would cater to those requirements. As advertised by the UK Health Security Agency:

> *The app is available in 12 different languages, and you can select your preferred language in the settings [UK Health Security Agency,13 May 2022]*

The above quote demonstrates the close relationship between technology and the societal fabric. The app's support for numerous languages means that a broader demographic can utilise it, enhancing its effectiveness in addressing health issues. and catering to the diverse needs of the population in England and Wales. The NHS COVID-19 app's language variety illustrates how technological features are intertwined with the broader societal context, influencing and being influenced by the social environment. This case emphasises the significance of considering social values and functionality in the design and dissemination of health technology to ensure that it is accessible and efficient for all users.

Considering inclusion is crucial when selecting a promotional strategy for health apps such as the NHS COVID-19 app that was designed to be used by diverse populations in

England and Wales. The app was developed and disseminated to ensure accessibility for all, regardless of cultural or linguistic background. It was available in 12 languages and employed various methods to engage with communities. The aim was not only widespread dissemination but also to ensure that each individual felt acknowledged and capable of utilising the app effectively. Inclusivity extends beyond mere translation of an app's content; it encompasses a comprehensive understanding of different communities' unique needs and preferences.

This approach was designed to foster trust and encourage broader usage of the app, including among those who might feel marginalised or overlooked by standard health communications. Leveraging influencers, local media and community initiatives holds great potential for inclusive health strategies, and in this case, could enhance the app's efficacy in managing COVID-19 for everyone. The next section discusses how the NHS COVID-19 app integrated technology with a commitment to cultural inclusivity to safeguard the well-being of all communities.

Presenting an app in multiple languages illustrates an interaction between technological innovation and respect for diverse backgrounds. Recognising the importance of language inclusion goes beyond technological features; it reflects an appreciation for the varied cultures and lifestyles of potential users. As the NHS COVID-19 app was offered in 12 languages, individuals in England and Wales who were not primarily English speakers could access vital health information and utilise the app effectively. Such efforts could promote adherence to health guidelines and also demonstrate a societal commitment to equality.

In developing the NHS COVID-19 app to support multiple languages, it was necessary to implement various methods for language selection, adapt the layout for different writing systems, and ensure that translations were accurate and culturally appropriate. These modifications would impact user interaction and overall experience with the app.

5.2.2 Role of Social Influencers in the Adoption of the app

Influencers and various media outlets helped to encourage the adoption of new health technologies; they used their influence and popularity to shape public perception and actions regarding technological innovations. When a famous person on Instagram or Twitter shared their experience with the NHS COVID-19 app, this encouraged their followers to try it, leading to more downloads and usage.

All types of media, from websites to television, played a role in promoting the app. They disseminated information about the app's functionality, benefits and user instructions,

encouraging more people to download and engage. These entities actively ensured that the public would understand and follow health guidance. The choice of media and the content shared heavily depended on the audience's preferences and information sources; for example, platforms like Instagram might be more effective in reaching a younger demographic due to their online presence. According to the BBC report:

> *The government paid social media influencers to promote the NHS Test and Trace service... Instagram influencers, including Love Island stars, were paid an undisclosed amount to make posts during lockdown [31 Aug 2020]*

The above extract reports the government paying well-known personalities such as stars of the TV programme *Love Island* to promote the NHS COVID-19 app, significantly enhancing its adoption and integration into the daily routines of various groups. The strategic combination of influential figures and media engagement expanded the app's reach and fostered its interaction and usability. Such an approach demonstrates the potent interaction of utilising societal networks and practical tools to encourage public health initiatives across diverse social environments.

Engaging local communities in disseminating information about the NHS COVID-19 app may have fostered a profound integration of community customs and public health strategies. Tailoring the app's dissemination to align with each locality's distinct culture, social fabric and language ensured the continuous incorporation of the app's functionalities into everyday life. Adapting the communication strategy to meet the specific requirements of different community groups was crucial. For example, local health authorities might emphasise particular features of the app, such as scheduling tests or symptom tracking, and circulate this information through familiar local channels. Community /national figureheads such as the Queen (as demonstrated in the introductory section of this chapter) and health professionals were instrumental in this endeavour. Trusted voices were crucial in alleviating concerns about the app and promoting its adoption; their endorsement and utilisation of the app could transform public perception and usage and overcome doubt regarding the app's functionality or privacy issues. Feedback from these community initiatives was also vital for app enhancement: input from the public could prompt modifications to the app's design and operation, ensuring that it was more user-friendly and culturally considerate. These refinements went beyond visual appeal; they enhanced usability and catered to diverse needs.

This approach illustrates how product utilisation can improve product development by integrating social dynamics, such as community activities, to enhance technological

functions. An app becomes integral to health routines when it aligns with the local populace's characteristics and necessities, exceeding its role as a mere instrument.

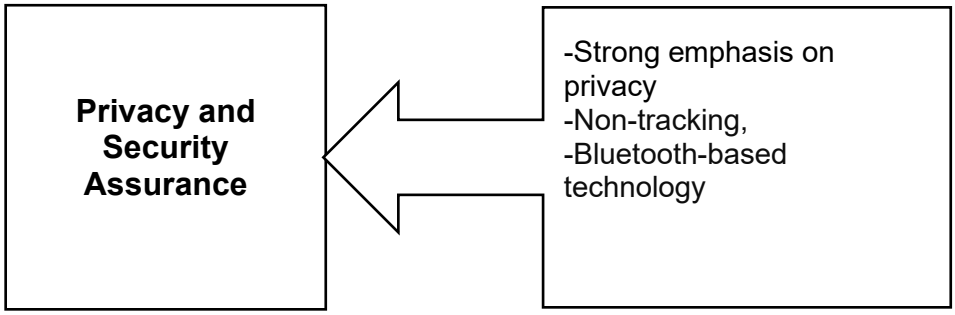
The following quotation is an example of local government urging a community to help control the spread of the pandemic and encouraging the uptake of the app:

> *People across North-East Lincolnshire are being urged to download the NHS COVID-19 app to help control the spread of coronavirus and protect themselves and their loved ones as case numbers rise across the UK [North East Lincolnshire Council, 24 Sept 2024]*

This message focuses on increasing usage of the app by engaging with individuals in the local area and encouraging them to download and use the app, allowing it to seamlessly integrate into their daily lives, thereby elevating its utility and significance. This approach exemplifies the necessity of matching technology with real-world dynamics: local authorities would have realised that for a health technology to be genuinely impactful, it would need to connect with people's everyday routines, promoting wider adoption and aiding in the progress of community health. More uptake was needed for the app to make an impact, and as such, an appeal for local community involvement was a necessary approach.

5.3 Privacy and Security Assurance

Figure 8.Thematic Map 2



5.3.1 Strong emphasis on privacy in the Adoption of the app

In using digital technology in healthcare, particularly in pandemic management, safeguarding user information is not a luxury but a necessity, as people care much more particularly about their health data. The developers of the NHS COVID-19 app recognised this importance by continuously saying that the design of the app prioritises user privacy and security. The app was designed to align with public expectations and

legal standards. Recognising the significance of privacy and security in health digital technology highlights the relationship between trust in digital technology and its dependable application.

Viewing privacy and security through a sociotechnical lens involves understanding the relationship between social interactions and the technical components of digital technology. This perspective is particularly appropriate to health applications like the NHS COVID-19 app, where data privacy and security challenges will encompass technological and societal aspects. This approach implies that privacy and security are not merely integrated into a system but are actualised through the system's use within social and cultural contexts. Technologically, the NHS COVID-19 app protects user data with multiple measures, such as encrypting data to prevent external access, localising data storage on the user's device rather than a central database, securely verifying user identities, and ensuring anonymity of user data. The NHS Test and Trace who was at the forefront of contact tracing published the following message placing emphases on privacy of users' data:

> *The app has been designed using Google and Apple technology to use as little personal data and information as possible. Data stored on the app is held on your phone, encrypted and not shared anywhere else. Any data that is provided from the phone will always be made anonymous to prevent us and anyone else from identifying you or others. The app uses random unique IDs for contact tracing. These codes are shared between other app users' phones and they change every 15 minutes. When shared, these codes will remain on phones for 14 days to cover the incubation period of coronavirus. There is no way for another app user to identify you from this code.*
>
> *[NHS Test and Trace, 24 Sept 2020]*

Each technological decision influences the public perception of the app. For instance, rendering all data unreadable from start to finish not only secures the data but also demonstrates to users that the app prioritises their privacy, thereby increasing their trust.

Moreover, opting not to store data regarding potential virus exposure on a central server but rather on the users' own devices reflects a foundational commitment to privacy and aligns with societal values around personal privacy and reducing surveillance risks. Socially, perceptions and attitudes toward privacy and security are influenced by cultural norms, historical experiences with technology, and prevailing legislation. Different factors can affect the public's view of an app's privacy and security features, ultimately impacting social acceptance. For example, worries about recent data breaches Google, H&M, British Airways, Marriott International Hotels and others might increase scepticism

about an app's capability to protect user data (BBC, 2021).

Building trust in health technology, such as the NHS COVID-19 app, centres on healthy technical security and effective public engagement. Trust is crucial for adequately implementing these technologies, particularly when handling sensitive health data. This section explores how technological features and engagement strategies contribute to establishing and maintaining trust. Public trust in the NHS COVID-19 app stemmed not only from its technical safety features but also from its user engagement methods. Ensuring trust and comfort in using the NHS COVID-19 app was crucial, and this involved a blend of providing clear technical explanations and encouraging user engagement.

Employing advanced security features transparently aids in building confidence in the privacy measures of a technology. For example, explaining how data encryption secures information or how decentralised data storage enhances privacy can reassure users. Policymakers and app developers must balance technological innovation and proactive user engagement. This involves creating a strategy for information dissemination in a relatable manner, leading to user involvement. Ultimately, earning user trust in the NHS COVID-19 app required a collaboration of healthy technical safeguards and authentic user communication, ensuring sustained trust as technology and user needs evolved.

The NHS COVID-19 app's data safety and privacy approach significantly influenced public acceptance. Ensuring that the app would effectively safeguard personal information was crucial for user comfort and widespread adoption. The privacy and security features of the app shaped perceptions and usage. For instance, encrypting messages end-to-end and decentralising data storage addressed concerns about personal information security, supported by literature (Wahsheh and Luccio, 2020).

Sociotechnical theory explores the mutual influence between technology and society. For instance, public feedback on the NHS COVID-19 app prompted developers to modify its features and implement updates to enhance user satisfaction. Essentially, the approach to privacy and security demonstrated in the design of the app exemplifies the interplay between technology development and societal behaviour. Understanding this interaction is crucial for ensuring that health apps safeguard data and meet societal expectations, encouraging wider adoption.

Effective communication about a health app's privacy features is vital for fostering understanding and trust. Discussions should address common concerns and transparently explain how the app protects user privacy. In this section, I will outline key communication strategies that may have helped increased public confidence and usage of the NHS COVID-19 app.

A primary objective was to explain the app's privacy aspects for all, regardless of technical knowledge. Overusing technical jargon can alienate or confuse users, potentially leading to distrust or misconceptions about data handling. The approach involves explaining data protection measures, such as encryption, in accessible language. For example, rather than detailing "encryption processes", we might say, "The app turns your data into a secret code to prevent hackers from accessing it". This clarity reduces the technology's mystery and demonstrates how privacy is maintained. It empowers individuals to learn more and make informed decisions about the app. Below is a message from the Department of Health and Social Care that adopted this method:

> *SMS (text) messages*
>
> *Text messages will come from 'NHStracing'.*
>
> *The text message reads:*
>
> *This is a public health message from NHS Test and Trace. Please download the NHS COVID-19 app from the App Store or Google Play. More info at https://covid19.nhs.uk/ [25 Sept 2020]*

Simplifying the messages about the app was likely to increase the number of people using it. Explaining that text messages would come from "NHStracing" and then giving an example text was straightforward and provided only essential details. The message from the NHS Test and Trace service confirmed its authenticity and directed users to download the NHS COVID-19 app from the App Store or Google Play, clearly indicating the next steps. Additionally, it included a link for further information, allowing users to learn more at their own pace. More precise language reduced confusion and aided in understanding and adhering to the instructions, encouraging more app downloads and usage.

Also, transparency was crucial for gaining trust in the NHS COVID-19 app in England and Wales, as explained by the statement below:

> *Experts from across the UK government and industry have reviewed our design and helped us test and improve the app. Specialists from the National Cyber Security Centre were involved to make sure it is safe and secure to use. The app is also subject to Apple and Google's privacy standards and review. We will always make sure the app is compliant with data protection law and meets the standards expected for data security and confidentiality. Contact tracing data stays on your phone until you choose to submit it. Nobody can track you, your movements or who you have been in contact with, including other app users [UK Health Security Agency, 13 May 2022].*

The UK Health Security Agency (UKHSA) explains that the app underwent rigorous checks by UK government experts and technology specialists to ensure its functionality and security, and collaboration with the National Cyber Security Centre further enhanced its safety, reassuring users of its reliability. The app complied with Apple's and Google's stringent privacy standards and underwent regular reviews to maintain user privacy; this adherence to data protection laws and commitment to information security and confidentiality would increase user comfort. Notably, the statement is clear that the app allows users to retain contact tracing data on their phones until they choose to share it, alleviating concerns about being monitored. This level of openness about the app's development and data protection measures would have encouraged wider adoption.

Furthermore, educational campaigns aimed to enlighten individuals about the significance of privacy and the measures taken to safeguard user data on the app. These initiatives further educated the public on online privacy and security, illustrating how the app's features contributed to the broader context. Campaigns used social media, television, radio, and the internet to reach a wide audience. Through these approaches, the app's creators aimed to ensure that users were well-informed, felt appreciated, and were confident in their decision to use the app. Some government messages were aimed simply to support and comfort the populace, for example:

> *The NHS COVID-19 app protects your privacy and identity from other app users and their privacy and identity from you. The app uses random IDs that cannot be used by the NHS or the government to identify who you are, or who you've spent time with.*
>
> *The app cannot:*
>
> *-use your GPS location or track where you have been*
>
> *-be used to check or monitor if you're staying at home*
>
> *-be used by law enforcement to identify or track you*
>
> *-see personal information on your phone, such as your messages, address book or your phone contacts.*
>
> *[UK Health Security Agency, 13 May 2022].*

Educating the public about the NHS COVID-19 app was aimed to ensure that they understood its role in safeguarding personal information. The app employs anonymous IDs that frequently change to maintain user privacy and anonymity, so that neither the NHS nor the government can identify users or their contacts. The app is designed with

robust privacy protections: it does not track individuals' locations via GPS, monitor adherence to quarantine rules, or allow police surveillance. Furthermore, it cannot access personal data on users' phones, such as messages, contacts or call logs. Transparency about these privacy measures increased trust in the app and probably led to higher download and usage rates.

Key Technical Measures for Privacy Assurance

Many technical measures were implemented to ensure the safety and privacy of the NHS COVID-19 app. These measures safeguard the information users provide and guarantee that they can use the app confidently and comfortably. This section will discuss in more detail some critical technical measures that were integral to the app's functionality.

The NHS COVID-19 app incorporates advanced technology to ensure exceptional privacy and security, including encryption methods that render data unreadable in transit and at rest unless accessed with a specific decryption key. It employs a tough encryption algorithm, AES, with a 256-bit key, which is currently considered highly secure against existing technological capabilities. This stringent security reassures users about protecting their data and minimises the risk of data breaches or hacking. The app's managers explain it in this way:

> *Data stored on the app is held on your phone, encrypted and not shared anywhere else. Any data that is provided from the phone will always be made anonymous to prevent us and anyone else from identifying you or others… These codes are shared between other app users' phones and they change every 15 minutes [NHS Test and Trace, 24 Sept 2020]*

The NHS COVID-19 app's widespread adoption can be attributed to public awareness of its robust privacy features. The app only uses data stored on the user's device, ensuring that it remains secure and private. It maintains anonymity by using random codes to track encounters, thus protecting the user's identity when transmitting information. These codes, which change every 15 minutes and are stored for only 14 days, are sufficient to detect virus exposure without revealing identities. This data management reassured users and would have resulted in increased downloads and usage. Explaining the app's privacy safeguards helped to ease concerns and fostered trust in its safety and dependability.

Secondly, decentralised data storage, or dispersing data, further reduces the risk of personal information breaches by retaining data on the user's device away from

centralised, vulnerable databases. The NHS COVID-19 app adheres to this principle by recording smartphone exposure and health information, avoiding transmission to central servers unless anonymised. This approach aligns with expert recommendations and privacy advocacy, underscoring the app's commitment to user privacy as explained:

> *The data collected by the app is stored on your phone. Any data you share with UKHSA is used to help us:*
>
> - *learn more about coronavirus (COVID-19) to support health services, such as your local hospital – for example, this could help to give them up-to-date information about COVID-19 in your area*
> - *provide advice to you based on your situation (for example, when you have been near another app user who has later tested positive for COVID-19)*
> - *provide advice to the public*
> - *improve and monitor the effectiveness of the app [UK Health Security Agency, 13 May 2022].*

The NHS COVID-19 app stores data on each individual's phone rather than in a central database, enhancing user comfort and trust. Users can share their data with the UKHSA, knowing it will monitor COVID-19 trends, provide personalised advice, disseminate safety information, and continuously improve the app's functionality. This transparent and decentralised approach to data management is likely to have increased trust, leading to higher download and usage rates.

Moreso, the app adheres to privacy-by-design principles, requesting only essential information for contact tracing and exposure notifications without tracking personal movements or details. Regular audits ensure that unnecessary data is not retained. The app reduces the risk of misuse by minimising data requests and simplifies data security, aligning with its intended purpose. When the app was launched, upholding user trust was paramount, particularly regarding data privacy concerns. NHS Test and Trace published the following on their factsheet:

> *The app collects the following information and holds it on your phone:*
>
> *• The postcode district you enter when you install the app, this is the first part of your postcode before the space*
>
> *• The symptom information you enter onto the app*
>
> *You are able to view all the data held on your phone and you can delete it at any time. The app has been designed using Google and Apple technology to use as little personal data and information as possible. [NHS Test and Trace, 24 Sept 2024]*

The NHS COVID-19 app was impacted by prioritising privacy, gaining user trust and increasing usage. The app stores only essential data on the user's device to ensure privacy. The initial segment of the user's postcode entered during setup indicates their broad location without revealing their exact address. The symptom data input by a user would only aid in identifying potential COVID-19 cases and providing subsequent guidance.

A further notable feature of the app is its transparency; it allows users to view all the data it holds on them and offers the option to delete it at their discretion, putting them in control of their information. Furthermore, the app's underlying technology, developed by Google and Apple, focuses on securing users' data and ensuring anonymity in its handling. These privacy measures have comforted users about their information security, making them more inclined to download and utilise the app. Transparency and careful user data management can encourage broader adoption of such applications.

In addition, keeping the app secure and precise through updates was also crucial in the early stages. For instance, an update in October 2020 improved the app's accuracy in determining the proximity between two phones, with significant contributions from Mark Briers, a prominent figure in the science community for defence and security. These updates ensured the app's proper functioning and maintained user trust, as explained:

> *In October 2020, an update was released which included improvements to the app's algorithm for measuring the distance between two phones – work that was led by Mark Briers, the Turing's Programme Director for Defence and Security, and the app's lead scientist. The updated algorithm, which makes use of a statistical process called an 'unscented Kalman filter', more accurately calculates the risk that the phone's user has been in contact with a COVID-positive person, meaning that the app can better identify those who need to self-isolate. [Baroness Dido Harding, Former Executive Chair: NHS Test and Trace].*

The app was updated with a new advanced mathematical technique called the 'unscented Kalman filter.' As indicated in the above extract, this addition significantly improved the app's capability to identify potential exposure to COVID-19 and provided more accurate guidance on who should consider self-isolation.

The significance of this update lies in its increased accuracy. It ensured that only those who might be genuinely at risk were advised to stay at home, which was crucial for maintaining public trust and preventing unnecessary isolation. Additionally, the app was enhanced with input from safety experts, providing users with confidence that they were safeguarding their health using state-of-the-art technology. As the app evolved, user

trust grew, strengthening the app's reputation for dependability and security. This encouraged wider adoption and use, contributing to more effective management of the virus's spread. The development team continues to address security vulnerabilities and incorporates new protective measures based on user feedback and regulatory standards. Regular updates have been vital to the app's integrity, demonstrating a commitment to safeguarding health information. Consequently, the NHS COVID-19 app adheres to strict privacy and security regulations, ensuring user safety and trust. NHS Test and Trace, here again, claimed:

> *The NHS COVID-19 app protects your privacy and identity from other app users – and their privacy and identity from you. The app uses random IDs that cannot be used by the NHS or the government to identify who you are, or who you've spent time with.*
>
> *[NHS Test and Trace, 24 Sept 2020]*

Building trust with users was paramount when the app was launched, especially regarding concerns about the potential tracking of individuals' movements. This finding highlights how protecting privacy was both a technical issue and a matter of public perception. Both the app's effectiveness in maintaining privacy and the public's view of these efforts were significant. Ensuring that users are comfortable with technology handling their information necessitates an open dialogue between the app developers and the users. They must communicate their privacy measures and remain adaptable to feedback, reflecting the community's thoughts and sentiments. Securely handling user data is essential for the success of new technologies in public health and user confidence.

The NHS COVID-19 app exemplifies the combined effect of technology aspects, like privacy and security, and user factors, such as trust and willingness to engage, which were necessary for the app's effectiveness. The app showcases advanced technological measures to safeguard users' information, including encryption, decentralised data storage, minimal data collection and continuous security assessments. These features were necessary when the app was introduced, as they ensured that users' details remained confidential, and public trust relied heavily on the robustness of these technological safeguards. The government information about the app placed emphasis on end-to-end data security and decentralisation features to alleviate user worries about data breaches, increasing the public's willingness to use the app.

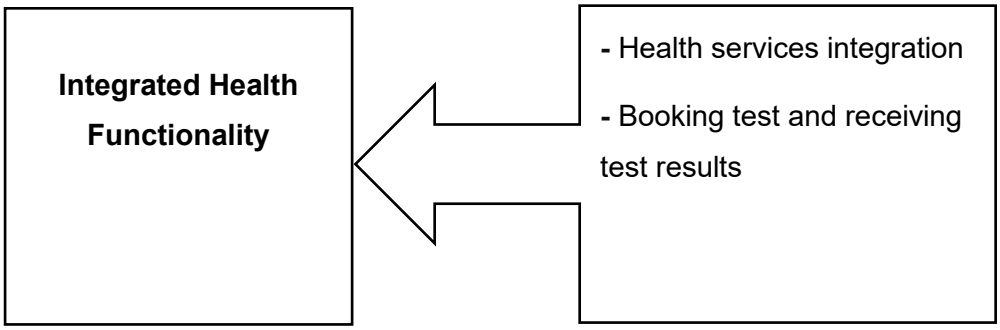
Trust in the app was based on its capabilities and also on the developers' responsiveness to fixing issues or promptly addressing potential vulnerabilities. Should privacy concerns escalate, it may be necessary for the app to enhance its security

features to maintain user trust. This illustrates that the perceptions of users and the app's functionality can mutually drive improvements. For example, if a security vulnerability is discovered, the developers must quickly address it to maintain user trust and comply with privacy regulations. This underscores that app security is an ongoing task that requires vigilance to user concerns and prompt resolution of issues. Therefore, we can say that the technical aspects and user expectations must align for technology like the NHS COVID-19 app to gain widespread adoption. Users must be assured that their privacy is prioritised and that the technology adheres to their safety values.

This dynamic underscores the importance of ongoing dialogue between app users, managers and developers that is a sociotechnical construct. App modifications should be driven by user needs and feedback, and privacy protections must be transparent and robust, informed by user interactions. Research such as the study by (Acquisti et al., 2015; Chan and Saqib, 2021) highlight how privacy concerns alter online behaviour. The narrative of the NHS COVID-19 app illustrates the challenge of maintaining a secure and trusted application. It involves balancing the right technological solutions with the development of user trust. Achieving widespread adoption of the app and ensuring its effectiveness for public health hinges on managing this balance effectively.

5.4 Integrated Health Functionality

Figure 9.Thematic Map 3



The concept of integrated health functionality involves integrating health features into the NHS COVID-19 app, enhancing its utility for public health management. This is not solely a matter of the technology; it is equally about how individuals utilise these features to maintain health and prevent the spread of COVID-19. The app facilitates various

health-related tasks, such as symptom checking, test booking, and result retrieval. It also aids in contact tracing to curb the virus's transmission. The app's design and data security measures are harmonised to simplify health management. This integration is crucial as it encourages adherence to health guidelines. The ease of scheduling a test or assessing potential exposure increases compliance with safety measures. By centralising all COVID-19 health tools in one accessible location, the app became more appealing for regular use. This was highly beneficial for rapidly detecting virus spread and implementing swift containment measures. The app assisted in monitoring users' health and contributed to broader safety by tracking the virus's presence. A notable feature is using QR codes for check-ins, simplifying contact tracing in public venues. This integration of advanced technology and healthcare, as discussed by (Greenhalgh et al., 2020), demonstrates the significant role digital tools can play in managing a health emergency.

The NHS COVID-19 app features an integrated health functionality, illustrating how the app's design and usage can benefit individual and public health. It is not solely about the app's functionality but also its integration into daily health management, contributing to overall well-being.

The ability of the app to connect with NHS health services was crucial for user reliance and health-related behaviour. This integration bridges the gap between technology and healthcare, influencing public health dynamics and individual actions. This section examines the app components that enable this integration and their impact on user dependence and health behaviour.

These components include:

- A symptom checker to determine if the user's symptoms align with COVID-19 and offer guidance on subsequent steps, such as self-isolation or testing.

- In-app COVID-19 test booking, utilising location data to suggest the nearest testing sites through health service database communication.

- Immediate notification of test results, facilitating prompt action for care or isolation.

These features work together to ensure the privacy and security of health information through advanced technology and encrypted data transmission. This was advertised as follows:

> *For your vaccination status, use the separate NHS app (England only). The app will also enable you to check symptoms, book a free test if needed, and get your test results.*

[Department of Health and Social Care, 23 May 2021]

This quotation highlights how the app integrates with health services' other digital tools such as the NHS app, enabling users to manage their health information and address COVID-19-related actions all in one place. This convenience and speed made the app a primary tool for health management during the pandemic. It was welcomed by health authorities as an efficient system and indicative of a shift towards digital engagement with health services. Monitoring symptoms and accessing testing via the app would empower individuals to oversee their own health more transparently. It would facilitate quicker identification of potential COVID-19 cases, preventing the virus's spread. The app allows test bookings and delivers results promptly, simplifying adherence to health guidelines, such as isolating when ill. Including known and reliable health services within the app was also likely to increase user confidence in the new technology. Observing the app's effectiveness in handling critical health tasks would encourage wider adoption, which could increase the app's user base.

The design of the app and its usage reflect the collaboration between technology and societal practices. The app's capabilities influenced health management practices, which in turn affected the perception and utilisation of the app. Integrating health services into the NHS COVID-19 app demonstrates a significant link between its functionality and benefits. This shows a way forward for public healthcare, illustrating how digital tools can revolutionise traditional healthcare approaches and patient behaviours, as discussed in more detail below.

The NHS COVID-19 app offers health features that influence how individuals manage their health as well as their perception of the app. These features immediately impact health and alter the broader interaction with the app. The app includes tools for symptom tracking, test booking, and receiving test result notifications. Utilising advanced technology and data, these tools expedite access to healthcare services. They were designed to monitor health and address health concerns more efficiently and effectively during the COVID-19 pandemic.

Quick access to health services: The app's integration with NHS services enables users to arrange tests and receive results swiftly. This rapid response can greatly reduce the time between the onset of illness and receiving care, crucial for managing infectious diseases like COVID-19.

Enhanced disease tracking and management: The app allows users to report symptoms and receive test results directly on their phones, providing health officials with a clearer view of the disease's spread and the infection rate.

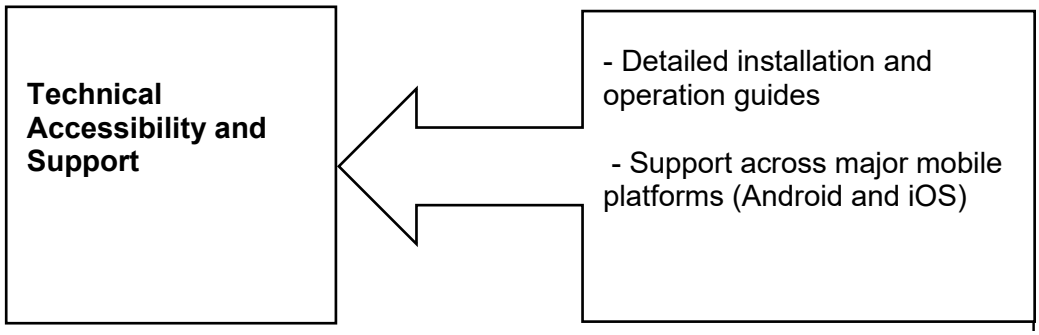
> *The app will also enable you to check symptoms, book a free test if needed, and get your test results [NHS Test and Trace, 24 Sept 2020]*

This extract illustrates how the app directly links users with healthcare services, aiding them in taking significant steps towards better disease management and enhanced health outcomes.

User experience with the app: The NHS COVID-19 app extends beyond practical assistance; it potentially transforms how individuals engage and interact with the healthcare system. Managing health issues via the app gives users control over their health decisions. This empowerment should lead to greater user satisfaction and increased trust in the healthcare system. The app's accessibility and ease of use did encourage people to adopt healthier behaviours, such as timely testing and staying home when necessary. These behavioural shifts were crucial for everyone, contributing to the containment of the virus. The interaction between the app's functionality and societal dynamics reflects a continuous interplay between technology and social environments. The app's design and capabilities influence user behaviour, which can subsequently affect its evolution to ensure that it remains beneficial and aligns with user needs. The app has undergone enhancements resulting from user feedback in order to align more closely with user expectations. Continual updates and efficacy have been essential for the app's sustained relevance. Closely examining the app's health features reveals their potential impact on privacy, empowerment, and public health management. The NHS COVID-19 app's design and technicalities probably had a significant influence on health outcomes and user behaviour. Bridging a vital gap between technology and health care, during the pandemic, the app was integral to individual health management and supported public health initiatives. The dynamic interplay between the app's capabilities and user engagement underscores the progressive nature of digital health technology within the contemporary healthcare landscape.

5.5 Technical Accessibility and Support

Figure 10.Thematic Map 4



The NHS COVID-19 app incorporated design principles that would cater to a diverse user base, including those less ‘tech-savvy’ or with disabilities. However, design alone is not enough: providing timely assistance keeps users engaged and addresses any issues they encounter. Resources such as straightforward guides, frequently asked questions (FAQs), and support hotlines are invaluable, as they help users overcome obstacles without undue stress or frustration. The interaction between the app's technology and its practical usage was vital. It was essential to develop an app that would function effectively and integrate smoothly into users' daily routines, providing them with both practical value and enjoyment. Examining how the NHS COVID-19 app combines these supportive designs and assistance reveals how intelligent technology solutions can fulfil user needs. This enhances the functionality of health apps for all and furthers the overarching aim of promoting public health. It is important to ensure that technology is easy to use and accessible to everyone, especially those who may find other technical tools challenging.

Assisting users with the NHS COVID-19 app was crucial for its practical use. This section explores the various support options available for users during the app's setup and operation and evaluates the impact of this assistance.

Support options included online assistance:

-The NHS COVID-19 app's *website* offers FAQs, how-to guides, and setup instructions, which were important for initial troubleshooting and inquiries.

- *Direct support*: For personalised assistance, the app provided a customer service hotline with knowledgeable representatives ready to address common problems or offer individualised support.

- *Video tutorials* allowed visual learners to learn through visual resources. These visual guides demonstrate the app's usage and features, which are ideal for newcomers to apps or those who learn best by observation. One of such instructions:

> *The app is designed to be used by one person per phone. You should download and use the app on your own smartphone, if you have one.*
>
> *[UK Health Security Agency, 13 May 2022]*

This instruction emphasises the significance of robust help features in the app, enabling users to navigate it easily. Access to comprehensive help centres and prompt customer

service empowers users, enhancing their proficiency. Quick resolution of issues streamlines the app experience and fosters user familiarity over time. The presence of reliable assistance relieves the fear associated with adopting new technology, particularly for critical applications like monitoring health during a pandemic. Straightforward guides and tutorials strengthen confidence, simplifying the app's functionality. How assistance is provided reflects the interplay between social dynamics and technology. Adequate technical support addresses technology-related issues, fostering user engagement and trust. Users who feel supported are more inclined to continue using the app and recommend it to others, significantly benefiting public health initiatives. Thus, the NHS COVID-19 app's help features have been pivotal in the technical and societal aspects of adoption of the technology. By instilling a sense of competence and confidence, these features enhance individual user experience and contribute to broader public health objectives by encouraging widespread adherence to the app's recommendations.

Technical accessibility pertains to the tangible components of the NHS COVID-19 app's design that enable its utilisation by a broad range of users, encompassing individuals with diverse technological skills and physical capabilities. The analysis centres on deploying these technical features to augment user accessibility and the ensuing societal consequences for various user segments.

Accessibility in the NHS COVID-19 app: ease of use for all is supported by the following features:

• *Simplifying the experience*: The app is crafted for simplicity to avoid overwhelming users, including older people and those unfamiliar with smartphones. Its large buttons, high-contrast colours, and clear instructions provide a user-friendly experience for all.

• *Accommodating everyone:* The app includes voice assistance, screen reader compatibility, and text enlargement options for individuals with disabilities.

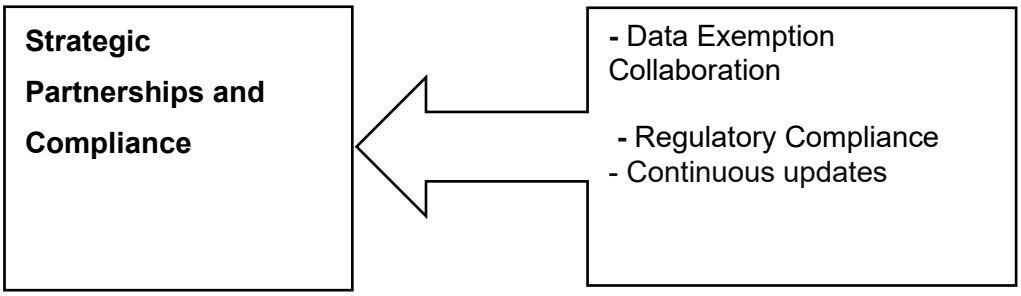
These inclusive tools enable users of all abilities to navigate the app independently on their smartphones without charging for the data used by the app:

> *To encourage adoption in England and Wales, the major mobile networks have agreed not to deduct data used by the app from subscribers' monthly allowances.*
>
> *In addition, the app now supports more languages than the test version - adding Turkish, Arabic, Mandarin, Romanian and soon Polish [BBC, 24 September 2020]*

This excerpt illustrates the significance of creating user-friendly apps for everyone, including individuals with varying needs. Ensuring the universal usability of an app leads to wider adoption, which is crucial for health apps that rely on widespread usage to be effective. Apps crafted with inclusivity in mind allow people of all ages, different languages, technological proficiency, and abilities to access the necessary information and support to manage their health independently without incurring any additional charge. This is particularly beneficial for those who may otherwise struggle to access health resources due to income. A tool such as the NHS COVID-19 app, by being more accessible, not only better serves its users' needs but also broadens inclusion, empowering more individuals to make informed healthcare decisions autonomously. This contributes significantly to the equitable distribution of health resources. The commitment to enhancing the app's accessibility demonstrates a substantial effort to ensure its utility and efficacy for all, which is fundamental to improving public health and equalising access to digital health tools.

5.6. Strategic Partnerships and Compliance

Figure 11.Thematic Map 5



This section explores the essential teamwork and compliance that were necessary for the app's optimal performance; ensuring that it would be developed to surpass mere legal requirements and could leverage collective support for more significant impact. *"Working Together and Following the Rules"* illustrates how partnerships across various sectors and strict observance of health and privacy laws enhanced the app's functionality and user trust, integrating the realms of organisations, technology and legislation. Engaging with technology firms, healthcare entities and community groups was vital to

increasing the app's recognition, efficacy and acceptance. Such collaborations provided technological assistance, introduced additional features and integrated the app into existing health and public health infrastructures. The developers could draw on external expertise and resources through these strategic alliances to maintain the desired lead in technological innovation and public health standards. The development strategy prioritised adherence to legal and regulatory frameworks including compliance with data protection laws such as the GDPR and health industry regulations. This was essential for maintaining user trust and ensuring the app's legality, especially regarding protecting user data and privacy. By adhering to these regulations, the aim was to offer a secure environment for users to integrate the app seamlessly into their daily health management routines.

Forming partnerships and ensuring regulatory compliance can significantly influence how the public views and uses technology. These elements were aimed to guarantee that the app could transcend its technological identity to become an integral component of a comprehensive health system, encompassing legal, social, and organisational aspects. Such integration enhances an app's utility and efficacy as a public health instrument by aligning its functions with societal needs and expectations. An in-depth examination of the NHS COVID-19 app reveals how it navigates the complexities of collaboration and adherence to regulations, illustrating how these endeavours contribute to developing a robust, reliable, and responsive public health application. This analysis will highlight the intricate dynamics crucial to the successful operation and sustained adoption of health technologies in the contemporary era.

The collaboration between the creators of the NHS COVID-19 app and mobile service providers marked a significant advancement in the app's distribution and user engagement. This partnership was crucial because it ensured that using the app would not deplete users' data allowances, so users could fully engage with the app, including receiving daily updates on virus exposure, without affecting their data quota. There was this announcement to this effect:

> *The UK's major network operators, including Vodafone, Three, EE and O2, giffgaff, Tesco Mobile, Sky Mobile and Virgin Mobile have all agreed to not charge for using it.*
>
> *Baroness Dido Harding, executive chair of England's NHS Test and Trace Programme, said: "We want to make it as easy as possible for everyone to engage with England's NHS Test and Trace service [Sky News, 24 Sept 2020]*

This was a significant measure to enhance accessibility and was particularly beneficial for individuals with limited data or concerns about additional costs. It was notably advantageous for those with financial constraints, increasing the likelihood of frequent app usage. The app's functionality relies on its ability to run continuously in the background for features such as proximity tracking and providing it without additional data fees could also have helped build confidence among prospective users and increased downloads and usage.

5.6.1 Regulatory Compliance: Material Requirements and Social Impacts

Ensuring that the NHS COVID-19 app adheres to regulations continues to be crucial. The app must comply with various laws and guidelines that protect users' personal and health information. Adherence to these rules enhances the trust and acceptance of the app among individuals and businesses. Businesses were affected by the new policy arrangements when below announcement was made:

> *From today certain businesses in England are required by law to display NHS Test and Trace QR codes so customers with the NHS COVID-19 app can use them to check-in. QR codes will help businesses meet their legal requirement to log contact details and allow public health leads to send alerts based on whether people have checked in at venues. So far, more than 160,000 businesses have already downloaded QR codes. Venues in Wales that are legally required to collect and keep a record of visitors will still need to do so [Department of Health and Social Care, 24 Sept, 2024]*

The above extract demonstrates the impact of specific regulations on businesses, particularly about a particular health application. Companies must integrate new functionalities, such as QR code scanning, into their operations, which may necessitate process alterations and additional expenditure. Following these rules step-by-step is essential to protect businesses from legal problems that could be caused by data breaches or privacy law violations. Following the regulations also increases a health app's reliability and trustworthiness for users. When users are confident that the app satisfies due legal and privacy standards, they would be more willing to share their personal information through it.

Additionally, the regulations ensure that users' rights are protected, including the right to access their data, request data deletion, and receive information on how their data is utilised. These rights afford individuals greater control over their personal information. Observing these regulations is essential to ensure that the app secures user data and contributes to public health objectives without compromising privacy or security. Fulfilling these high standards can also alter public perception of privacy, raising expectations for

other digital tools and influencing the development of future technologies. Compliance with these regulations when using the NHS COVID-19 app encompasses technological and societal dimensions. It involves technological adaptations and how businesses and users of the app respond to these changes. By adhering to these rules, industries and applications fulfil legal requirements and foster societal trust and support for public health initiatives.

The NHS COVID-19 app has continually improved as users provide feedback and the developers implement changes. This ongoing dialogue enhances the app's functionality. The following are some examples:

- *Enhancements:* The team behind the NHS COVID-19 app continues to work on adding new features, resolving issues and ensuring user safety.

- *Security*: Maintaining user data security is paramount. The team vigilantly monitors for cyber threats and promptly addresses them.

- *User-Friendly:* The developers prioritise user feedback to make the app more intuitive and enjoyable. Challenges or frustrations expressed by users are quickly addressed.

> *The app will be updated occasionally with new functionality and improvements. The latest version includes up-to-date features and advice so it's important to keep it updated [UK Health Security Agency, 13 May 2022]*

This dedication to continuous improvement is crucial to ensuring that the NHS COVID-19 app remains practical and relevant. With the ever-evolving nature of COVID-19, including new information, regulations and virus strains, updates to the app are vital. They adapt to changing user needs, whether usage patterns or requirements. The app can swiftly incorporate changes by staying current, such as simplifying functions or introducing desired features, keeping users satisfied, and supporting public health management effectively.

The role of user feedback in-app enhancement

Collecting opinions: It is vital to grasp user perceptions of an app. Methods to ascertain this include surveys, review analysis, or usage pattern examination. This informs the development team about the app's performance.

Identifying issues: User feedback is invaluable for detecting problems such as bugs or user dissatisfaction, which may be overlooked initially.

Generating new feature ideas: Users often suggest innovative features or enhancements to increase an app's usability.

The evolution of an app is intertwined with user feedback, ensuring that improvements align with user preferences. As the app evolves, it adapts to user needs and desires and can pivot to address shifting demands and maintain relevance by heeding user input.

5.7. Challenges in the Promotion of the NHS COVID-19 App: A Sociotechnical Perspective

Researching the successful rollout of the NHS COVID-19 app in England and Wales required consideration of various factors, including the interactions of people, technology and societal systems. Sociotechnical theory played a significant role in understanding how social influences and tangible factors intertwine to shape experiences and outcomes.

For instance, in the context of launching the NHS COVID-19 app, sociotechnical theory helped us understand how technological architecture can align with public opinion and institutional guidelines, influencing the uptake or rejection of an app.

The challenges encountered during the rollout were not just technical issues but also highlighted broader societal problems, such as privacy concerns and digital disparities, which impacted the practical use of the app in combating the pandemic.

5.7.1. Misinformation and Fake Apps: Sociomaterial Dynamics of Trust

The NHS COVID-19 app encountered challenges in gaining widespread adoption due to misinformation about the pandemic and the app's functionality. This misinformation, influenced by social and technological factors, significantly eroded public trust in the app as a digital tool. As quoted:

> *The volume of inaccurate information circulating around the COVID-19 outbreak has prompted a global 'infodemic.' Widespread misinformation has included proposed underlying causes of the virus (such as 5G radio waves), conspiracies around the actions of public bodies, and unverified treatments and preventative measures [UK's Parliament Post, 23 April 2020]*

The quotation illustrates the complex nature of misinformation, attributing it to technological and societal factors. It highlights the role of digital tools, mainly social media platforms, in spreading false information, as well as societal influences such as fear, scepticism towards authority figures, and interest in conspiracy theories that contribute to its impact.

Misinformation concerning COVID-19, including baseless rumours about 5G radio

signals and other unfounded speculations, eroded public trust in health measures like the NHS COVID-19 app. This issue extends beyond the purely technical and encompasses a socio-technical challenge involving the convergence of technological platforms that enable the spread of misinformation (e.g., social media) and specific human factors that contribute to their popularity (e.g., distrust of authorities and engagement in conspiracy theories).

Furthermore, cybercriminals took advantage of this situation by creating counterfeit apps that mimicked genuine sources, such as the 'NHS' COVID app, further complicating efforts to build trust in authentic initiatives. According to the report:

> *COVID-THEMED cybercrimes have driven the number of scams taken down by the UK's security agency up 15-fold... among the scams were 43 fake NHS COVID-19 apps [The Telegraph, May 10, 2021].*

The quote shows the deceptive tactics employed by scammers during the social disruption caused by COVID-19. They exploited the public's increasing dependence on digital platforms and susceptibility to online fraud. These fraudulent activities posed a substantial risk, endangering individual users and undermining broader health initiatives. Their presence undermined the functionality of authentic applications and heightened public distrust.

5.7.2. Age-Related Digital Divide: Sociotechnical Gaps in Accessibility

Promoting the NHS COVID-19 app faced online challenges, especially among older people. The issue of computer literacy and technology usage extends beyond physical access and possession of devices, encompassing individuals' social training to navigate these technologies effectively. As one elderly individual (name withheld) reflected in an interview with the BBC:

> *You tend to feel a bit lonely. I didn't go out—well, I couldn't at the time because of COVID... and I was sat here, and all I had to do was watch the television [BBC 25 June 2021]*

The above excerpt outlines the challenges many elderly individuals encountered during the global health crisis. Due to limited access to digital technology, they faced difficulties in staying connected with others and participating in virtual activities. This situation brought attention to two interconnected issues: social isolation (a sociocultural challenge) and restricted availability of electronic devices (a technical obstacle). Consequently, the 'digital divide' significantly hindered the adoption of the NHS COVID-

19 app among older people, who often lacked the necessary resources or knowledge to utilise it.

Charitable organisations such as Age UK aimed to narrow this gap by providing seniors with technology access and training. However, the effectiveness of these initiatives was constrained by the entrenched nature of the technological gap, which was inherent in broader societal inequality. Thus, strategies for promoting the app needed to take careful account of sociotechnical barriers and aim to develop more inclusive solutions.

5.7.3. Privacy Concerns and Trust Deficit: Sociomaterial Tensions

The need to balance personal privacy with high-tech surveillance presented a significant sociomaterial obstacle when the NHS COVID-19 app was launched. The opposition between individual privacy and technology-powered tracking illustrates how social elements, such as trust issues towards surveillance activities, intersect with material aspects like a technological framework. The app's contact tracing-driven mechanism necessitated extensive data gathering and this led to heightened public anxiety over the potential mishandling of private information. This anxiety was rooted in past incidents where individuals had felt compromised or exploited via digital platforms designed for state-wide observation purposes. As one report noted:

> *Wide-ranging security flaws have been flagged in the COVID-19 contact tracing app being piloted in the Isle of Wight. The security researchers involved have warned the problems pose risks to users' privacy and could be abused to prevent contagion alerts from being sent [BBC 9 May 2020]*

The quotation emphasises the complex interaction between social and material consequences, as the app's technological foundation was seen as an infringement of privacy. This perception led to a decline in public trust, a critical societal factor. Although the authorities' acknowledgement of mistakes and efforts to rectify them were vital in restoring confidence, these initial perceptions hindered the app's adoption.

From a sociomaterial perspective, it is essential to recognise that privacy concerns are not solely technical issues that can be resolved through improved encryption or security protocols; they are inherently tied to societal perceptions of reliability and governance practices, extending beyond pervasive surveillance methods. Consequently, promoting technology must address both aspects simultaneously, both by bolstering physical security measures and also dealing with societal factors through transparent usage and guarantees regarding data protection techniques.

5.7.4 Technological Barriers and Compatibility Issues: Sociotechnical Exclusions

The NHS COVID-19 app also faced challenges in achieving widespread adoption due to technological compatibility issues. These sociotechnical barriers resulted from the interplay between the app's design, smartphone capabilities, and social inequalities regarding access to up-to-date technology. As the BBC stated:

> *A number of people—in particular, those with iPhones earlier than the 6S which went on sale in 2015—are finding that they are unable to install the app on their phone [BBC 28 Sept 2020]*

The limitations arose from the app's reliance on Bluetooth technology, which older phone models did not seamlessly support. Technology giants like Apple and Google chose Bluetooth as the operational medium, although they recognised that older models would not fulfil the dynamic requirements of their applications. However, this decision had significant socioeconomic consequences, particularly affecting individuals who could not upgrade their devices or who lived in areas with limited access to advanced technology.

This issue highlights the sociotechnical implications of technological design. Choosing cutting-edge Bluetooth for apps is an engineering decision, but one with potential social equity effects. Any promotion of such applications should address device compatibility issues – providing alternatives for less-advanced phones is one solution; alternative paper-based contact tracing methods might be another. Ensuring the availability of other public health measures for those without smartphones is crucial to protect everyone from potential crises.

Despite the challenges in achieving broad acceptance, the app did succeed in one critical aspect – it effectively prevented a substantial number of COVID-19 cases from increasing and saved many lives at risk. According to Oxford University, this technological solution prevented roughly 1 million pandemic-related incidents in its first year alone and saved approximately 10,000 lives (University of Oxford, 2023). However, this accomplishment existed alongside persistent social inequities that limited the reach and use of the app across different societal groups.

The NHS COVID-19 app encountered various challenges during its launch in England and Wales, stemming from a complex interplay of societal and technological factors. These challenges encompassed issues such as public trust, privacy concerns, digital inequality, technological compatibility problems, and regional disparities. This demonstrates the intricate relationship between social and technical elements when

engaging with technology of this nature.

Overcoming these obstacles required more than technical solutions; it necessitated a deep understanding of the sociotechnical context in which the app was being used. Recognising and addressing these factors early on could have improved the app's effectiveness and fostered stronger confidence in online health initiatives among the general public.

5.8 Analysis Through Sociotechnical Lenses

This chapter contains an analysis from a sociotechnical perspective of the various strategies that were implemented by the NHS in England and Wales to promote the COVID-19 app. The sociotechnical viewpoint emphasises the relationship among technological infrastructure, societal behaviours, and government policies in determining the practical use of an app.

According to Systems Theory, the COVID-19 app was part of an extensive public health system. Its success was affected by its technological features, policy structures, and user engagement. Privacy protection and compliance with regulations were crucial to its usability. Incorporation of the app into daily life, accompanied by official guidance, transformed it from a digital health tool into a vital resource for handling the pandemic challenges.

A significant aspect was the accessibility of the app to various demographic groups, which was achieved by offering different language options and adjusting designs to ensure smooth integration of the technology into users' everyday lives. This illustrates that the app's value was increased by its assimilation within society rather than its complexity.

Actor-Network Theory: Stakeholder Collaboration and Public Trust

From the ANT viewpoint, the implementation of the NHS COVID-19 app involved a complex web of technology developers, government bodies, healthcare organisations, and users(MacLeod et al., 2019; Peng and Woodlock, 2009). The marketing strategy to encourage its download was marked by interactive engagement rather than a straightforward approach, with trust and confidence among users being crucial factors.

Privacy concerns played a significant role in people's decisions whether or not to download the app. Initiatives to alleviate these worries included secure data management practices, clear communication strategies, compliance with GDPR, and local privacy laws. This situation illustrates how digital implementation decisions were

influenced by regulatory mandates and society expectations, highlighting the importance of the reciprocal connection between technology and policymaking. Assurance of the security and privacy of data helped to sustain public trust and promote participation in digital health initiatives.

The app's features, such as the tracking of symptoms, scheduling of tests, and notification of users about test outcomes, aided its integration into the NHS structure and enhanced the management of public health issues. The application of ANT illustrates how these collaborative efforts improved the credibility and acceptance of the app among diverse segments of the population.

Structuration Theory: Institutional Roles and Behavioural Patterns

Structuration Theory adds another layer to the comprehension of the uptake of mobile tools to tackle public health challenges during pandemics. It highlights the interrelatedness of institutional frameworks and their effects on individual behaviours, concentrating on how these aspects interact to drive participation (Ali et al., 2023; Giddens, 1984).

The plan to create apps associated with the NHS was drawn up alongside strict regulations that were focused on protecting public health. Institutional structures directed the implementation and operational tactics of these digital solutions within government programmes. Public awareness and involvement were vital, although instances of privacy breaches led to modifications of in-app features.

Structuration Theory emphasises the evolving changes in trust dynamics among users as technology advances. Continuous interactions between the public and government-led health programmes, framed within specific regulations, have encouraged a more nuanced appreciation of trust in technology. Initial opinions of these tools shifted from experimental to increasingly accepted, as prompt reactions to user feedback encouraged broadened participation.

Ultimately, these innovations in digital health tools highlight the need to ensure data security and privacy and, hence, to strengthen public trust while encouraging involvement in health initiatives. The ongoing integration of user requirements and regulatory standards is essential to ensure these technologies function and are adopted successfully.

Sociomateriality: The Role of Trust in Digital Health Adoption

A sociotechnical examination emphasises that Sociomateriality must be appreciated in

order to understand trust and adherence among digital health service users (Pepper et al., 2022; Ranisch et al., 2021). The public's perception of technological aspects, regulatory insights, and societal concerns shaped its confidence in the NHS COVID-19 app.

The app development team focused on reducing data usage while enhancing transparency and empowering users. These moves addressed public worries about online surveillance and loss of privacy. DPIAs were utilised to balance technological capabilities and social expectations, and this use ensured that ethical standards were upheld throughout the app's development. This strategy aligns with sociological materialism as it recognises the relationship among technological trust, socially acceptable practices, regulatory frameworks, and available infrastructure.

5.8.1 Enhancement of Accessibility and Overcoming Barriers

A multidisciplinary approach was taken to ensure that all stakeholders were included during the digital health adoption process. Interactions needed to be streamlined, as this enabled participants, regardless of their technical skills or disabilities, to engage meaningfully. Support tools were created to assist users in navigating digital platforms so that broad applicability was ensured through the use of various assistance methods, which included online resources, telephone support, and visual instructions.

Moreover, partnerships with mobile service providers eliminated internet access charges and therefore addressed obstacles faced by potential users who had limited web connectivity. This initiative aimed to develop comprehensive solutions that considered both technological logistics and the necessity for communal equity, which ultimately would maximise participation in these programmes for enhanced impact.

5.9 Chapter Conclusion

Chapter 5 explores the promotional methods that were used to encourage public acceptance of the NHS COVID-19 app. These methods were analysed through a sociotechnical systems approach. The results suggest that to be successful, marketing must carefully balance technological attributes, societal norms, and expectations. The app's availability in various languages enhanced engagement among diverse communities, and this feature highlighted the convergence of technology and social inclusivity.

Social influencers and community leaders were crucial in underscoring the app's usefulness beyond its technical features. This factor reaffirmed the app's significance within the larger community. It was essential to prioritise privacy and security in order to build user trust. The decentralisation of data storage and encryption technologies demonstrated the developers' understanding of users' concerns about the safety of their data. Initial doubts that arose from confusion and fears about digital privacy rights emphasised the complexities of establishing trust from a socio-material viewpoint.

The app enabled easy access to healthcare services so that users could schedule checks, track symptoms, and obtain results quickly. This factor added to perceptions of its effectiveness, as it blended with existing healthcare systems, and its use fostered positive changes in user behaviour (Dowthwaite et al., 2022). Employment of sociotechnical system analysis underscored the need to understand interactions within health-oriented digital solutions that supported promotional initiatives.

Despite the positive aspects, obstacles such as misinformation, privacy concerns, and challenges related to the technology's accessibility to senior users persisted. These issues mirror traditional concepts that are explored within Structuration Theory, such as the dynamic nature of institutions, user behaviour, and regulatory frameworks. The discussion points to critical intersections between principles of social awareness and the efficacy of strategies to promote collaboration and inclusion in strategic planning for e-health initiatives, especially in disaster response.

CHAPTER 6: THE ROLE OF NHS COVID-19 APP IN SAPPING COVID-19 PANDEMIC MANAGEMENT AND AS A CATALYST FOR DIGITAL HEALTH INNOVATION IN ENGLAND AND WALES

6.1 Introduction

The NHS COVID-19 app has significantly transformed digital healthcare in England and Wales during the pandemic. Many now have the option to consult their doctors from home, providing safe medical assistance to thousands. Previously, video calls accounted for only 3% of doctor visits, but within a year, this soared to 99% due to the preference of both patients and doctors. The app also supports the NHS Test and Trace by facilitating online testing appointments and advice, while preserving phone services for those in need. Additionally, care homes received digital tools, enabling online doctor consultations and distributing over 2000 tablets, helping residents maintain contact with loved ones, which benefits their mental health. These advancements, including improved health data management, are permanent. Mr. Matt Hancock stated on July 30, 2020, that these innovative practices in the NHS are here to stay, marking a new era in healthcare management and pandemic response. The excerpt from Mr Hancock stated:

> *Remote consultations, for instance, have supported thousands of patients to stay safely at home and get the healthcare they need. 99% of practices can now offer video consultations, up from 3% at the start of the year, and the feedback from both patients and clinicians is overwhelmingly positive. 111 online has also been amazing and will get stronger and stronger. Much of NHS Test and Trace is already online. You can book a test and get advice online, while of course, the telephone service is available for all those who need it. Throughout the lockdown we've supported care homes in introducing modern digital tools; whether online check-ins with local GPs, getting care homes onto NHSmail or the over 2000 tablets we've given to care settings to allow residents to stay in close touch with loved ones, something that's so important for people's wellbeing. There is no going back on these improvements, and it's not just the front-end patient-facing services that have been transformed, it's the digital back-end too. Getting our data infrastructure into shape has been a vital part of the NHS response to the pandemic.*
>
> *[Mr. Matt Hancock, then Secretary of State for Health and Social Care, 30 July 2020]*

Mr. Hancock's remarks in July 2020 describe healthcare innovations that surfaced during the COVID-19 pandemic and suggest that they will have lasting effects in improving healthcare delivery ("There is no going back on these improvements..."). These innovations and their continuity beyond COVID-19 are the areas of interest for this chapter.

One such innovation was the role of the NHS COVID-19 app in supporting traditional manual contact tracing during the pandemic in England and Wales. The app employed digital technology instead of manual contact tracing, using Bluetooth to quickly and anonymously alert users if they had been near someone who had tested positive for COVID-19. This eliminated the need for human tracers to interview people and identify their recent contacts. It also shortened the time required to inform potential contacts, which contributed to controlling the spread of the virus.

Furthermore, Mr Hancock claims that deploying the NHS COVID-19 app has played an essential role in the broader digital modernisation of the healthcare system. Significantly increased use of remote consultations has received “overwhelmingly positive” feedback from patients and clinicians. He also praises the development of the 111 online service as offering a convenient platform for booking tests and obtaining advice, complementing the existing telephone service. He refers to the usefulness of contemporary digital tools for care homes, including online check-ins with local GPs and NHSmail, and mentions the allocation of more than 2000 tablets to care environments so that residents could stay in touch with family and friends, aiming to support mental health during periods of isolation.

The healthcare crisis triggered by COVID-19 resulted in the development of healthcare innovations such as the NHS COVID-19 app and it can be said that, in addressing the immediate challenges, a groundwork for future healthcare advancements was also laid. These developments have continued their impact beyond the pandemic, marking a shift towards digitising healthcare services throughout England and Wales. My inquiry primarily focuses on exploring the impact of the NHS COVID-19 app, and in this chapter, seeks answers to the question 3: ***How did the NHS COVID-19 app shape COVID-19 pandemic management and digital healthcare in England and Wales?***

It is important to understand the impact of the NHS COVID-19 app on public health practices and the broader implications of such innovations for the medical field. The understanding of managing pandemics and advancing digital healthcare concepts is vital for assessing effective digital solutions, steering policy execution, addressing fundamental ethical concerns, and enhancing awareness of technological progress. This research aims to expand our understanding of the effectiveness of public utility apps in critical situations, contributing to the latest technological progress in healthcare. Insights from thorough analysis are invaluable for advancing technological applications, especially those that improve tracing processes.

Specifically, the analysis categorises the NHS Covid app's impact into five themes:

Public Health Efficacy, Healthcare System Integration, Policy Impact, Ethical Considerations, and Digital Healthcare Evolution. The goal is to understand its complex role thoroughly. These considerations are important in preserving the unique dynamics between society and technology; they have been extensively debated, leading to informative and productive discussions. The concluding part reaches a consensus and considers the sharp contrast between the swift progress of digital healthcare and the recent shifts in both the evidence base and the documented changes.

To gauge its societal impact, it is essential to comprehend how the app confronts ethical issues and affects public trust. The app's contribution to promoting digital health practices is critical to hastening the integration of online tools in healthcare settings.

From a sociotechnical standpoint, the analysis probes the detailed interrelations between technological attributes and user behaviour, encompassing healthcare providers and software overseers. This perspective allows for examining the subtle elements that dictate how this health management tool informs healthcare strategy.

Each of the following sections links sociotechnical principles to illustrate how the material aspects of the app (its features and functionalities) and the social aspects such as usage, policies, and ethical considerations are connected.

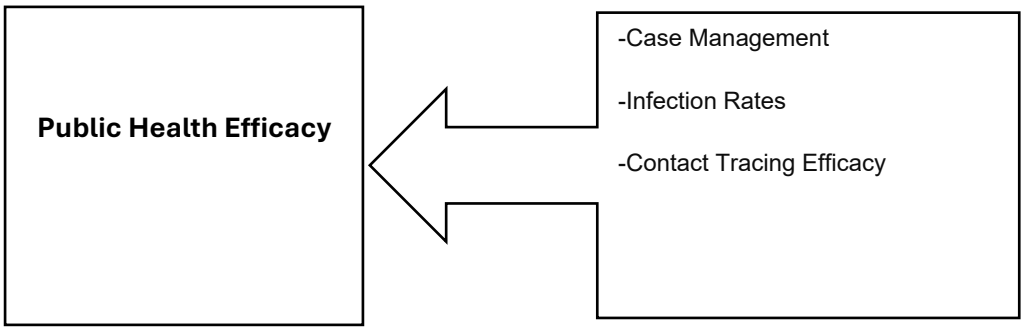
Table 9. Themes, codes and their brief descriptions.

Theme	Codes	Description
Public Health Efficacy	Case Management	-Impact on managing confirmed cases
	Infection Rates	-Effect on controlling or reducing COVID-19 spread
	Contact Tracing Efficacy	-Exploring the role of the app's contact tracing technology in identifying and notifying contacts
Healthcare System Integration	Test and Trace Integration	-Coordination between the app and other NHS testing and tracing services
	Healthcare Provider Support	-How the app supports healthcare providers in case management and resource allocation
	Data Sharing and Utilisation	-How app-generated data is used by healthcare professionals and public health authorities
Policy Impact	Public Health Policy	-Influence on public health policy development
	Regulatory Changes	-Changes in laws or regulations prompted by the app
	Guidance Development	-Development of new health guidelines influenced by app data
Ethical Considerations	Privacy Concerns	-Public concerns regarding data privacy and how they are addressed
	Ethical Debates	-Ethical discussions surrounding the use of digital tracing
	Behavioural Impact	Changes in public and patient behaviour due to app interactions
Digital Healthcare Evolution	Digital Tool Adoption	-Influence on the broader adoption of digital tools in healthcare
	Strategic Digital Transformation	-Impact on long-term digital healthcare strategies
	Innovation Catalyst	Role of the app in spurring further innovation within the NHS

Source: Author

6.2 Public Health Efficacy: The NHS COVID-19 app's Role in Pandemic Management

Figure 12.Thematic Map 1



In this Public Health Efficacy section, my examination focuses on the NHS COVID-19 app's role in public health management during the COVID-19 pandemic. The discussion highlights how the app contributed to case management and considers whether it reduced infection rates and enhanced contact tracing efforts. The app sought to improve and streamline traditional public health practices by utilising advanced technological features such as instant alerts, symptom tracking, and automated contact tracing. This review evaluates the outcomes of these functionalities and emphasises the benefits of integrating technology and community engagement in public health initiatives. It uses the idea of sociotechnical to understand how the app's features and social habits worked together and investigate whether the app helped to fight the spread of COVID-19.

A notable feature of the NHS COVID-19 app was its capability for automated contact tracing, which contrasts with the labour-intensive conventional methods. Traditionally, health workers were required to personally interview infected individuals to identify recent close contacts and then to notify the contacts; this can be a time-consuming process, prone to omissions and potential delays. The app utilises Bluetooth to detect proximity between users. If a user tests positive for COVID-19, the app promptly notifies others who are in close contact with them. This automated tracing accelerates the notification process and ensures that potentially exposed individuals are informed promptly so that they can self-isolate and seek testing. Minimising delay in alerting people to exposure is crucial in halting the spread of a virus, as stated by the NHS COVID-19 Support team:

> *The algorithm uses the date of symptom onset to calculate who they are most likely to have infected. The algorithm looks at the daily risk for every app user whom they came into contact with from 2 days before symptoms first appeared, up to a maximum of 7 days after symptoms first appeared [NHS COVID-19 app Support, 27 Oct 2021]*

The rapid alert feature of the app is considerably faster than the traditional method of notification, which could take days, during which time the virus could have spread to more people. The speed of the alert adds to the sense of urgency, which makes users who are contacted more likely to follow the advice and get tested, thus helping to stop the virus from spreading.

Another critical function of the app was to enable users to track any symptoms they may have. This allows health officials to understand how the virus spreads and where it might be a problem. With this information, they can act quickly to deal with new outbreaks. The app will also tell a user if their symptoms mean they should get a test, which can assist in finding infections early and slowing the development of the virus. The NHS Test and Trace Team shared this information:

> *Test: This feature will help you book a test. If you have coronavirus symptoms, the app will take you to a website where you can book a test to see if you have coronavirus or not. If you are under 18, you are advised to discuss with a trusted adult before booking a test [NHS Test and Trace, 27 Sept 2020]*

The feature for tracking symptoms has the advantage of getting users involved in watching out for the virus, and the information provided helps to paint a clearer picture of how the virus moves around. This way of doing things improves information about public health and enables the public to have a part in dealing with the pandemic. These features of automated contact tracing, instant alerts and keeping track of symptoms are believed to have made a significant difference in the fight against the COVID-19 virus. According to the NHS Directorate:

> *From September to December 2020, the NHS COVID-19 app prevented approximately 600,000 cases of COVID-19.*
>
> *[NHS Transformation Directorate 2020].*

This claim suggests that the app helped considerably in lowering the chance of getting the virus and played a major part in dealing with the pandemic. By catching possible infections early and ensuring that people who might be infected stayed alone, the app cut down the number of further infections, also easing the burden on hospitals and health workers. This level of success in stopping new cases proves that using technology to

help control diseases is important. With its real-time data and quick action, software such as the NHS app can be crucial for fighting contagious diseases and stopping them from spreading far and wide.

Adding the NHS COVID-19 app to healthcare work greatly impacted case management. Before, taking care of cases of notifiable disease was labour-intensive, requiring paperwork, talking to patients directly, and keeping track of whom patients met. It was time-consuming and could easily lead to mistakes. The app made some of these tasks automatic, faster and more precise. The NHS COVID-19 Support Group shared in its explanation pack:

> *The app will help the NHS understand where and how quickly the virus is spreading, so it can respond quickly and effectively. The app helps the NHS track the virus, not individuals [NHS COVID-19 app explainer pack, 29 Oct 2020]*

The app also helped doctors and health workers to make good decisions by giving them rapid and up-to-date information when dealing with many cases during the pandemic. The app let them see what was happening with the virus in real time. They could watch how things were changing and decide what to do next based on the facts. For example, if more people started getting sick in one area, the health officials could test more people, lock down that area, or tell everyone how to stay safe. The information from the app also helped hospitals to get ready for a potential influx of patients, making sure they had enough beds and medical supplies.

6.2.1 Some Difficulties

However, ensuring that everyone used the NHS COVID-19 app was difficult. Many people needed to use the app for it to work well. People needed to trust that their personal information was safe and to feel comfortable about using the app. In an attempt to address some of these concerns, a government agency, the Information Commission Office, published a statement explaining how people's data collected by the app would be put to use:

> *Data is not used for analysis or for other purposes in ways that may detrimentally affect information rights and privacy.*
>
> *[Information Commission Office (ICO), 15 Oct 2020]*

The ICO made this statement to ease worries about safety and privacy linked to the app; it emphasised that keeping user information safe and private was a top priority for the app's design. Making sure everyone knew that their privacy was protected was critical to getting more people to use the app, which, in turn, would help to control the spread of

the virus better.

Some technical issues needed fixing. For example, the technology used to determine if a user has been close to someone who might have the virus did not always work perfectly because physical obstacles or other electronic signals could interfere with the smooth running of the app. Importantly, the app only works if people keep their Bluetooth on and always have their phones with them. The BBC reported this:

> *At one point its algorithm had to be tweaked after tens of thousands of people were receiving alerts every day telling them to self-isolate in case, they were infected. This period was dubbed the "pingdemic", and in one week in December 2021, the app sent nearly 700,000 notifications [BBC, 30 April 2022]*

These reports demonstrate that during the COVID-19 pandemic, the app was not yet a perfect contact tracing tool. Maintaining the app's updates, ensuring widespread use and instructing individuals on its use were crucial for its effectiveness. Notwithstanding some of these hitches, it can be said that the NHS COVID-19 app played a significant role in public health during the pandemic. Even though there were some difficulties in getting the app to everyone, it showed that using technology can help manage public health issues. Thus, it is essential to keep developing and improving these tools for the future. The claim that the app played a role in preventing about 600,000 cases of COVID-19 between September and December 2020 proves that it was believed to be significantly helpful (NHS Transformation Directorate, 2020). As we learn from how the NHS COVID-19 app was used, this knowledge can help improve future health tools, making sure they work well, are safe to use, and that everyone will want to use them when we face similar health challenges.

6.2.2. Sociotechnical Interplay: The Role of the NHS COVID-19 app in Pandemic Management

The NHS COVID-19 app worked well in handling the pandemic because it combined technology with people following the rules. This combination demonstrates the mutual influence of technology and human actions. Looking at how the app was developed, its focus on keeping information safe, and how people trusted and used it shows why it helped to reduce the effects of COVID-19. The app featured innovative technology to support public health, such as automatic tracking of users' contacts, instant notifications if users had been near someone who became ill, and symptom monitoring. However, for this technology to work well, a sufficient number of people had to use the app correctly, for instance, to keep their Bluetooth on at all times (an example of how technology and people mutually shape each other in addressing societal issues).

Using Bluetooth, the app could tell when users were close together and, when someone got sick, could rapidly inform others close to them. The speed and accuracy of the alerts were significant factors in preventing the spread of the virus by enabling at-risk individuals to self-isolate and seek testing promptly. The facility for users to tell the app about their symptoms was a good example of material and social working together, which helped to monitor where the virus might be increasing and act fast to stop outbreaks.

For such an app to function effectively, widespread and consistent usage is necessary. Achieving this requires the app to ensure that users' private information is secure. The NHS COVID-19 app was designed to track the virus, not spy on people, and it used technology to keep user information safe. Initial concerns were how to protect users' privacy and how their information might be used, and addressing these concerns was a major hurdle in persuading a sufficient number of the public to use health apps during the pandemic. The app was required to respect privacy and ensure data security if it was to gain user trust.

The NHS COVID-19 app maintained the privacy of users' information and did not monitor their locations. It mainly tracked meetings that might suggest the virus could be spread. The app implemented robust safety measures to safeguard users' information against unauthorised access or breaches; information about each user was limited and securely coded. The app's creators were confident that they could guarantee that all health information would remain private and secure, thereby increasing users' comfort levels with the application.

The interaction of technology and users with this app shows how technology and people shape each other. This idea is critical when thinking about technology not just as a tool but as something that actively changes and is changed by how people act. The app changed how people acted by making them, report if they felt sick, self-isolate and get tested. These actions were vital in controlling the pandemic and were made easier by the app, particularly in terms of the speed of alerts encouraging rapid responses from users.

On the other hand, responses from users did help to make the app better. In the early stages, the app used a lot of battery power because it constantly checked for Bluetooth signals. Users raised concerns about this, so the creators made the app use less battery without losing its main features. This interaction is a typical example of how user feedback can change and improve technology. Paying attention to privacy and keeping data safe helped people to trust the app more, which led to more people using it, which

was important as it needed large numbers of users in order to function correctly. Emphasising privacy was aimed at encouraging app usage, not solely enhancing the technology.

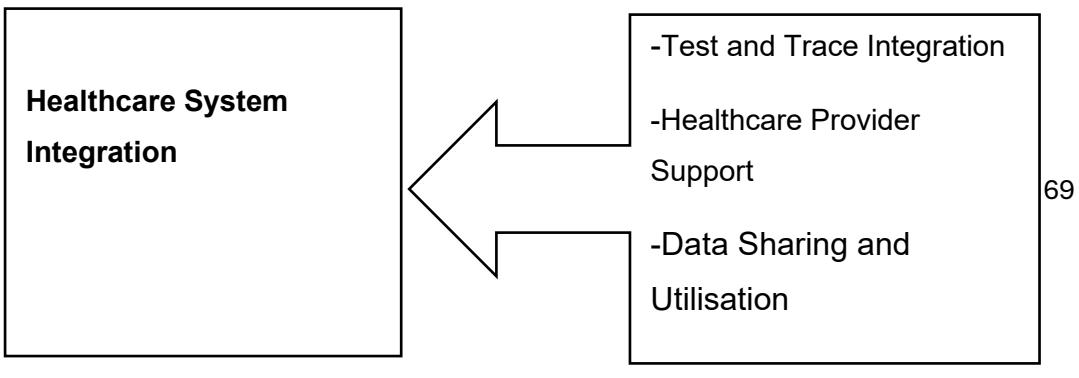
The data from the app's space helped doctors and health workers to decide where resources were most needed and how to reduce the impact of outbreaks. Acting quickly and putting resources where they were required helped health authorities to manage the pandemic and took some pressure off healthcare systems. This interaction was another demonstration of humans and non-humans complementing each other to address a social challenge.

The release of the NHS COVID-19 app sparked extensive conversations about privacy and the suitability of utilising individuals' data. The primary issue centred on protecting personal information while informing people about possible exposure to COVID-19. The app's development prioritised user privacy and security, so it did address these concerns significantly. In order for the app to function correctly, users were required to consent for their data to be used. Nevertheless, informing users about the usage and protection of their data was crucial; the public needed to feel safe about using the app and be sure that it would continue to use their information in a regulated and fair way. Ensuring that the app did its job without infringing on users' privacy was tricky, but it was achieved by focusing on tracking the virus, not individuals, and using rigorous methods to keep data secure.

Looking at how the NHS COVID-19 app helped with the COVID-19 situation shows us how technology and people's actions work together. Because the app was known to prioritise privacy and safety, people trusted it, and many decided to use it. This was key to how well the app worked and its success in slowing down the spread of the virus, helping to manage cases, and supporting healthcare workers. The lessons learned from the introduction of this app should support the development of new and effective health tools in the future. The following section focuses on how the app's integration into the healthcare system may have extended the boundaries of digital healthcare.

6.3 Healthcare System Integration: The Unification of the NHS COVID-19 app into the Broader Healthcare Landscape

Figure 13.Thematic Map 2



The NHS COVID-19 app helped to manage the pandemic in England and Wales by working with the existing health system. It supported the NHS Test and Trace system and made it easier for public health efforts and healthcare providers to work together. The app has the potential to integrate with various segments of the healthcare system, aiding in case management, efficient resource utilisation, and enhanced information sharing. This analysis examines the collaboration between the app and the healthcare (NHS) system, especially hospital staff, highlighting the benefits and obstacles encountered when employing digital tools during health crises. It underscores the importance of interaction and proficient technology in controlling a pandemic.

The NHS COVID-19 app was said to have improved case management within the healthcare system. Previously, case handling involved extensive paperwork, direct patient communication, and manual contact tracing, which was labour-intensive and prone to errors. The introduction of the NHS COVID-19 app automated several tasks, resulting in quicker and more precise case handling. A significant feature of the app was its ability to automatically trace contacts, eliminating the need for workers to manually identify and inform individuals who have been near infected patients. Although effective, the traditional method took considerable time, potentially leading to further virus spread. The NHS COVID-19 app operated more rapidly by using Bluetooth technology to identify proximity between users. If a user received a positive COVID-19 test result and shares it through the app, the app would automatically and swiftly alert individuals who would come nearby. This advancement expedited contact tracing, allowing quicker interventions and reducing virus transmission. According to the NHS Test and Trace Team, this approach significantly shaped pandemic management.

> *The NHS COVID-19 app complements NHS Test and Trace processes by extending the speed, reach, and precision of contact tracing [NHS Test and Trace, 22 Oct 2020].*

Including the NHS COVID-19 app in healthcare strategies influenced the utilisation of resources such as test kits, protective equipment and medical personnel. It was essential to use these supplies wisely in order to handle the pandemic well. The app let people share their symptoms, and this data could subsequently be analysed by specialists to determine the prevalence of symptoms in various locations. This real-time information proved to be highly beneficial for public health officials, who could see where the virus might be spreading and act fast to stop it from worsening, providing resources where they were most needed. Having fresh data from the app meant that public health workers could make informed choices, and at the peak of the pandemic making swift and considered decisions was crucial. The app's regular updates on how many people were

ill helped health authorities to be aware: they could see if the virus was about to flare up in a particular area and take actions such as issuing more tests, imposing short lockdowns, or increasing public information on how to stay safe. Additionally, the information provided by the app could enable hospitals to prepare for an influx of patients and, if possible, to secure sufficient supplies and staff to attend to everyone's needs. Such preparedness was instrumental in managing the pandemic and alleviating the strain on healthcare services.

The NHS COVID-19 app necessitated a shift in the operational methods of doctors and nurses to leverage the app's capabilities fully. They became adept at utilising the app to monitor health indicators and make informed decisions based on the latest data. The app immediately notified healthcare professionals when an individual was potentially exposed to the virus, prompting swift action for testing and isolation to prevent further spread. This represented a significant departure from previous practices. Moreover, the app facilitated seamless information sharing among various health entities, fostering collaboration, which was crucial for a more effective response to the virus and ensuring a unified approach to combating the pandemic. The app proved particularly beneficial when an outbreak occurred in a specific area, as it facilitated improved collaboration between hospitals and health officials to address the issue effectively. This collective effort ensured optimal utilisation of health resources and efficient implementation of health strategies. The app supported health workers in exchanging information to enhance their collective response to the virus and help healthcare resilience against emerging viral threats. User trust was fundamental for continued app usage, encouraged by a strong emphasis on data security and privacy, to track the virus rather than individuals, thereby promoting a sense of comfort and security among users. UK Government DHSC shared on the government official website, .gov.uk:

> *The app has been designed with user privacy in mind, so it tracks the virus, not people and uses the latest in data security technology to protect privacy. The system generates a random ID for an individual's device, which can be exchanged between devices via Bluetooth (not GPS). These unique random IDs regenerate frequently to add an extra layer of security and preserve anonymity [DHSC, 2020]*

The app was designed to prioritise data security and privacy to ensure its trustworthiness and alleviate concerns about surveillance or data misuse. This approach was not merely an attractive feature but a strategic move to encourage wider adoption and adherence to the app's recommendations. In the same way, the NHS COVID-19 app gained traction among healthcare professionals, prompting updates that further tailored it to their needs. For instance, when feedback highlighted excessive battery consumption due to

continuous Bluetooth scanning, the developers optimised it to be more energy-efficient while retaining its practical features. The app altered the approach of doctors and nurses during the pandemic by swiftly identifying and notifying individuals of potential virus exposures via its automated contact tracing and alert system. Consequently, healthcare professionals had to adapt their methods, which highlighted the reciprocal impact between the app and healthcare procedures. NHS Test and Trace reported the app as aiming to play a significant role in managing the pandemic through the introduction of innovative tools and methodologies within the healthcare system:

> *The app will help the NHS understand where and how quickly the virus is spreading, so it can respond quickly and effectively. The app helps the NHS track the virus, not individuals [NHS Test and Trace, 27 Oct 2020]*

The app was seen to be beneficial during the pandemic because it streamlined processes, enabled fact-based decision-making, and fostered collaboration. Its success was mainly due to its privacy protection and meticulous planning, which gained widespread trust and usage. The interplay between technology and the lifestyle of the population is clear, highlighting the need to consider both the development and use of technology to tackle health challenges, a subject we will delve into more deeply.

6.3.1 Sociotechnical Dynamics: The Integration of the NHS COVID-19 app

The NHS COVID-19 app has been recognised for enhancing healthcare systems during the pandemic, demonstrating the interconnection between technology and social practices, particularly within the realm of healthcare. This discussion highlights how the NHS COVID-19 app made healthcare more efficient and how healthcare workers changed their daily tasks using this digital tool. By handling and automating tasks like contact tracing and tracking of symptoms, the NHS COVID-19 app was recognised to have made healthcare more efficient. The app strengthened NHS Test and Trace initiatives by enhancing the speed, scope and precision of contact tracing. With the app handling contact tracking autonomously, healthcare professionals could gain more time to care for patients and perform other critical tasks, reducing their burden and improving public health measures. Additionally, the NHS COVID-19 app provided real-time data on symptom trends as users reported their health status through the app. Data aggregation can help healthcare workers and public health authorities monitor trends and make informed decisions.

The app provided doctors and health workers with real-time updates on symptom changes across various regions. This enabled them to identify potential new outbreaks of illness and respond promptly. For instance, if an increase in illness was detected in a

specific area, the app could alert health workers to deploy additional resources, such as more tests and medical staff, to prevent further spread. This efficient method of assisting the most needed areas ensured that health systems could rapidly and effectively combat threats like COVID-19, easing their burden. Health workers needed to adapt their work practices to fully utilise the utility, incorporating the app's tools and data into their daily routines. A significant shift was the necessity for health workers to become proficient in using digital tools for monitoring health information and making informed decisions. Comprehending the app's data was crucial for making swift, informed decisions regarding testing and isolation of patients.

Moreover, the app facilitated seamless data sharing between various health entities, enhancing collaboration between hospitals, public health authorities and medical staff, which was vital for an effective virus response and a cohesive strategy. The app's collaborative features enabled healthcare organisations to operate more effectively. For instance, a surge in cases within a specific locale, as indicated by the app, could prompt local hospitals and health officials to combine efforts to address the issue. Such collective action ensured the efficient utilisation and the proper execution of health measures.

The NHS COVID-19 app succeeded primarily due to the trust it garnered from users. The developers ensured that privacy was a priority, reassuring users that their data would remain secure. The app alleviated concerns about surveillance or data misuse by focusing on virus tracking without monitoring its users, encouraging wider adoption. Trust maintenance was paramount for the creators, who concentrated on data security to prevent any apprehensions about monitoring. This commitment to privacy was integral to their strategy, which aimed to maximise user numbers and consistent app usage. The app's integration into the daily routines of healthcare professionals like doctors and nurses also played a crucial role as it evolved to better assist them in their work. The application continued developing as developers considered user and healthcare professionals' feedback. Initially, the app was draining phone batteries due to constant Bluetooth use. However, after receiving user input, the developers optimised the app to consume less battery while maintaining its effectiveness. The Department of Health and Social Care addressed concerns regarding rapid battery depletion, ensuring the app's efficiency:

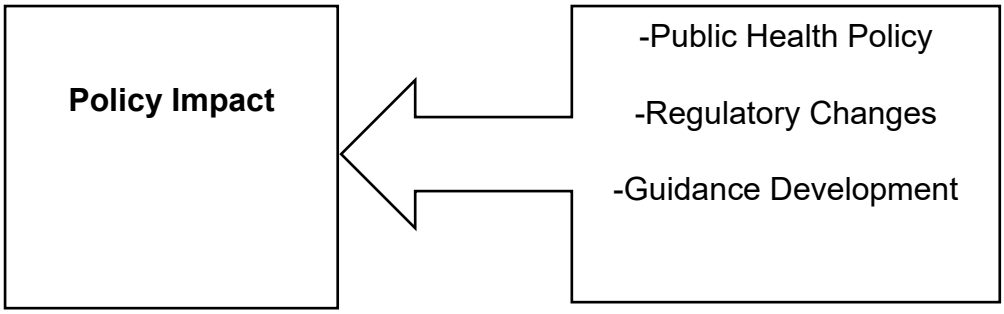
> *The contact tracing element of the app works by using low-energy Bluetooth to log the amount of time you spend near other app users, and the distance between you, so it can alert you if someone you have been close to later tests positive for COVID-19 – even if you*

don't know each other [DHSC, 24 Sept 2020]

The NHS COVID-19 app may have gained popularity due to its continuing assurance of commitment to user privacy. It was engineered to monitor the spread of the virus, not the individuals, which alleviated privacy concerns and led to a higher adoption rate.

6.4. Policy Impact: The NHS COVID-19 app's Influence on Public Health Policy

Figure 14. Thematic Map 3



This analysis delves into the app's role in guiding rules, laws, and health plans throughout the COVID-19 crisis. It aims to explore the app's influence on the formulation of health policies. The investigation will underscore the amendments to regulations prompted by the app, its impact on rules and standards, and the lessons that can be gleaned from health technology initiatives. As the excerpt below explains:

> *The* introduction *of the NHS COVID-19 app has influenced public health policy, emphasising the importance of digital tools in managing health crises [NHS Test and Trace, 24 Sept 2024]*

The NHS COVID-19 app brought about changes in public health regulations. It was designed to enable reliable and swift contact tracing and data collection, demonstrating the efficacy of digital tools in managing health crises. Consequently, policymakers were prompted to revise and enhance health strategies with increased digital integration. A notable innovation of the NHS COVID-19 app was its automatic contact tracing feature. Utilising Bluetooth technology determines proximity between users, alerting those who have been near an infected individual. This facilitated quicker and more accurate tracking of the virus's spread, which was critical for containment. Additionally, the app's capability to send immediate exposure notifications allowed individuals to act promptly by self-isolating and seeking testing. This underscored the importance of rapid response

in a health emergency and encouraged policymakers to incorporate similar technologies into broader health initiatives.

6.4.1. Policy Changes Initiated by the Deployment of the NHS COVID-19 app in England and Wales

The NHS COVID-19 app, utilised in England and Wales, aided public health officials in tracking the disease more effectively, managing responses more efficiently, and ensuring the safety of personal information. This review discusses the app's initiation of new health policies in the healthcare landscape in England and Wales. A primary function of the NHS COVID-19 app was to promptly notify individuals if they had been in proximity to someone who had tested positive for the virus. Consequently, new policies were established to inform users immediately whether to seek testing or self-isolate to prevent further virus transmission.

> *Features of the app include contact tracing using Bluetooth, risk alerts based on postcode district, QR check-in at venues, symptom checker and test booking – with user privacy and data security at its heart [DHSC, 24 September 2020].*

Transitioning from manual processes to automated tools for contact tracing represented a significant shift that enhanced the speed, reliability and accuracy of tracking efforts. Specific procedures were implemented to combine app data with other health systems to maintain precise and thorough tracking. This integration provided a more complete view of potential COVID-19 exposures and simplified management of the situation.

> *It is available to those aged 16 and over in multiple languages. It forms a central part of the NHS Test and Trace service in England and the NHS Wales Test, Trace, Protect programme - identifying contacts of those who have tested positive for coronavirus [DHSC, 24 September 2020]*

Integrating the app into the broader public health system could enhance the NHS's data utilisation, streamlining the Test and Trace system.

The app's ability to swiftly identify and notify potential exposures has prompted updates to testing and isolation guidelines. These guidelines aim to provide clear and prompt instructions on the actions to take if advised to isolate, encompassing legal requirements and available support.

> *The app will advise you to self-isolate if you have been in close contact with a confirmed case. It will also enable you to check*

> *symptoms, book a free test if needed and get your test results.*
>
> *[DHSC, 24 September 2020]*

This approach ensures that individuals receive prompt assistance and guidance. It also helps to prevent the virus's spread by encouraging those who may be infected to isolate more quickly.

The app simplified getting tested for COVID-19 by enabling users to arrange a test directly through the app. This ensured the availability of sufficient tests for all, and the app also notified users of their test results.

> *The rollout of the app in Wales coincides with a national campaign around how people in Wales can best support the NHS Wales Test, Trace, Protect programme, including only getting a test if they are showing symptoms; self-isolating when required; and working with local contact tracers if they are contacted [Welsh Government announcement, 24 September 2020].*

The new regulations simplified testing, which was important for effective pandemic management.

Since the app handles sensitive health data, measures were implemented to safeguard users' privacy and secure their information. The app collects only essential data for contact tracing and refrains from requesting personal details such as names, addresses, or phone numbers.

> *The app does not hold personal information such as your name, address or date of birth, and only requires the first half of your postcode to ensure local outbreaks can be managed. No personal data is shared with the government or the NHS [NHS England Transformation Directorate,24 September 2020].*

This approach protects individuals' private information while facilitating effective contact tracing. Upon the app's deployment, policies were implemented to safeguard data in compliance with the General Data Protection Regulation (GDPR). These measures include data encryption, robust security and restricted access.

> *The app has been designed with user privacy in mind, so it tracks the virus, not people, and uses the latest in data security technology to protect privacy. The system generates a random ID for an individual's device, which can be exchanged between devices via Bluetooth (not GPS). These unique random IDs regenerate frequently to add an extra layer of security and preserve anonymity [NHS England Transformation Directorate,24 September 2020]*

Implementing these policies was crucial in enhancing the app's trustworthiness among users; this sense of security contributed to the app's effectiveness. Upon its release, the app also revised policies for workplaces and public areas to ensure safety. During the height of the pandemic, public venues and workplaces were required to display QR codes to help facilitate the tracking of contacts in the event of an outbreak.

> *From today, certain businesses in England are required by law to display NHS Test and Trace QR codes so customers with the NHS COVID-19 app can use them to check-in [DHSC, 24 September 2020]*

These policies assisted businesses and public venues in engaging with contact tracing, enhancing safety for all. The COVID-19 outbreak accelerated the adoption of cutting-edge technology in healthcare, potentially influencing future policy changes. The deployment of the NHS COVID-19 app in England and Wales initiated a shift in managing public health concerns, disease surveillance, and protecting personal information. Introducing such technology emphasises its vital role in supporting healthcare systems by improving service delivery and fostering safer practices. Insights gained from this tool will inform the broader application of technology in healthcare, ensuring that innovations are beneficial rather than problematic.

6.4.2. The Impact of Policy Changes on Public Health Strategies

The adaptations prompted by the NHS COVID-19 app have highlighted the critical role of digital tools in managing health crises and their potential to influence future public health policies. A notable improvement was the enhanced speed at which public health officials could respond. The app enabled them to rapidly identify potential exposures to the virus and implement swift measures to prevent its spread. This rapid response was crucial in controlling COVID-19, demonstrating that prompt action can significantly impact the management of health emergencies. Policymakers recognised the effectiveness of digital tools and decided to implement them more broadly in order to address emerging health threats quickly. The application provided real-time data, enabling healthcare professionals and public health authorities to make informed decisions. This was crucial for allocating resources, implementing effective measures to combat the virus, and staying proactive in crisis management. Newly established regulations mandated the inclusion of digital tools in public health strategies for immediate threat assessment and rapid response, contributing to long-term health improvements. A critical aspect of these regulations was the assurance of data privacy and security, increasing user confidence in the app and ensuring that their information

was safeguarded. Building trust in digital health tools leads to wider usage and is imperative for their success. Privacy protections demonstrate to the public that these tools are secure and reliable, enhancing their utility in managing health crises.

6.4.3. Challenges and Considerations

The NHS COVID-19 app introduced many benefits, yet it faced challenges that needed to be addressed in order to aid public health via digital technology. A significant hurdle was ensuring widespread and consistent use of the app. Vaughan Gething, who was the Welsh Minister for Health and Social Services during the pandemic, stated that the app's effectiveness depended on its widespread adoption:

> *The launch of the NHS COVID-19 app is an important part of Wales's coronavirus response, bolstering our Test, Trace, Protect programme. The more people who download and use this app, the more it will help us to prevent the spread of COVID-19* [DHSC, 24 Sept 2024*]*

Leaders implemented strategies to boost the app's usage, including informational campaigns, incentives, and addressing barriers to usage. The app also encountered technical issues, such as accurate Bluetooth tracking and battery life preservation, necessitating continuous improvements and fixes. Decision-makers recognised the importance of investing in research and enhancing digital health tools to ensure their reliability and effectiveness, particularly for public health crises. Equally crucial was the collection of necessary data without infringing on privacy. Keeping data current is essential for public health management, and it is equally important to ensure that this data is collected and utilised to safeguard privacy. New regulations were established to balance maximising the benefits of digital health tools and protecting personal information.

The introduction of the NHS COVID-19 app modernised the use of digital tools in managing health emergencies. It simplified technology integration into our healthcare system, enhancing our preparedness for health crises. The app's automated contact tracing and real-time updates demonstrated the significant role of digital tools in supporting public health initiatives. These advancements made protecting personal health information paramount, leading to improved incorporation and utilisation of current information in health emergency responses. The NHS COVID-19 app and its policy reforms exemplify the transformative potential of digital health tools in public health crisis management. Incorporating technology into our health strategies can enhance our

healthcare system's readiness and response to health issues, ultimately contributing to better overall health and a stronger framework for future health crisis management. This discussion highlights that the app's success was heavily reliant on public participation, suggesting that the concept of sociotechnical offers further avenues for investigation.

6.4.4. Sociotechnical Implications: How Technological Tools Drive Regulatory Changes and Broader Adoption

The NHS COVID-19 app can be a valuable lesson in the role of technology in public health. It illustrates a transformation in healthcare practices and significant regulatory changes, encouraging wider adoption of technology for health maintenance.

The rollout of the NHS COVID-19 app highlighted the need for new regulations to maximise the benefits of health technology within national healthcare strategies. The app's introduction underscored the necessity of collaborative efforts to integrate technology into healthcare effectively. New policies facilitated the incorporation of such tools into our healthcare framework. For instance, the app's ability to trace contacts and promptly alert individuals to potential exposure demonstrated the value of technology in managing health risks. Consequently, this spurred interest among leaders to embed technology in healthcare, recognising its vital role in disease control. A significant policy shift focused on safeguarding data privacy and security. The effectiveness of the NHS COVID-19 app hinged on public trust, necessitating stringent data protection measures. Updated regulations guaranteed that the app monitored the spread of the virus, not individuals, and protected personal information. This assurance contributed to the app's acceptance and could pave the way for future health technologies.

Additionally, the app prompted the enhancement of protocols for emergency preparedness. Healthcare professionals and authorities could identify patterns and respond swiftly to outbreaks by leveraging timely data on symptoms and transmission. Improved regulations bolstered our surveillance systems, enabling quick data collection and analysis. These initiatives aimed to streamline our healthcare system's response to health crises, ultimately promoting better public health.

The NHS COVID-19 app's rule changes significantly accelerated the public health response. The app's contact tracing and immediate alerts simplified identifying potential virus exposure, enabling rapid intervention to halt its transmission. This prompt response was crucial in managing COVID-19, highlighting the importance of quick reactions in health crises. Leaders recognised the value of these tools and incorporated them into

public health strategies. Digital methods providing instant updates empowered public health teams to respond more swiftly to emerging health threats. Based as it was on the most recent data, the NHS COVID-19 app's timely information facilitated informed decision-making by healthcare and public health professionals. Utilising data-driven decision-making was essential for allocating resources effectively, making informed assistance decisions, and preparing for potential health issues. New regulations ensured that digital health tools capable of immediate data collection and analysis could become integral to public health policies. These regulations aimed to enhance our public health system's ability to monitor and address health threats through precise, current information, ultimately improving overall health outcomes. Guaranteeing data privacy with the NHS COVID-19 app was also crucial. Leaders fostered trust in digital health tools by addressing concerns about excessive surveillance or data misuse. This trust encouraged broader app adoption and regular use. Public trust is imperative for the success of any health initiative. The new data protection regulations have become a benchmark for future digital health tools. Prioritising privacy and security, these regulations are pivotal in building confidence in digital health solutions' efficacy for managing health crises.

Encouraging widespread use of the app was a significant challenge. The app's effectiveness depends on its continuous use by many people. The team considered various strategies to increase usage, such as widespread promotion and incentives, and resolved any issues that might deter usage. Upon the rollout of the NHS COVID-19 app, they encountered operational problems, including Bluetooth contact tracing accuracy and excessive battery consumption. Continuous improvement and problem resolution were necessary for the app's proper function. The leadership recognised the need for ongoing investment in these health technologies to ensure their efficacy in health crises.

Moreover, it was crucial to collect extensive data while safeguarding user privacy. The careful handling of personal information was essential for effective health management. Therefore, protocols were established for collecting, storing and utilising user data, balancing privacy protection with the advantages of digital health tools in managing health emergencies.

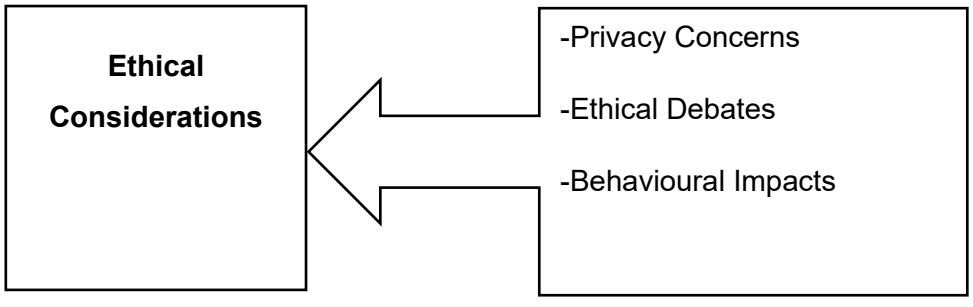
The deployment of the NHS COVID-19 app shows that technology like this can change the rules to help more people use it effectively. The idea that technology and how we work together affect each other is essential here. For example, when healthcare providers started using the NHS COVID-19 app, they had to change how they did things. They gave feedback, leading to updates and making the app better. This shows that the

way in which people use technology can help to shape its future. At the same time, the app changed how healthcare worked by making it easier to find and respond to possible exposures to the virus. This made it necessary to update how things were done, showing how technology and everyday practices influence each other. Strong data privacy and security rules ensured that people trusted the app. By dealing with worries about surveillance and data misuse, these rules made people feel more comfortable using the app. Trust in digital health technology is crucial. When people have confidence in these tools, they are more likely to utilise them, enhancing their effectiveness in managing health crises. The app enabled health professionals to identify trends and swiftly intervene to halt outbreaks. This capability improved policies for addressing public health dangers, integrating the rapid collection and analysis of data into the national healthcare system. These measures aimed at enabling healthcare providers to promptly identify and respond to health threats, thereby improving public health. Using the NHS COVID-19 app resulted in policy shifts that underscored the importance of digital tools in managing health emergencies, cementing the role of digital health technology in public health preparedness and response.

The app utilised technology to monitor who fell ill and the pattern of the disease's spread, highlighting the crucial role of digital tools in maintaining our health. The introduction of the app led to new regulations for safeguarding health information, enhancing the use of technology in healthcare, and the importance of having current information during a health crisis. Deploying the app and adapting regulations brought substantial benefits, though it was challenging as it required ensuring widespread app usage, resolving technical problems, and collecting vital health data without breaching privacy. The NHS COVID-19 app and its associated new regulations demonstrate how technology can positively transform our management of health emergencies. By intelligently integrating technology into our healthcare strategies, we can improve hospitals' and doctors' efficiency in combating illnesses, boost overall health, and prepare for future health challenges.

6.5. Ethical Considerations

Figure 15.Thematic Map 4



The rollout of the NHS COVID-19 app during the pandemic represented a significant advancement in the use of digital tools for public health management, simplifying the tracking of cases and allocating resources. However, it also raised substantial ethical concerns about privacy and the acceptability of data usage. Examining the situation reveals these issues and how modifications to public health regulations in response to these apprehensions have fostered greater trust and adoption of digital health tools.

The launch of the NHS COVID-19 app highlighted crucial issues such as safeguarding personal information and obtaining consent for data usage. Balancing the app's role in curbing the virus spread while preserving user privacy was challenging. The app had to gather sufficient data to be effective without compromising privacy. To address these concerns, the government health agencies emphasised the significance of people's privacy and assured the public that the app protects privacy:

> *The app tracks the virus, not people, utilising the latest in data security technology to protect privacy [NHS Test and Trace, Sept 2024].*

Ensuring the safety of people's information was crucial for gaining their trust and encouraging widespread app usage. Despite assurances of privacy protection, concerns about surveillance and data misuse persisted. The app's administrators implemented stringent rules to safeguard user information and alleviate these fears. These regulations were strict about data collection, storage and utilisation; for instance, the app was designed to ensure that collected information could not be traced back to individuals, and rigorous controls were in place to prevent data abuse. These rules mandated transparency with users about the types of data collected and how it was used. Users were required to give informed consent before their data could be utilised, guaranteeing their understanding of the app's functions and their rights regarding their information. Maintaining user trust was essential for the app's effectiveness. The detailed discussions on data privacy and the necessity for user consent highlighted the significance of openness and accountability when launching digital health tools. Addressing these concerns with strict regulations made users feel secure, thus fostering the app's adoption. The app's commitment to information security and the assurances provided by the rules reduced fears of surveillance and data misuse. Establishing a trustworthy relationship between the technology and its users was imperative for encouraging active

engagement and adherence to the app's recommendations, enhancing its role in managing the pandemic.

The discourse on ethics and policy has underscored the importance of integrating digital health technology into our national healthcare strategies. The app's efficiency in improving public health responses shows the potential of digital tools to enhance health outcomes. So, public health authorities are working on making digital health technology a big part of the medical world. They are looking to pump money into digital systems, teach healthcare workers how to use digital gadgets better and encourage everyone to develop and use new health technology. These steps are expected to make digital tools a key player in making our health strategies work better and more smoothly. Also, the introduction of the NHS COVID-19 app has raised the bar for keeping data safe and private. It promises to look after everyone's personal information while ensuring that digital tools can do their job in public health. These benchmarks require data anonymisation, strict data management practices, and regular checks to ensure compliance. These efforts are designed to strengthen public trust in digital health technologies by assuring the ethical handling and application of users' data. The real-time analytics of the NHS COVID-19 app empower health professionals and public health authorities to track trends and rapidly react to potential outbreak risks. This has prompted the formulation of policies to enhance preparedness for public health exigencies, integrating immediate data collection and analysis into the national health infrastructure. The objective is to improve readiness for public health challenges and to ensure that health systems are better equipped to manage future health crises.

6.5.1 Impact on Public Health Strategies

The NHS COVID-19 app's integration into health policy accelerated the management of public health crises. It enabled the swift identification of individuals at risk of exposure and facilitated immediate measures to prevent further transmission. This rapid action proved crucial in combating COVID-19, highlighting the significance of prompt responses during health emergencies. Incorporating digital tools that provide real-time updates and data allowed health systems to respond more quickly to emerging threats. Consequently, decision-makers had the tools to make informed choices and implement effective strategies to safeguard public health.

Additionally, the app simplified decision-making processes by offering current information, enabling health professionals and authorities to base their actions on live data. This is vital for efficiently allocating resources, strategising containment measures, and maintaining a proactive stance. New regulations ensured that immediate data

collection and analysis tools were central to health strategies, aiming to enhance public health systems' capacity to monitor and respond to threats with the latest information, promoting overall health. The emphasis on data security and privacy was a significant aspect of these changes. When individuals felt confident about the safety of their information, they were more inclined to utilise the app and adhere to health guidelines. Trust is crucial for the success of any health initiative, and establishing regulations that safeguard our data serves as a benchmark for all digital health tools. Concentrating on protecting our data guarantees that these digital instruments will gain trust and usage, enhancing their efficacy in managing health crises.

6.5.2 Challenges and Considerations

One significant challenge in ensuring the NHS COVID-19 app's effectiveness was achieving widespread adoption. Despite the app's safety features and compliance with regulations, continuous communication about its functionality and benefits was crucial. Educating everyone on using digital tools like this app was critical to its success. Post-launch, the app faced issues such as inconsistent detection of nearby phones and variable performance across different devices. The developers had to persistently refine and verify the app's functionality to address these issues. Implementing policies that supported exploring new technological solutions for health was vital in overcoming these obstacles.

Another critical consideration was collecting necessary data without compromising user privacy. It was imperative to use the data solely for public health purposes. Establishing policies for transparency with users, obtaining their consent for data usage, and conducting regular oversight were strategies that helped to maintain trust. The deployment of this app during the pandemic necessitated adaptive regulations, demonstrating the potential of digital tools in managing health crises. These adaptations facilitated technology integration in healthcare, enhancing the system's readiness and response capabilities for future health emergencies. The debate on data privacy and consent for the use of personal information highlighted the necessity for stringent regulations and the new guidelines emerging from these discussions were crucial in building trust in the app and encouraging its use. The NHS COVID-19 app demonstrated the potential of digital tools to streamline processes, support fact-based decision-making and enhance collaboration, contributing to improved public health outcomes. The policy shifts that it initiated underscored the significance of integrating digital technology into public health strategies. Moreover, it emphasised the need for continuous enhancement and education on using these tools to maximise their benefits.

The NHS COVID-19 app has provided valuable insights for the future use of digital health tools. It demonstrates that prioritising protecting personal information, ensuring user willingness, and addressing technical issues enables digital tools to enhance our response to health crises more efficiently. The principle that the app maintains simplicity by not requesting a user's name, residence or birth date, and only requires the initial part of the user's postcode, assists in addressing local health concerns without disclosing users' personal information to the government or NHS. This approach illustrates the potential to safeguard personal data while improving public health for all, setting a precedent for future digital health initiatives.

6.5.3 Sociotechnical Perspective: Balancing Ethical Concerns in Digital Health Interventions

The launch of the NHS COVID-19 app raised significant privacy concerns and questioned public comfort with data handling. This scrutiny reveals the deep connection between technology development and societal values. Ensuring the security of personal information is crucial for the sustained adoption of health technology.

The primary concern with the NHS COVID-19 app was the safety of personal information. Users were apprehensive about their data being collected, stored and potentially used by others. The developers designed the app to monitor the spread of the disease, not individuals, which was crucial in gaining user trust and widespread adoption. It was stated that "The app monitors the disease, not people, and employs advanced technology to protect information". Transparency regarding the use of personal data was also vital. Users needed to understand what data was being collected and why. Providing clear, understandable information about the app's data usage was essential to ensure user comfort with the app. This transparency alleviated concerns about surveillance or misuse of information, fostering trust between the app and its users. To safeguard data, strict protocols were in place. These protocols ensured that data was collected, stored, and used carefully, maintaining anonymity and robust security against misuse. These protocols were instrumental in maintaining user trust and ensuring the app's proper use.

The NHS COVID-19 app has profoundly transformed healthcare systems, incorporating advanced technological features such as rapid contact tracing and exposure notifications. These innovations have streamlined healthcare operations, necessitating adjustments in healthcare workers' routines to integrate these digital tools. This interplay between technology and operational methods is evident. The app enhances the speed and precision of identifying potential COVID-19 exposures through Bluetooth

technology, simplifying the process for healthcare professionals and enabling more direct patient care. Additionally, the app monitors reported symptoms, providing invaluable data for healthcare workers and authorities to effectively identify trends and allocate resources. Early detection of potential outbreaks through the app allows for a more efficient and prompt response to health crises.

6.5.4 Changes in Policies and Health Strategies

The app's impact led to numerous discussions about establishing rules for using technology in healthcare. These talks culminated in new policies promoting increased use of digital tools in healthcare settings. Additionally, new regulations were implemented to protect personal information, ensuring that data collected by the app remained anonymous, was managed with care, and underwent regular checks for accuracy and compliance. Strengthening these privacy regulations bolstered public trust and comfort in using the app. Moreover, the app's data contributed to developing new policies and preparing the nation for potential health crises. Public health authorities were now better equipped to swiftly identify and respond to health threats, thanks to integrating rapid health data analysis into the healthcare system. This underscores the significance of digital tools like the COVID-19 app in enhancing the speed and efficiency of healthcare responses.

In summary, using an app accelerated the identification of potential exposure to the virus and facilitated prompt action to prevent its spread. Such measures were critical in controlling the spread of COVID-19, underscoring the importance of swift action in health emergencies. The app provided timely information, enabling doctors and health officials to make informed decisions. This approach was crucial for efficiently allocating resources, targeting specific issues, and preventing health crises. Guaranteeing the app's privacy and security was critical to gaining public trust. By addressing concerns over surveillance and data misuse, the app increased the public's willingness to engage with digital health tools, which is vital for effectiveness.

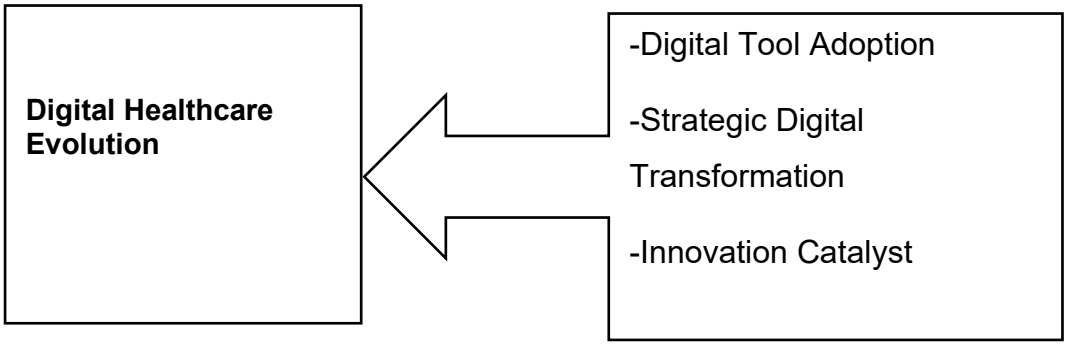
Ensuring widespread adoption of the app required continuous education and engagement of the public. Individuals need to comprehend the app's usage and its advantages. The app needed to determine the proximity of individuals using Bluetooth precisely. Consistent resolution of technical issues was necessary for the optimal performance of the app. Moreover, it was imperative to meticulously gather data and ensure its use solely for public health protection. Transparency, user consent, and regular audits were vital in balancing data collection with privacy preservation. The deployment of the NHS COVID-19 app raised essential concerns among the public

regarding data privacy and user consent. Addressing these concerns through stringent regulations was necessary for gaining public trust in the app. The app's application in healthcare thus illustrates the interplay between technology and society. Initiatives to address ethical dilemmas and promote the adoption of digital health tools have led to innovative approaches to health strategies. Concentrating on privacy, user expansion and technological troubleshooting enables health systems to utilise digital tools more effectively for future health crises.

In essence, evaluating the ethical implications of adopting new technology for health is crucial. The NHS COVID-19 app is a prime illustration of this principle in action. It demonstrates that digital health tools can be instrumental in maintaining our health while safeguarding our privacy. The app is precisely engineered to track the virus rather than individuals, employing innovative and secure methods to protect personal information while combating the virus's transmission.

6.6. Digital Healthcare Evolution

Figure 16.Thematic Map 5



The rollout of the NHS COVID-19 app has catalysed significant advancements in digital health technology, providing a blueprint for future digital health initiatives and accelerating the adoption of digital tools across the healthcare sector [NHS Test and Trace, 2024].

The NHS COVID-19 app, developed during the pandemic, has in essence revolutionised our perception of digital healthcare. The app's introduction has spurred a significant shift towards the increased use of digital tools in healthcare. In England and Wales, medical professionals now utilise online tools such as telemedicine to monitor patients' health remotely. This shift became more pronounced during the pandemic as efforts to maintain health intensified, and the NHS COVID-19 app played a significant role in accelerating the transition towards digital healthcare solutions. This evolution promises to enhance

the strength and efficiency of future health services. An examination of the app reveals its pioneering role in advancing new digital health concepts. A notable feature of the app was its ability to quickly and efficiently track exposure to COVID-19 through Bluetooth technology, enabling individuals close to an infected person to be promptly informed. It facilitated greater accessibility for healthcare professionals and demonstrated the substantial impact that digital tools can have on disease management. The effectiveness of these tools in public health has been demonstrated. Additionally, the app was crucial in issuing swift alerts to those potentially exposed to the virus, allowing them to isolate and seek testing more quickly. Such prompt measures were instrumental in curbing the spread of the virus. The success of these rapid notifications underscores the potential of digital tools to enhance public health initiatives more effectively.

The NHS COVID-19 app represented a significant advancement over previous methods by allowing individuals to report their symptoms in real time. This data was aggregated to identify common symptoms across different regions. Health professionals and public health monitors found this instantaneous information valuable for detecting trends and making informed decisions. The app's efficiency in processing information underscored the importance of rapid updates during a health emergency. With the data provided by the app, healthcare providers could determine where to allocate additional resources, such as tests and medical personnel, especially if a surge in illness was reported in a specific area. This targeted response ensured the judicious use of resources, and the ability to make decisions based on up-to-date information affirmed the effectiveness of digital tools in enhancing healthcare services.

The introduction of the NHS COVID-19 app initiated significant changes in policymaking, positioning digital tools as vital in addressing public health issues. The government established regulations to enhance the use of these digital health tools, prioritising the protection and proper handling of personal information. This set the stage for the future integration of digital tools in healthcare, underscoring the necessity of appropriate policies to support technological advancements. The success of the NHS COVID-19 app was primarily attributed to public trust. The NHS COVID-19 app Support Team made reassuring statements, such as:

> *Experts from across the UK government and industry have reviewed our design and helped us test and improve the app. Specialists from the National Cyber Security Centre are involved to make sure it is safe and secure to use. Apple and Google have also done a privacy review [NHS COVID-19 app Support, 24 September 2024]*

Its developers have been committed to safeguarding user privacy, securing personal

data, and addressing surveillance and data misuse concerns. The app emphasised its role in monitoring the virus rather than individuals, which increased user comfort and adoption. Trust-building was essential, not merely as an app improvement but as a fundamental aspect of encouraging widespread usage. This experience highlighted the critical importance of gaining public trust for the success of new health technologies.

The NHS COVID-19 app demonstrated the transformative potential of new technology in healthcare management. Its success highlighted the benefits of automatic data collection, real-time analysis, and user-centric design. Future health initiatives can build upon the app's achievements to develop superior digital tools. The app's adoption underscores the significance of integrating technology to enhance healthcare services. Upon its release, the NHS COVID-19 app sparked discussions on ethical considerations, particularly protecting personal data and consent. Ensuring data security while maintaining effective contact tracing was crucial; the app employed cutting-edge security technology and maintained transparency in data usage, setting a precedent for future health applications. It exemplified the need to prioritise ethics and privacy in order to earn public trust and encourage widespread app utilisation. As noted:

> *The app tracks the virus, not people, utilising the latest in data security technology to protect privacy [DHSC, 24 Sep, 2020].*

The NHS COVID-19 app has significantly impacted healthcare and has continually improved through feedback from users and medical professionals. The evolution and enhancement of digital health tools are crucial for their success. Continuously soliciting user feedback is vital for the future, ensuring that these technologies will advance and align with the requirements of both doctors and patients. The app's responsiveness to input highlights the ongoing necessity to refine digital health services.

The NHS COVID-19 app has proven to be a valuable asset in public health. It provides current information, enabling health workers and public health teams to make informed decisions. Observing the latest trends and patterns, they can quickly identify where to effectively direct their efforts and address health issues. The app demonstrates the efficacy of digital tools in enhancing the speed and precision of public health responses, serving as a model for future actions. Data from the app has informed the development of new policies to anticipate public health requirements. Continuous data collection and analysis allow public health systems to identify and respond to health threats promptly. The app's success underscores the significance of immediate data access during health emergencies, highlighting the necessity for robust digital infrastructures. Additionally, the app has facilitated better collaboration among healthcare teams by simplifying

information sharing, leading to a coordinated approach to managing the pandemic. It underscores the importance of unity in public health strategies and illustrates how digital tools can unite various stakeholders to tackle health challenges effectively.

6.6.1. Challenges and Considerations

Educating the public about the benefits of digital health devices is crucial to encouraging regular use. Ensuring that everyone understands digital technology and its advantages can be highly beneficial. The NHS COVID-19 app demonstrated that such technology can be effective when users are engaged and enthusiastic. However, digital health tools sometimes face challenges, such as when using Bluetooth to gauge proximity. Ongoing improvements and problem-solving are necessary to maintain their usefulness. The NHS COVID-19 app's enhancements, driven by user feedback, underscore the importance of addressing issues to retain the tool's efficacy.

Moreover, handling health data collection with care and respect for privacy is vital. Clear guidelines are needed to ensure that data is used appropriately and solely for health maintenance. When users are confident that their information is secure, they are more inclined to trust and use digital tools. The NHS COVID-19 app can advance the integration of digital technology in healthcare. It has streamlined operations, facilitated data-driven intelligent decision-making, and promoted collaboration. The app demonstrates how digital tools can transform public health management by addressing ethical concerns, engaging a broad user base, and continuously seeking enhancements. As healthcare evolves, insights gained from the NHS COVID-19 app can guide the incorporation of more digital technology into healthcare systems. Concentrating on building trust, judiciously applying new technology, and addressing challenges can enhance the utility of digital health tools for health improvement and readiness for public health emergencies. The app offers a glimpse into the potential of digital tools to support and enhance healthcare during crises. As noted, the deployment of the NHS COVID-19 app spurred significant progress in digital health technology, setting a standard for future digital health endeavours and expediting the integration of digital tools within the healthcare industry.

6.6.2 Sociotechnical Integration: The Role of the NHS COVID-19 app in Digital Healthcare Transformation

The shift towards employing apps and digital tools represents a notable enhancement in managing health crises with real-time data. The NHS COVID-19 app demonstrated the integration of new technology into our daily lives, transforming healthcare systems. The

app has played a significant role in digital healthcare and in reshaping healthcare practices and regulations.

Receiving immediate notifications from the app about potential exposure to the virus was transformative; it allowed at-risk individuals to isolate and seek testing swiftly. This rapid notification system also enabled public health teams to respond quickly, further preventing the spread of the virus. The app's effectiveness in delivering instant alerts demonstrated how digital tools can expedite and improve public health measures. Its ability to rapidly collect and analyse extensive data offered a comprehensive view of symptom patterns across different regions. This information was crucial for healthcare providers and public health authorities, aiding them in identifying potential hotspots and making informed decisions.

The introduction of the NHS COVID-19 app necessitated significant changes in the working practices of health professionals. They were required to acquire new digital skills to utilise the app's features effectively. This was crucial for leveraging the app to make informed decisions with the latest information. The app's inception led to the establishment of new guidelines, underscoring the importance of digital tools in managing public health issues. These guidelines facilitated the integration of more digital health technologies into primary healthcare strategies, simplifying access for a broader user base. They also guaranteed the safety and privacy of these digital solutions, setting the stage for future technological advancements in healthcare and the necessary regulations for innovation.

Moreover, the app enhanced collaboration among various health organisations, enabling seamless information sharing and improving the synergy between hospitals, public health entities and other healthcare providers. Such collaboration ensured efficient resource utilisation and the effective implementation of public health initiatives. The app demonstrated the critical role of unity in healthcare strategies, illustrating how digital tools can unite different entities in addressing health emergencies.

The NHS COVID-19 app was implemented amid extensive discussions on safeguarding user information and securing consent for data usage. Protecting user privacy was essential for the efficacy of the app's contact tracing feature. Utilising the latest security technology, the app maintained transparency in data usage, which was pivotal in retaining public trust, and this trust was a significant factor in the widespread adoption of the app and engagement with it. The emphasis on data security and privacy alleviated concerns about surveillance or misuse of information. This approach was not merely a feature but a core strategy to sustain high levels of trust, serving as a benchmark for

future health technologies and highlighting the importance of trust in adopting new tools.

6.6.3. The Broader Impact on Digital Health

The NHS COVID-19 app represents an advancement in online health services, demonstrating the potential of technology to enhance healthcare by automatically collecting data, analysing it in real time, and prioritising user needs. The Royal College of General Practitioners has emphasised this:

> *The effective use of information and digital technologies is a key enabler in delivering health and social care now and in the future [RCGP, 2021]*

A report by the Royal College of General Practitioners emphasised the benefits of leveraging technology for doctor appointments, making healthcare more accessible and efficient. The NHS COVID-19 app demonstrated the feasibility of managing numerous health-related tasks online, marking a significant step towards broader adoption of online health services. According to the RCGP, information and digital tools have become crucial in health and social care and will continue to grow in importance, complementing Mr. Matt Hancock's statement that:

> *There is no going back on these improvements, and it's not just the front-end patient-facing services that have been transformed, it's the digital back-end too*.

The NHS COVID-19 app has been instrumental in addressing the health crisis during the pandemic, initiating a significant shift in healthcare delivery by normalizing remote consultations with doctors and nurses. This transition highlighted the advantages and challenges of integrating technology in healthcare. Moving forward, it is vital to continue embracing digital solutions to enhance healthcare, ensure its accessibility, and prioritize patient needs. Preparing for future health emergencies and adapting to diverse patient requirements are also crucial insights gained, and the digital infrastructure established due to the app is set to significantly influence the future of healthcare in England and Wales.

This success lays the groundwork for the development of superior digital health tools such as telemedicine and remote consultation. The app provides doctors and healthcare workers with continuous updates from its users, leading to its iterative improvement. Future digital health initiatives should continue engaging with user feedback to refine these technologies, aiding professionals and patients. The app's evolution through user input underscores the importance of regular updates in digital health.

Moreover, the app has highlighted the importance of utilising real-time data, enabling

health experts to make swift, informed decisions. This has been crucial in allocating resources effectively, planning targeted actions, and preparing for health crises. The app has established a new standard for employing digital tools to tackle health challenges more efficiently.

6.6.4 Challenges

Continuous education and engagement are essential to the success of digital health tools. Everyone must understand the benefits and usage of these tools. The NHS COVID-19 app demonstrated the importance of user involvement for achieving broad adoption and effective digital solutions.

Addressing Bluetooth accuracy issues is vital for the reliability and usefulness of digital health devices. Keeping these devices updated is crucial for their optimal functioning. The NHS COVID-19 app's enhancements resulting from user feedback highlight the importance of resolving technological issues for sustained success. It is paramount for digital health devices to gather information securely and uphold privacy. Trust is fostered when data is seen to be exclusively used for health purposes. Establishing transparent policies, seeking user consent, and conducting regular checks can guarantee the effective operation of these tools while safeguarding privacy. The NHS COVID-19 app can be said to have advanced digital healthcare by demonstrating the transformative potential of such tools. It has streamlined processes, informed decisions with data, and promoted collaboration. Its success has depended on prioritising privacy, ethics, user engagement, and continuous improvement to maximise digital health benefits. As healthcare evolves, insights from the NHS COVID-19 app will guide better utilisation of digital health in the future. Trust is essential, as is adopting new technology to address challenges. This approach will aid healthcare professionals and enable policymakers to leverage digital tools for improved health outcomes and emergency preparedness. The NHS COVID-19 app exemplifies how digital tools can assist in health crises and enhance healthcare delivery.

6.7 Analysis from Sociotechnical Perspectives

This chapter contains an analysis of how well the NHS COVID-19 app functioned. The study underscores the necessity of combining technological innovations with societal conditions. The app's performance is examined through a sociotechnical lens, highlighting that while technical capabilities are essential, they must align with institutional frameworks, public trust, and healthcare requirements. A thorough comprehension of both social dynamics and technological mechanisms is vital for the

effective rollout of digital health initiatives, especially within the intricate landscape of public health (Hoch et al., 1987; Samuel and Sims, 2023).

Systems Theory: Integration into Healthcare Infrastructure and Policy

Application of Systems Theory supports the notion that successful implementation occurs as part of a more extensive system that incorporates policy choices and healthcare service delivery (Bertalanffy, 1969; Greenhalgh et al., 2005). The NHS COVID-19 app was noteworthy because it could be used to swiftly identify potential virus hotspots and to alert those who had been exposed, thus aiding in controlling the spread of the virus. This finding validates the use of digitisation tools in public health crises. Furthermore, the incorporation of the app into existing healthcare procedures boosted operational efficiency by utilising digital contact tracing, and this issue illustrates the close relationship between technology and healthcare delivery systems.

The app aided data usage and accessibility, enhanced resource allocation, and evolved traditionally manual methods within a digitally connected context. It demonstrated how advances in digital infrastructure could be used to tackle systemic challenges and promote improved healthcare results. These advances would also facilitate the management of degenerative diseases through the use of data science and geospatial analytics (Kamel Boulos et al., 2018).

Actor-Network Theory: Stakeholder Dynamics and User Adoption

The application of ANT indicates that the creation and acceptance of the NHS COVID-19 app reveal the interactions among essential stakeholders, such as government organisations, service providers, technology vendors, and the public. ANT visualises the interconnectedness of policy regulations, societal trust, and infrastructural limitations, and it illustrates how these elements influence the outcomes and efficiencies of technological implementations (Booth et al., 2016; Troshani and Wickramasinghe, 2014).

The incorporation of Bluetooth-enabled proximity-tracking features into the app marked significant progress in contemporary healthcare, but it brought attention to critical considerations regarding privacy and confidentiality. This necessitated a balanced approach to meet society's needs while ensuring that technological capabilities complied with governance and legal standards. The overall reception of the app and its effect on public trust underscore the significance of stakeholder involvement and communication during the transition to digital health solutions.

Structuration Theory: Measuring Success and Engagement

Structuration Theory can be used to examine the elements that affect an app's effectiveness, such as user adoption, technological innovations, and policy changes (Ali et al., 2023). The theory implies that for digital tools to succeed, they must garner considerable and sustained user acceptance. The example of the NHS COVID-19 app demonstrates that mere technical precision is insufficient; user trust, comprehension, and active involvement are essential factors. Continuous iterations based on user insights and shifts in policy highlight the need for constant evaluations and flexible knowledge in health-oriented technological solutions.

Sociomateriality: Importance of Trust Within Digital Healthcare Management

A sociotechnical perspective underscores the importance of understanding Sociomateriality to comprehend adherence to electronic healthcare solutions (Orlikowski, 2010). This concept highlights the relationship between user trust in e-health tools and the foundational technological and regulatory structures. The NHS COVID-19 app exemplifies the need for a balance between surveillance to track diseases and concerns regarding privacy and ethical data handling. Centralised initiatives such as DPIAs promote stakeholder transparency and cooperation, improving customer-focused processes and experiences.

6.7.1 Technological and Social Factors in Digital Health

From a sociotechnical perspective, technological solutions function within social environments. The NHS COVID-19 app played a crucial role in advancing digital health strategies that incorporated advanced technology into healthcare initiatives, which were widely accepted and performed well.

During the app's development, accessibility and usability were paramount, as they would facilitate broad adoption. Assistance was provided through resources such as internet-enabled help desks, instructional materials and adaptive hotlines. These initiatives were part of deployment strategies that were designed to be inclusive and tailored to meet varying customer needs and levels of literacy. Collaborative efforts in patient engagement are vital to advance comprehensive health practices, resource provision, and community-focused preventive strategies, which ultimately enhance the well-being of populations. Healthcare systems can be positively transformed through efforts to detect disease early and prevent it, and through the fostering of an atmosphere of ethical,

responsible, and impactful contributions to societal health outcomes (Minkkinen et al., 2023; Ranisch et al., 2021).

6.8 Chapter Conclusion

Chapter 6 describes a comprehensive examination of the NHS COVID-19 app's function during the pandemic and its influence on digital health innovation within England and Wales. The analysis reveals that the use of the app improved public healthcare practices by enhancing contact tracing abilities through Bluetooth notifications and symptom monitoring. These features aided the isolation process and played a key role in effective infection control. The data reviewed indicates that the app significantly contributed to reducing the transmission of COVID-19. Some reports even suggest that it prevented approximately 600,000 cases between September and December 2020 (NHS Transformation Directorate, 2021).

The NHS COVID-19 app was crucial in merging digital health solutions with broader healthcare frameworks. Its introduction resulted in substantial changes to case management strategies and resource allocation. The app's real-time data was an essential resource for health officials that enabled prompt identification and strategic management of outbreaks. This integration was vital to alleviate pressure on healthcare resources during the crisis.

Chapter 6 further explores the intricacies of sociotechnical relationships, focusing on the interplay between technology and social elements. Trust from the public is identified as a critical element that affected the app's uptake. This trust was linked primarily to concerns regarding personal privacy and the ethical considerations surrounding user attitudes toward such apps. Transparent protocols for data protection and ethical data usage are highlighted as essential for sustaining an active user community. This finding signifies the necessity to balance technological progress with societal acceptance.

Additionally, the policy implications that resulted from the launch of the app point to potential advancements in regulations within the digital health sector. These advances encompass cybersecurity measures and a heightened attention on customer-focused interactions. These elements are identified as key factors that should shape future health technology initiatives. Nonetheless, issues such as the pandemic underline the importance of continuing improvements both in technical issues and public awareness to ensure continuous usage and effectiveness of these models.

The NHS COVID-19 app illustrates how the introduction of digital technology can change healthcare delivery, particularly in times of crisis. The effective incorporation of the app

into the broad public health strategies in England and Wales emphasises the need to align technological and sociocultural factors. The chapter emphasises the importance of developing technological solutions that take into account societal values and ethical standards. The insights could guide future digital health strategies, which should focus on flexibility, audience-centred design, and the employment of collaborative governance in response to emergency healthcare situations.

CHAPTER 7: DISCUSSION

7.1. Introduction

As indicated earlier, digital health tools became more prominent during the public crisis that was caused by the global COVID-19 pandemic. Tools such as the NHS COVID-19 app leveraged mobile technology to inform users about exposure risks and, therefore, aid efforts to mitigate virus spread. This review examines how the app was developed and implemented during a crisis, emphasising promotional strategies and its integration with existing healthcare infrastructure. While this discussion is focused on digital adoption during emergencies, through this case study, it is crucial to avoid sweeping generalisations about similar technologies (Yin, 2014). It is essential to be aware of the specific challenges and opportunities in these contexts in order to comprehend electronic adoption in emergencies, as illustrated by the analysis of the NHS COVID-19 app.

This investigation covers the interaction between technological and policy factors that are consistently shaped by user behaviour (Chauvin and Rispel, 2016). The discussion utilises the ANT, Systems Theory and Structuration Theory to gain insights into the complexities that are related to materiality, trust dynamics, and society's perceptions of privacy. Achievement of equilibrium in this context necessitates flexibility while nurturing sociocultural connections that affect institutional practices (Chauvin and Rispel, 2016; Elmer et al., 2020). This approach is vital for effective digitisation in emergencies, especially at the crossroads of theoretical insights and practical applications.

Consequently, a systematic approach is employed to ensure that each finding is coherently linked, aiming to produce actionable insights (Creswell and Poth, 2016). This method emphasises understanding and analysis rather than extensive theoretical exploration; it is focused on pertinent knowledge that is derived from practical experiences. The analysis is limited to the scope of the case study, but it highlights the subtleties of digital health acceptance during emergencies (Yin, 2018). It aims to present an objective perspective on related crises and the implications for digital health tools in scenarios that demand immediate public health reactions.

7.2 Linking Findings to the Research Questions

7.2.1 Mobilisation of the NHS COVID-19 App

The introduction of the NHS COVID-19 app underscored the relationships among technological advancement, institutional governance, and community engagement. The

app's creation and rollout were propelled by the pressing needs that resulted from the pandemic and that necessitated cooperation among government entities, healthcare organisations, and tech companies. Analysis of the implementation process can be accomplished effectively through the application of ANT, Systems Theory and Structuration Theory, which offer insights into the dynamics among stakeholders, integration within established health frameworks, and the development of official-public interactions.

Understanding Stakeholder Interactions Through ANT

Employing ANT to investigate the stakeholders involved in launching the NHS COVID-19 app highlights their interconnected roles and objectives, which shaped the app's design and execution stages.

Government agencies, such as the Department of Health and Social Care and organisations such as NHX, played crucial roles in overseeing data governance and establishing communication pathways that enhanced transparency and built public trust. Moreover, assistance from technology firms, especially Apple and Google, was vital to create the Exposure Notification Framework, which established new benchmarks for compatibility across different mobile devices while addressing privacy concerns.

Care organisations, the most common being the NHS and Public Health England, collaborated to align virus tracing and isolation protocol efforts at the national level. This teamwork enabled smooth integration and strong community involvement, which led to favourable outcomes (University of Oxford, 2023; Wymant et al., 2021). Initial stakeholder engagement followed a unified strategy to balance challenges and foster progress, resulting in regulatory solutions that prioritised the building of trust among community groups. The application of the ANT framework offers a perspective from which to comprehend the complexities of stakeholder collaborations during the app’s development. It illustrates the equilibrium among technological capabilities, policy adherence, and initiatives to enhance public confidence (Frimpong et al., 2022).

Systems Theory: Embedding the App into Public Health Infrastructure

Examination of the NHS COVID-19 app through the lens of Systems Theory demonstrates that it was not merely an isolated technological solution. Instead, its effectiveness hinged on integration within broad public health frameworks, which encompassed testing initiatives and the formulation of related policies.

Connection of the app with national infection testing systems was a significant challenge.

Its completion enabled users to report positive test results to enable prompt exposure notifications. Adjustments in government regulations required continuous modifications that coincided with evolving public health strategies. Furthermore, success hinged on the fostering of adequate user engagement with smartphone functionalities, which called for cooperation among diverse stakeholders, including healthcare administrators, media organisations, and community representatives. This highlights that technology alone is not an all-encompassing solution; digital capabilities must be harmonised with practical policy execution to bolster systemic reinforcement measures. For instance, recent projects demonstrate that effective integration of these solutions demands alignment with broad governance frameworks that relate to disease management and patient care (Cresswell et al., 2012).

Structuration Theory: Interaction Between Institutions and Public Adoption

Deeper insights can be derived through the use of Structural Theory, which investigates the interactions between established institutions, such as government agencies, that influence user interaction and behaviours. This interaction generates feedback loops that affect user engagement levels (Elkhodr et al., 2021; Malik et al., 2022).

The initial worries regarding data privacy illustrate the responsive cycles that can be initiated among stakeholders. In the case of the NHS COVID-19 app, these responses led to a transition from centralised data management to more decentralised approaches. This shift corresponded to demands for increased autonomy and consideration of user perspectives before policy determinations, and this sequence mirrored ongoing societal discussions surrounding technology.

Moreover, the influence of the media on public perceptions underscores the intricacies involved in the enforcement of mandatory public health regulations. Resistance from the public, primarily fuelled by concerns over digital surveillance and potential data misuse, required enhanced transparency and independent assessments to adjust policy frameworks in response to shifting societal dynamics. This situation emphasises the reciprocal effects of governance and stakeholder involvement, which contribute to progress in digital healthcare and illustrate the iterative influence of all parties concerned.

Challenges and Lessons from the Mobilisation Process

The NHS COVID-19 app faced numerous challenges throughout its rollout. These difficulties provided valuable lessons that could inform future digital health initiatives. A

significant issue was the technical bottlenecks and dependency on private sector collaborators, which required continuous adjustments to resolve compatibility and usability issues. Additionally, the dependence on Apple and Google's Exposure Notification application programming interface created design limitations due to external corporate decisions, restricting the potential to be flexible regarding data storage.

Another challenge arose from public concerns regarding trust related to privacy. People voiced fears about the possibility of surveillance and data misuse. To promote transparency and restore public trust, independent audits were implemented, and frequent updates about data management practices were promulgated.

The resistance to adoption and the difficulties in engaging users complicated the deployment. Regions with socio-economically disadvantaged populations encountered challenges related to mobile accessibility and internet access, and this led to distrust in government-led healthcare programmes. Future technological innovations in healthcare must more effectively consider economic disparities and access to technology to encourage broad participation.

The mobilisation process related to the NHS COVID-19 app highlighted the convergence of technology, governance, and public engagement. A collaborative approach that aligns societal needs with technological progress is essential. Support for integrated systems and cooperation among all parties is critical for success (Hagemeijer et al., 2022).

The obstacles that were faced during deployment highlighted the need to implement flexible policies that allowed for adjustment. As new healthcare initiatives emerge, communication strategies that prioritise transparency will be key to building public support and boosting adoption rates. Future health-tech projects should strive to draw up a comprehensive plan that aligns emerging technologies with suitable governance frameworks and social dynamics. This approach can improve crisis-response measures and elevate levels of community trust, ultimately enhancing healthcare systems' resilience.

7.2.2 Promotion Strategies for the NHS COVID-19 App

The promotion of the NHS COVID-19 app was crucial to the successful management of the pandemic. Widespread engagement was vital, and this meant that effective communication strategies were essential to educate the public and foster trust. Government agencies utilised various approaches to increase awareness of the app, including television commercials, social media campaigns, and celebrity endorsements, all designed to encourage the download and use of the app to handle COVID-19 and to

counter myths regarding privacy issues. It was important to instil confidence among users, especially given the public's concerns about data breaches, which called for complete transparency from officials.

Sociomateriality and the Role of Public Trust

Elements of Sociomateriality shaped public confidence in the app. The app was engineered with cybersecurity protocols, which featured secure cryptographic systems and decentralised data storage, to address worries about government surveillance and to protect against identity theft.

Nonetheless, technical protections were insufficient; broad societal anxieties related to misinformation campaigns and fears of potential government overreach directly affected public perception and acceptance levels. Tackling these concerns became a key priority, as organisational leaders publicly reassured users that any metadata gathered by devices would not undergo unauthorised scrutiny or be misused for purposes unrelated to health. Despite these efforts, scepticism remained prevalent among specific demographics, particularly those with less trust in government institutions. This ongoing doubt was heightened by the rampant circulation of misinformation on digital platforms, which required improved engagement strategies to foster trust within various communities. Collaboration with independent web safety advocates and initiatives to strengthen ties with trusted public figures was suggested to enhance the app's credibility.

The Interplay of Public Involvement and Systems Theory

From the standpoint of Systems Theory, the NHS COVID-19 app required a large user base to function effectively. Digital contact tracing tools operate within a broad public health context, in which their success hinges on extensive usage to gather pertinent data on disease transmission patterns. A lack of user participation could have restricted the app's capability to identify at-risk individuals.

Different levels of user engagement across various regions led to modifications based on the current insights into promotional techniques. Authorities tracked regions with lower rates of user engagement and made targeted adjustments to boost adoption in those areas. This reflects how societal issues can drive technology adaptation; government actions often shift in response to community involvement, and in this case, these actions resulted in improved messaging content and app functionality.

Strategies to enhance user adoption involved partnerships with local healthcare providers and community organisations to ensure that promotional content resonated

culturally. Elements such as language obstacles and distrust towards government initiatives influenced people's willingness to adopt the technology, and this finding highlighted the need to align communication strategies with local healthcare narratives (Kendall et al., 2023; McCue et al., 2022).

Structuration Theory and the Evolution of Messaging Strategies

Structuration Theory offers insights into how institutional communication practices and reciprocation patterns shape individual behaviours. The initial messaging regarding the app centred on the idea that its utilisation would lead to a safer environment and support the national treatment supply chain. However, increasing public concern about personal data privacy required a shift in the presentation of information to address these pressing issues and to adapt to changing narratives.

The government continuously refined its messaging to alleviate growing reservations by highlighting security protocols, the choice that users had to opt in or out, and the clarity regarding data management practices. Furthermore, media narratives played a significant role in shaping how the public viewed the app. Reports of initial technical difficulties and confidentiality worries added to general doubt, prompting the government to combat misinformation with positive success stories. This demonstrates that technology acceptance is affected not just by government initiatives but also by sociocultural trends.

Insights into Adoption Patterns Using Actor-Network Theory

The adoption of apps across various groups shows significant differences, even with comprehensive promotional activities. ANT can be used to explain the different reactions to app promotions by highlighting the unique roles of adopters, resisters, and intermediaries.

Adopters: Individuals who adopt government-directed apps typically include those who trust messages from government sources, believe in an app's effectiveness, or are motivated by the potential for shared benefits.

Resisters: Individuals who raise concerns about, for instance, tracking and surveillance systems have resisted adoption. Factors that influence this resistance include worries over privacy violations, distrust of government entities, and the acceptance of misinformation that has arisen from inadequate instruction materials or the use of obsolete technology.

Intermediaries: In the case of the COVID-19 app, community leaders and healthcare professionals shaped public opinion. Their support significantly affected how the potential outcomes of the app's implementation were perceived.

The trends in the adoption of the app indicate that technology acceptance does not follow a straightforward path. Instead, it entails negotiations among various actors that are shaped by social, political, and technological influences. Health agencies and governance advocates consider the mobile app a means for societal benefit, yet users have diverse views regarding the associated risks, particularly concerning data privacy. This highlights the evolving nature of technology adoption trends and points to the need for flexible and responsive communication strategies that address local concerns instead of solely depending on global dissemination methods.

The promotion of the NHS COVID-19 app underscored the significance of communication, public trust, and societal participation in the acceptance of digital health. This discussion has utilised Sociomateriality, Systems Theory, Structuration Theory, and ANT to clarify how technology design interacts with policy messages and shapes public perception.

Ongoing worries about privacy, misinformation, and general scepticism were obstacles to government efforts to boost app usage through various methods. The establishment of public trust was affected by particular features that were integrated into technological systems and was greatly influenced by broad social conversations. The Sociomateriality framework highlights this interplay. Systems Theory offers insights into how adoption strategies can be made successful; it indicates that the achievement of a critical mass of NHS COVID-19 app users was vital to gather comprehensive functional use cases. Additionally, Structuration Theory clarifies that institutional interactions and individual behaviours led to refined messaging strategies in real-time, thereby improving engagement and informing the development process of digital health ecosystems. ANT portrays individuals' various roles in shaping their risk perceptions in connection with government credibility and privacy issues, and shaping in favour of using the app was crucial to enable tracing of the trajectory of viral control programmes.

The insights gained from these research studies emphasise the necessity for adaptability, transparency, and community involvement to encourage a user base that aids the implementation of effective data-driven public health programmes. The presence of all these elements offers substantial benefits in the integration of digital technologies that are focused on enhancing public health on a large scale.

7.2.3 Impact of the NHS COVID-19 App on Pandemic Management and Digital Healthcare

The NHS designed its COVID-19 app to offer widespread accessibility, accelerate contact tracing, and facilitate the prompt identification of potential patients, with the aim of cutting the transmission chain. Nevertheless, the initiative encountered difficulties, including technical issues, general public reluctance, and the complexities of incorporating advanced healthcare technology into current healthcare systems.

Actor-Network Theory: The Role of Human and Non-Human Actors

Utilising ANT to assess the NHS COVID-19 app highlights the dynamic interactions between human agents (such as users, policymakers, and developers) and non-human components (including software updates, mobile device compatibility, and predictive models). This finding demonstrates that the effectiveness of technology is shaped not just by innovative advancements but also by the ongoing interplay among these actors.

• App developers and companies such as Apple and Google defined technological limitations, such as Bluetooth-based proximity tracking, which posed challenges in achieving accurate results.

• Public health authorities adjusted their strategies to improve awareness while tackling issues related to privacy safeguarding and the app's functionality.

• The general population played an active role in this network, influencing adoption trends. Some embraced the app to support community health. Others resisted due to mistrust of government actions and worries about potential surveillance. Technical issues exacerbated these concerns.

The continuous interactions among all stakeholders determined the app's effectiveness. For example, users encountered problems with app notifications, primarily when they received false alerts due to the limitations of Bluetooth technology to distinguish between short and long periods of contact. This caused frustration, which was worsened by the drain on device battery life due to the need for constant activation, and this issue impacted rates of use.

ANT offers vital insights into the changing narratives that surrounded prevalent issues, suggesting that operations required ongoing refinement. Initial pushback sparked greater interest among designers in decentralised data collection models, and this led officials to explore implementation alternatives while addressing personal security issues. This indicates that digital healthcare initiatives are not fixed entities but fluid

systems that evolve in response to stakeholder behaviours and real-time conditions (Baxter and Sommerville, 2011).

Structuration Theory: The Reciprocal Influence of Institutions and Public Behaviour

Structuration Theory emphasises the reciprocal dynamics within societal structures, in which public actions and official policies mutually influence one another (Giddens, 1984). This illustrates that neither exists in isolation but through interconnections, which significantly affect organisations such as the NHS in the case of the COVID-19 app.

Initially, public attitudes toward the app, which was designed to control the pandemic, were shaped by government instructions and encouragement from the NHS. People's primary worries were focused on privacy concerns and the effectiveness of enforcement, which influenced policy development.

As public doubts about data protection grew, policymakers adopted more apparent communication strategies. They strengthened transparency efforts by providing assurances that data would be anonymised for use and by involving external watchdogs to monitor privacy issues. These changes highlighted the role of public opinion in shaping policies.

Narratives presented in print media and on political platforms played crucial roles in influencing public perceptions. Early technical challenges, combined with unenforced regulations and inconsistent government messaging, created confusion that obstructed adoption efforts. Structuration Theory posits that initiatives about digital health are inherently tied to large sociopolitical frameworks, which can either promote or hinder advancement depending on how institutions respond to public discourse (Shaw and Glover, 2023).

Lessons from the NHS COVID-19 App's Impact

The deployment of the app demonstrated its potential for effective crisis management through technological means, but also revealed limitations in practical application. These findings reinforce significant lessons.

1. While technical accuracy is essential, so is emphasising user experience. Problems such as battery drain, connectivity issues, and misleading notifications adversely

affected user trust and participation. Future developments for healthcare apps should concentrate on straightforward navigation and reliable functionality.

2. Gaining public trust is essential for acceptance. Concerns about privacy impact people's views on government actions. Ensuring transparency and incorporating independent oversight can build trust and promote engagement.

3. A comprehensive healthcare strategy is crucial, as a contact tracing app alone is insufficient. Coordination with testing initiatives, quarantine measures, and transparent public health instructions is imperative to maximise effectiveness.

4. Consistency in policy is essential if user engagement is to be sustained. Conflicting self-isolation guidelines led to confusion, and this situation underscored the importance of providing clear direction and effective communication from institutions.

5. Tackling the digital divide is critical. Socioeconomic factors affected usage patterns, and this emphasised the necessity for alternative communication options, such as SMS alerts, to ensure accessibility for various population groups.

The NHS COVID-19 app showcases both the potential and the challenges that are associated with the application of health technology during emergencies. Analysis of its use through Systems Theory, ANT, and Structuration Theory reveals that digital contact tracing is not solely a technological fix but necessitates integration with existing systems, stakeholder engagement, and societal buy-in. This app's performance underscores the significance of usability and the crucial role of user trust. It is also clear that policies must complement these technologies to promote broad acceptance.

Future medical app advancements may use the NHS COVID-19 app profile as a framework, but developers should remember that successful implementation involves more than technological progress; it must address public concerns and align with comprehensive healthcare strategies.

7.3 Comparison with Previous Research

The results from this project align with those from published research, such as that by Ferretti et al. (2020) and Kendall et al. (2023), on digital contact tracing within community health initiatives. These studies highlight that privacy issues can heavily impact user adoption rates. Government hesitancy significantly influences these rates, mainly due to

emerging fears concerning data security and personal monitoring, which affect the efficacy of online tracking.

The NHS COVID-19 app findings show that individuals' concerns about the control of personal information impact the app's acceptance. To implement health apps successfully, developers must prioritise the strengthening protection against the misuse of private data and be transparent about how sensitive information will be managed. These actions can build trust in such initiatives for broad populations.

Moreover, previous discussions by Dowthwaite et al. (2022) and Troncoso (2021) suggest that decentralisation boosts user trust, and clear communication enhances perceptions of security. The design of the NHS app, which featured less centralised data storage, alleviated some worries regarding the misuse of extensively collected data. Government transparency regarding the safeguarding of sensitive information could be vital to encourage public trust and reduce resistance, and could thereby pave the way to more favourable public responses. However, concerns related to surveillance persist, particularly as the government's digital health initiatives continue to face scrutiny due to credible evidence that, in some cases, personal data has been mishandled.

The research indicates that reliance solely on digital health tools may be insufficient to drive behavioural change. While advanced technology is essential to manage pandemics, it is inadequate to alter health behaviours at the individual and community levels. The study emphasises the significance of sociotechnical interactions—such as building trust, ensuring regulatory oversight, and fostering community involvement—as essential factors that should accompany technological advancements to optimise outcomes.

For example, initiatives aimed at sustaining trust, such as impartial evaluations and certifications from objective third parties, have been identified as elements that can enhance confidence in digital health tools (Kendall et al., 2023). These authors illustrate how perceptions of government transparency and prior experience with state-led technological initiatives influenced confidence in the NHS COVID-19 app. Historical surveillance concerns negatively affected the app's adoption rates despite measures that were implemented to address privacy concerns. These results suggest that broad societal and political contexts may significantly impact public trust in digital health technologies more than the tools' characteristics.

The study also highlights the importance of regulatory oversight. The authors examined how regulatory frameworks influenced levels of acceptance of digital health solutions

that were designed to promote physical well-being. Previous studies had indicated that the existence of clear legal frameworks could enhance community trust in technology, but the Kendall researchers argued that such regulations alone were inadequate to provide authentic assurance or compliance. For instance, despite the alignment of the NHS COVID-19 app's safety measures with UK data protection laws and GDPR, significant public opposition indicated the need for increased community involvement to address data privacy concerns.

The study described in this thesis has presented a perspective on the necessity for community engagement as a critical factor in interactions with digital health technologies. It underscores the role of community-driven efforts in shaping the implementation of health applications in real-world contexts. The findings suggest that partnerships among medical professionals, local community members and advocacy organisations can positively influence the acceptance of health technologies. By integrating well-supported digital health guidance and fostering public trust, these collaborative initiatives have the potential to promote cooperative behaviour and enhance the effectiveness of health interventions. This research highlights the importance of collective action among community stakeholders in addressing challenges related to the adoption of digital health solutions.

This research has explored neglected areas in online health management, including digital literacy and accessibility. Most prior studies have focused on privacy laws and related concerns; however, this analysis reveals that the uptake of virtual healthcare is also impacted by users' technical skills and ability to navigate digital platforms.

People with limited technological abilities or those without access to mobile devices, such as smartphones, face more challenges. This highlights the need to improve web-based healthcare approaches to ensure inclusivity, regardless of the various levels of technology access that are related to socioeconomic differences. It is clear that to be effective, public health strategies must extend beyond mere protection of privacy rights; they must also consider usability and accessibility.

This study adds to the current academic conversation by reevaluating the critical importance of ensuring the integrity of personal information, effectively implementing decentralisation methods, and ensuring transparency in regulations. These are key elements for building community confidence in telehealth services. This is especially significant in the post-COVID landscape, in which new realities warrant further investigation and discussion.

Arguments that dispute the belief that technological solutions alone can resolve these challenges have been introduced. It is essential to consider behavioural changes and to highlight the necessity of fostering trust by creating regulatory frameworks that support effective practices. Collaboration and community involvement are crucial in this regard.

The example of the NHS's COVID-19 app demonstrates that technology-driven initiatives must correspond with broad sociotechnical factors to maximise effectiveness. This emphasises the significance of a comprehensive approach that assesses the connections and subtleties within online healthcare interactions.

7.4 Theoretical Implications

7.4.1 Sociotechnical Perspective

The facilitation of digital healthcare solutions, particularly in times of crisis, relies on a blend of cutting-edge technology, well-crafted policies, and public willingness. This study highlights the need to assess medical interventions through social and technical lenses to grasp the diverse elements that affect their success rates. The adoption of frameworks such as ANT, Systems Theory, Structuration Theory and Sociomateriality offers a thorough perspective on how tools such as the NHS COVID-19 app operate within intricate healthcare systems without altering established theoretical frameworks.

Actor-Network Theory and Interdependencies in Digital Health Adoption

The application of ANT helps to pinpoint the connections among crucial stakeholders in the creation of health-oriented technological advancements (Booth et al., 2016; Kendall et al., 2023). The path to introducing such technologies involves collaboration among various parties, including government bodies and tech firms, each of which plays an important role.

- Organisations such as the NHS and the Department of Health and Social Care ensured legal adherence, managed project funds, and implemented public communication outreach efforts.
- Firms such as Apple and Google offered expertise in software and engineering. They incorporated privacy elements into the app's framework and hence made it practical for use.
- Medical professionals evaluated product performance standards while aligning new protocols with current clinical guidelines, which helped patients and the wider public to accept technological methods.

A successful outcome in digital health projects depends on the management of a broad spectrum of interconnected factors. Neglecting these areas may lead to significant challenges related to regulatory requirements, operational effectiveness, and efforts to build trust, which are crucial to promoting collective comprehension and ensuring backing for technology-driven initiatives.

Systems Theory and the Integration of Digital Tools in Healthcare

From a Systems Theory perspective, digital health resources should be integrated into large healthcare structures rather than treated as standalone solutions (Bertalanffy, 1969; Cresswell et al., 2012). The NHS COVID-19 app exemplified this integration by serving multiple functions within the broad framework of pandemic control, aligning with testing protocols, public health guidelines, and hospital operations.

- It was effective because it connected core functionalities with national isolation practices and diagnostic protocols.
- The public's confidence influenced the level of app usage and its integration with existing health measures.
- Insufficient collaboration between testing centres and epidemiological databases negatively affected performance metrics.

Systems Theory principles underscore the need for comprehensive integration of electronic healthcare systems. Fragmentation can diminish the advantages of even the most advanced technical solutions if they are not connected to existing medical networks. This lack of integration highlighted systemic shortcomings and challenges during the implementation of coordinated national response policies.

Structuration Theory and the Evolution of Digital Health Policies

Structuration Theory offers valuable insights into the evolution of e-health guiding principles and emphasises the relationships between institutional frameworks and community attitudes regarding the use of related applications (Ali et al., 2023; Giddens, 1984). The COVID-19 viral outbreak led to a global reaction, prompting questions about preparedness and response strategies.

A notable aspect was the adaptive nature of the NHS's software projects, which continuously evolved in response to changing circumstances. This demonstrates the challenges of planning based on assumptions in unpredictable real-world conditions.

- Government bodies' communicative strategies shifted from a strict authoritative approach to a more persuasive method, reflecting concerns about public perceptions of privacy and control during crises.
- Data privacy frameworks were adjusted from centralised data storage to a decentralised model in response to public scepticism.
- Public demand for enhanced safety features regarding personal data led to significant changes, including a transition from centralised to decentralised storage models to protect sensitive information and maintain public trust.

The integration of digital health solutions with broad healthcare strategies is essential to the achievement of enhanced safety and efficiency in public health management. The balance between innovation and privacy remains a key focus for stakeholders as they navigate the complexities of modern healthcare needs.

Sociomateriality and Public Trust in Digital Health

Sociomateriality serves as an essential framework through which to understand the role of public trust in the adoption of digital health technologies, particularly concerning privacy, data management, and regulatory compliance (Dowthwaite et al., 2021; Orlikowski, 2010). While technological features such as encryption, anonymisation, and decentralised storage were implemented to enhance data safety, broad sociopolitical factors significantly impacted public perceptions.

- Historical instances of government surveillance and data misuse shaped individual views regarding the handling of personal information in digital apps despite technological security measures.
- Media narratives and misinformation campaigns influenced public awareness regarding the storage, processing, and sharing of personal information.
- Transparent practices and independent oversight addressed user concerns; however, ingrained anxieties related to online privacy resulted in inconsistent implementation across different contexts.

The Sociomateriality perspective indicates that technology-based solutions alone are insufficient to enhance public trust; instead, policy clarity and community engagement are needed to complement legal protections that ensure compliance and regulatory adherence.

This study has employed ANT, Systems Theory and Structuration Theory within the Sociomateriality framework to provide a meta-theoretical analysis of the UK NHS COVID-tracing platform. The intent is not to expand current or establish new theoretical frameworks but to offer well-supported conclusions on the dilemmas and potential

challenges that affect trends in digital health uptake.

The findings highlight that successful cyber-health initiatives require alignment between technological innovation, legislative frameworks, and societal acceptance. ANT emphasises the importance of coordination among relevant stakeholders, while Systems Theory underscores the need for an inclusive approach across the healthcare sector. Structuration Theory contributes to understanding the evolution of necessary legislation, and Sociomateriality highlights the importance of establishing a foundation of public trust.

Furthermore, the study articulates the necessity for dynamic regulatory governance, structured communication, and comprehensive systems integration. These elements are essential contributions to the academic discourse surrounding digital public health initiatives and stress the importance of incorporating interdisciplinary, theoretically established methods in future research for effective policy planning.

7.5 Practical Implications

This study emphasises that apps must be pertinent to public health strategies and digital health, especially in the context of pandemic management and the creation of digital healthcare systems. The NHS COVID-19 app demonstrates that the success of digital health projects relies on technological innovations, well-crafted policies, public confidence, user-friendly interfaces, and fair access. Future e-health initiatives be designed to integrate thorough policy frameworks, collaborative development, and a strong focus on end-user needs to ensure widespread acceptance and lasting efficacy.

7.5.1 Public Health Policy: Insights

Integrating Digital Healthcare within Policies

Key insights that have been derived from the studying of the NHS mobile app are that such tools do not function well in isolation; they rather work well when incorporated into comprehensive, government-led efforts to prevent disease outbreaks. This app's effectiveness was closely linked to the presence of testing resources, public compliance with quarantine measures, and organised contact tracing efforts. When such measures are implemented in isolation or as standalone solutions, outcomes frequently fall short, and this undermines public trust.

It is important for future strategies for pandemic management to ensure that mHealth technologies are developed in conjunction with established methods that reinforce

community-wide preventive efforts. This necessitates constructive discussions among policymakers, epidemiological specialists, and technology developers to encourage integrated care instead of the replacement of existing measures. Governments can adopt a comprehensive viewpoint and recognise that IT-based solutions should enhance broader virus surveillance and governance frameworks rather than function independently.

Secure data management practices are essential and be visible to sustain public trust and promote app usage. Enhancing transparency about data collection and storage practices can address worries that may hinder the adoption of health apps, particularly concerns regarding privacy and government surveillance. Users of the COVID-19 app frequently voiced their apprehension about how their data was managed, and this bred scepticism about its use and objectives. Insufficient clarity on these matters can adversely impact public acceptance and reduce the practical effectiveness of such initiatives.

To prevent similar issues in future digital healthcare responses, policymakers can emphasise open communication regarding data management processes and ensure the embedding of user-friendly practices. This includes instituting:

- independent evaluations of current systems to ensure strong privacy protections;
- clear protocols outlining the status and deletion of stored digital information, informing users about when and how their data will be erased; and
- public communications that clarify how aggregated personal data can enhance community health outcomes.

Governments and health organisations can also combat misinformation while building public trust by prioritising transparency in communication and decision-making practices concerning health data management.

Ensuring Equitable Access to Digital Health Solutions

Identification of the barriers that various groups encounter in utilising apps such as the NHS COVID-19 app poses significant challenges. Specific demographics, such as older people, individuals with lower incomes, or those lacking access to smartphones, may not engage fully with this health resource, and this issue reduces its overall impact. These challenges can result in digital exclusion and the obstruction of efforts to manage virus spread, as many of these communities experience heightened risks of infections but are less inclined to take advantage of valuable healthcare resources.

Future developments should ensure equitable access for all community segments to

technological solutions, regardless of their financial situations or technological skills. To expand the reach of digital health tools, numerous strategies could be explored:

- offers of alternative options for those without smartphones, such as text message alerts;
- the provision of financial assistance alongside subsidised use of mobile devices and internet access, specifically targeting marginalised groups; and
- collaboration with well-established community organisations to boost enrolment rates.

Furthermore, the application of inclusive design principles and effective outreach strategies allows decision-makers to tackle technology inequality, thereby improving public health initiatives.

7.5.2 Practical Insights for Digital Healthcare Implementation

The emphasis should be on the initial partnership between technology firms and healthcare professionals. The production of practical digital tools necessitates continuous collaboration between technology developers and medical practitioners to design and execute these solutions strategically. It is vital to confront the challenges of reconciling privacy concerns with the requirements for location tracking.

Looking ahead, it is essential to involve frontline healthcare providers throughout the entire app development process to ensure alignment with both therapeutic and epidemiological objectives. Increased collaboration can be fostered through the following:

- development of diverse teams that incorporate specialists, epidemiologists, data protection experts, and user experience designers;
- performance of pre-launch testing in real-world clinical environments before wider releases; and
- crafting of app features that facilitate rather than obstruct existing operational workflows within healthcare systems.

The integration of feedback from frontline healthcare experiences into the technology's design and implementation can maximise the effectiveness and acceptance rates of digital health tools.

User-Centric Design for Broader Adoption

The effectiveness of digital health resources is greatly affected by how accessible and user-friendly they are. The NHS COVID-19 app, despite its innovative features, faced various challenges that hindered its adoption, such as problems with battery drain, too

many notifications, and technical issues.

To enhance the design of digital health tools, it is crucial to adopt user-centred strategies. This means ensuring that tools are:

- simple to use and understandable without the need for extensive technical expertise;
- reviewed by diverse demographic groups, including older adults and individuals with disabilities; and
- provided with clear user manuals and accessible support for troubleshooting.

Measurement of usability tests before a broad launch can help to identify and overcome obstacles, and completion of this step will increase rates of user engagement and foster long-term sustainability.

The above highlights again that technological capability alone does not guarantee successful healthcare digitisation. Policy feasibility and the design of user-focused apps are equally vital. Effective public health strategies should integrate elements of pandemic response into e-Health applications, ensuring data transparency and equitable access. Early collaboration between technology professionals and healthcare providers is essential, alongside adherence to responsible design principles that optimise resources while keeping future ethical considerations in mind.

7.6. Reflections on the Research Process

7.6.1. Methodological Insights

Studying the impact of the NHS COVID-19 app on managing pandemic obstacles posed unique challenges in data gathering, methodological rigour, and ethical considerations. The study was conducted during an evolving pandemic, which presented difficulties in handling sensitive information.

One of the primary challenges was the reliance on document analysis for data collection. While this method is integral to qualitative research, verifying the authenticity and relevance of documents proved to be a complex task due to the abundance of available, but possibly unreliable, information during uncertain times (Javad et al., 2023). Rigorous checks were implemented to ensure the authenticity of the documents used in the study, adding credibility to the findings.

Another significant obstacle was managing ethics when dealing with sensitive health information. Safeguarding privacy laws and adhering strictly to established norms

throughout each stage of the investigation process required extra attention. Obtaining approval from the Aston University Research Ethics Committee remained a top priority to ensure that ethical standards were upheld.

Balancing methodological rigour while staying agile to accommodate the constantly changing dynamics of the pandemic posed challenges. Designing a dynamic research framework encompassing changes without compromising the core objective proved essential (Vandermause et al., 2017).

The research utilised a flexible qualitative approach to address the challenges and to adjust to emerging data and insights. Thematic analysis was employed to uncover central themes and patterns from the collected information, enriching the understanding of how contact tracing apps were used to manage the pandemic (Vindrola-Padros et al., 2020).

Due to the study's interdisciplinary nature, juggling multiple perspectives from fields like public health, technology and government policy was also challenging. To address this, case studies explored the app's role in broader pandemic settings and focused on stakeholder interactions, providing a more straightforward overview of how mobile applications impacted overall public disease-handling capabilities (Molinari and De Villiers, 2021).

Discussion on the Strengths and Limitations of the Research Approach

The research methods used to study the NHS COVID-19 app's rollout have various strengths and limitations relevant to its role in public health.

One strength is the in-depth qualitative examination, primarily rooted in constructivist and interpretive foundations, which allowed for a detailed analysis of user perspectives on using the app. User ‘buy-in’ is crucial for e-health strategies, and this method provided valuable insights into user perceptions (Zanaboni et al., 2018).

Another strength is the thorough collection and analysis of details, contributing multiple layers of comprehension to the rollout of the app. This approach aligns with the principles of in-depth investigations, providing insights into how the app's surroundings affected its outcomes (Nilsen, 2015; Pham et al., 2019).

Flexibility is also a key strength, particularly in rapidly changing pandemic conditions. The method's adaptability allowed for practical analysis amidst unexpected and vital shifts during crisis management (Berry et al., 2016; Durant and Kortes-Miller, 2023).

Despite its strengths, the method has limitations. One noteworthy drawback is the

potential for bias in handling and interpreting the collected data. It was necessary to exercise caution to ensure the authenticity of the findings and guard against potential interpretational biases (Gilbey et al., 2020; Durant and Kortes-Miller, 2023).

Another limitation is the risk of incomplete data collection, particularly concerning marginalised communities whose perspectives might not be readily accessible in public sources (Holmen et al., 2023; Voorheis et al., 2023).

The method's narrow focus is both a strength and a limitation. While it provides close-up views, it may not capture broader perspectives or conditions. Its findings may apply more to specific target groups or conditions (Wesley and Fizur, 2015; Thai et al., 2022).

The use and impact of the NHS COVID-19 app, examined using a qualitative research method, provides a comprehensive understanding. This method offers adaptability and detailed analysis, enabling a more profound comprehension of digital health strategies. However, it is essential to consider potential biases and generalisability when concluding. In future research, incorporating other qualitative approaches, such as interviews or discussion groups, could enhance the diversity of viewpoints, thus strengthening the findings (Lie et al., 2017; Naef et al., 2024).

7.6.2. Personal Reflections

Exploring research on the NHS COVID-19 app provided me with valuable insights into managing a universal health issue. This journey involved encountering challenges and discoveries that contributed to intellectual growth and an increased understanding of the complexities of digital healthcare investigations.

A critical lesson from this experience was identifying methodological issues associated with document analysis. It became apparent that evaluating sources required scrutiny beyond their content, including considerations of their origins, potential biases, and relevance to addressing specific inquiries. This underscored the importance of maintaining scepticism when dealing with secondary data, particularly in rapidly evolving situations like COVID-19.

The unpredictable nature of pandemic circumstances called for a previously unexplored level of adaptability. The frequent changes in public health guidelines, shifts in communal sentiment, and rapid technological advancements necessitated flexible approaches in both the design and execution stages of research. This experience emphasised the need for adaptable methods to accommodate rapidly unfolding events and ensure the timeliness and relevance of results.

Acquiring multi-dimensional viewpoints emerged as another significant learning outcome. This study required integrating insights from diverse disciplines, including societal norms, health measures, digital advancements and regulatory frameworks. Embracing an interdisciplinary approach facilitated the comprehensive analysis of theoretical concepts from different fields, enhancing the ability to address a wide range of interconnected issues.

Navigating ethical considerations throughout the research process posed substantial challenges. Managing sensitive information, respecting personal privacy rights, and upholding journal integrity required meticulous attention to detail. This journey reinforced my understanding of the responsibilities inherent in conducting studies involving human health risks and their implications for individual privacy.

This project has highlighted the importance of a flexible and adaptable research design. In the future, emphasis will be placed on creating study plans that allow for alterations and adaptations as new insights surface, especially in fields where changes happen rapidly or in situations like public health crises that may affect the course of research.

Another important insight from this project emphasises the advantages of incorporating multiple disciplines in investigations. In the future, efforts will be made to continue offering opportunities that blend diverse viewpoints into one platform, harvesting knowledge from different domains to enhance analysis depth and widen investigation areas.

Encountering ethical hurdles illustrated the necessity for rigorous moral monitoring throughout all studies. Ethics should be considered at every phase related directly to researching methods, concentrating on participant privacy protection rights and informed consent under transparency conditions.

This study has emphasised for me, as a researcher, the importance of critically evaluating sources and understanding their significance in the exploration of the subject. I have appreciated that efforts should be focused on approaching sources with a fundamental mindset, questioning their accuracy, and identifying any biases or limitations. Trustworthiness and integrity should be prioritised throughout the research process.

To sum up, the challenges faced during this research journey have been influential in reshaping future scientific quests, enriching my skills as a scholar, and providing a deeper understanding of intricacies within the digital health realm of study. The complications confronted served to intrigue and educate me, ultimately contributing to

delivering robust and impactful results in future investigations.

7.7. Chapter Conclusion

The case study of the NHS COVID-19 app offers essential insights into the interaction that can occur between technology and social factors during major health emergencies such as the novel coronavirus pandemic. This research underscores the significance of e-Health platforms in meeting public health demands. The execution of government protocols and the refinement of policies are crucial to maximise the effectiveness of digital healthcare initiatives. A holistic approach is required when planning and implementing future digital health solutions.

The analysis reveals that advanced technology alone is inadequate for managing public health emergencies effectively. The NHS COVID-19 app, despite its sophisticated features, experienced varying degrees of effectiveness that were shaped by societal and institutional factors. Concerns regarding privacy, regulatory decisions, and public confidence in government-led digital efforts played crucial roles. These observations highlight the importance of operational transparency, effective communication strategies, and community participation in building trust in digital healthcare initiatives.

Employment of multiple theoretical frameworks—including ANT, Systems Theory, Structuration Theory, and Sociomateriality—has offered a holistic view of the adoption process for digital health interventions. ANT underscores the significance of crucial players, such as government agencies, technology firms, and health institutions, in influencing these apps' potential strengths and limitations. Systems Theory emphasises the importance of integrating these tools within large public health frameworks to boost their effectiveness rather than allowing them to function separately. The conflict between organisational processes and user behaviour illustrates the need for regular policy updates, a notion that aligns with Structuration Theory. Sociomateriality is especially relevant for understanding user interactions regarding data safety and confidentiality, which significantly affect the acceptance of digital solutions.

The study's insights add to ongoing debates surrounding governance challenges, obstacles encountered during crisis management, and the ethical considerations of technology use in public health responses. A significant takeaway is the need to promote mutual trust, align policies, and adapt to evolving conditions to enhance the success of electronic health initiatives. Future endeavours should focus on boosting participation, implementing data encryption measures, and ensuring user-friendly design to improve

stakeholder engagement, all of which will ultimately enhance the efficacy of modern healthcare tools.

The NHS COVID-19 app represents a critical case study that highlights the challenges and prospects for digital adoption in crises. Although e-health innovations promise to transform strategies for pandemic response, their successful implementation requires that intricate issues be addressed: socioeconomic factors, public perception, and deployment methods. Ongoing research and policy reforms are essential to the fostering of a strong, evidence-based strategy to encourage the acceptance of digital solutions within the health sector, which would ensure that technological advancements support public welfare fairly and enhance resilience.

CHAPTER 8: CONCLUSION

8.1. Summary of Main Findings

This research has explored the NHS COVID-19 app as an example of digital adoption in managing public health crises and emphasised key elements of it. Examination of the app's usage offers valuable insights for future e-health initiatives. Successful virtual health solutions must be integrated with large healthcare systems and aligned with policy frameworks, and societal issues must be considered.

The study highlights crucial interdependencies among government bodies, technology firms, and healthcare organisations, showcasing the vital importance of collaborative governance in the rollout of digitised medical interventions and practices. Creating innovations under pressure—such as in a pandemic—requires swift decision-making across multiple sectors. A lack of timely coordination can expose practical limitations in technology use and trust-related issues that obstruct desired outcomes.

The NHS COVID-19 App: Successes and Limitations

The app was utilised during contact tracing efforts. Its use enhanced traditional resource management by decreasing manual labour demands. The existence of the app enabled swift alerts of potential exposure risks using features such as proximity detection, and it leveraged smartphones' Bluetooth capabilities, which reflects its potential in tackling real-world challenges that are associated with virus containment strategies.

Nevertheless, several challenges affected efforts to make the app widely acceptable.

- Privacy concerns: Anxiety over possible data misuse and government monitoring affected the app's acceptance. Queries about the handling of data collected through the app and the required assurances were crucial for initial user involvement and sustained engagement.

- Technical limitations: the app's dependence on Bluetooth interactions raised issues related to false test positives and inaccuracies in risk evaluations due to software and hardware communication failures, alongside resource utilisation challenges that might deter active participation.

- Digital access disparities: some devices were not compatible, and this impacted users who could not receive necessary hardware updates. This underscores a 'digital divide' during health emergencies, representing potential complications for digitally

underserved populations.

-Sociopolitical influences: public sentiment regarding government responses can significantly influence the acceptance of technology-driven measures. Misinformation and negative views surrounding pandemic management can undermine the effectiveness of well-meaning initiatives.

These elements collectively affect the adoption of technology-based solutions, with the COVID-19 case as a significant example.

Interdisciplinary Theoretical Insights

This study has adopted a sociotechnical viewpoint to assess the implementation of the NHS COVID-19 app. The ANT, Systems Theory, and Structuration Theory were applied to analyse the findings. The use of these frameworks facilitates the understanding of digital health usage as a fluid process that is influenced by various interconnected elements.

Actor-Network Theory: The Role of Stakeholders in Digital Adoption

ANT emphasises the intricate connections among primary stakeholders—government regulatory bodies, technology creators, and public health institutions—that affect an app's development, deployment, and societal acceptance. A joint effort among UK government representatives, NHS virtual teams, and private sector firms such as Apple and Google contributed to the establishment of the NHS COVID-19 app. The contributions of these stakeholders included:

- a guarantee from government regulators that the app adhered to legal standards, including regulations about data privacy; and

- offers of technical support from technology companies that were centred on a Bluetooth contact tracing solution for decentralised data management.

Public health platforms strove to incorporate mobile apps into overall pandemic response strategies, fostering public confidence in the apps' usage.

Nevertheless, varying interests among stakeholders occasionally led to disputes. This issue was illustrated by the friction between entities that were aiming for centralised record-keeping and technology firms that emphasised user privacy, which postponed the app's delivery. Such disputes highlight the significance of negotiations and arrangements in shaping an app's delivery, as demonstrated by ANT.

Systems Theory: Embedding Digital Health Tools within Public Health Infrastructures

From the standpoint of Systems Theory, the NHS COVID-19 app should be regarded as part of a comprehensive network within the large health ecosystem. The success of digitally focused health initiatives relies on their smooth integration into epidemiological models and crucial medical workflows, encouraging public cooperation. When combined with testing capabilities and quarantine protocols in the case of the pandemic, digital tools could improve outbreak management procedures. However, there were several challenges related to integration that needed to be addressed:

- inadequate data synchronisation between the health app and testing facilities led to extended waiting periods for people seeking confirmation of detected infections, resulting in delays in notifications;

- discrepancies were observed in the synchronisation between manually created contact tracing lists and automatic notifications produced by different app versions; and

-a lack of personalised healthcare advice within the app resulted in confusion among users about the appropriate actions to take after they had received exposure alerts.

These challenges highlight the need for a systems-oriented approach when implementing health technology protocols. Future advancements should focus on incorporating technological tools into healthcare systems to guarantee integrated functionality instead of functioning as separate elements.

Structuration Theory: Public Engagement and Institutional Adaptation

Structuration Theory offers a framework through which to understand the advancement of digital health adoption. It illustrates the interplay between institutional frameworks and societal behaviours. This research has assessed how public reaction, scepticism, and behaviours influenced the creation of the NHS COVID-19 app, which was initially intended as part of state-led pandemic management strategies.

Notable observations are listed below.

- Worries about privacy violations prompted early changes in data retention practices during the app's rollout.

Mass media narratives shaped public perceptions of the app; some users viewed it more as a surveillance tool than as a healthcare resource.

- The official communications evolved from early demands for adherence to the promotion of voluntary adoption. This change highlights the app's advantages and the possibility to avoid mandates.

The theory clarifies that acceptance of digital health technologies is neither uniform nor fixed; it evolves through public feedback mechanisms. Attention to policy changes and broad societal dialogues is crucial to guide future interventions, and adaptability and transparency are essential to modify policies that are based on a thorough understanding of public concerns.

Insights for Future Digital Health Initiatives

Essential points regarding the development of future technological healthcare initiatives include:

- privacy as a priority: key areas should emphasise user control, data privacy, and efficient communication strategies to boost user acceptance;

- collaboration among stakeholders: a unified way to engage stakeholders that is shared by technology firms, government agencies, and users can reduce conflicts and enhance implementation efficiency;

- integration with existing infrastructure: the linking of new tools to current medical practice standards can improve effectiveness; and

- focus on usability: to normalise the use of digital health devices among various populations, it is vital to ensure that functionalities are accessible and processes are straightforward.

The findings indicate that while the goal is to enhance population well-being, public attitudes toward technology adoption differ significantly based on perceptions of transparency, inclusivity, and shared advantages. As digitised medicine continues to progress, these insights could assist in informing flexible and innovative strategies to reduce disparities and enhance health outcomes for everyone.

8.2. Contributions to Knowledge

This analysis adds to the research on implementing digital health during public health emergencies. It has concentrated on the interpersonal and technological factors that

affect the effectiveness or shortcomings of digital strategies. The examination of the NHS COVID-19 app reveals that the mere presence of technology does not guarantee user adoption; a successful implementation necessitates the alignment of policies, the establishment of trust, and its integration with current healthcare systems.

The investigation employed ANT, Systems Theory, and Structuration Theory as frameworks through which to comprehend the functioning of digital health initiatives within sociotechnical frameworks. These theories highlight the interdependence of technological features and institutional aspects, including societal factors. They demonstrate that the processes of digital uptake are influenced by brokers negotiating with regulatory standards and public trust.

8.2.1. Theoretically Informed Contributions

Embracing a sociotechnical perspective on digital health initiatives underscores the need to recognise that institutions and emerging technologies converge within contexts shaped by community behaviours. These elements must be assessed collectively in strategic efforts to coordinate responses during contagious outbreaks that provoke public health emergencies.

Instead of developing new theoretical models, this analysis primarily leverages ANT alongside ideas from Structuralism and Information Control Structures to pinpoint the challenges and successes that were encountered during the deployment of tracing initiatives. The emphasis of this study is on apps that were designed to monitor the movements of individuals who may have contracted COVID-19, specifically the app that was driven by the NHS that sought to trace infection pathways in areas frequented by potentially infected users.

Actor-Network Theory: Negotiating Digital Health Adoption

ANT clarifies the intricate interactions among various stakeholders that affect the adoption of digital health technology. Significant spheres of influence are listed here.

- Governance issues: these pertain to network interaction and user communities. The deployment of the NHS COVID-19 app underscored public interest in government-led initiatives that connect public health institutions with private technology companies. Discussions often showcase differing viewpoints among citizens, although a consensus can develop around practical applications to tackle public health issues.

- Trust among users is enhanced by user-friendly app features while privacy is preserved.

- Performance guarantees are key factors driving user adoption. They reflect shared interests in having secure access to data when managing health information.

The ANT analyses have helped to uncover how digital health technologies absorb various influences while navigating the changing dynamics of stakeholder engagement. The study suggests that despite ongoing changes in interaction patterns, progress continues toward sustainable network engagement through active involvement from chosen stakeholders. Furthermore, governance protocols may need to be revised to address new challenges that arise from technological advancements and sociopolitical dynamics.

Systems Theory: Integrating Digital Health Tools into Public Health Infrastructures

In the context of Systems Theory, digital health tools are considered essential parts of larger healthcare systems. For example, the NHS COVID-19 app was created to help manage the pandemic but faced obstacles due to its inadequate integration with testing facilities, healthcare providers, and disease-tracking systems.

- A key function of the app was to deliver real-time alerts based on test results; however, delays in connecting with these systems diminished the app's effectiveness.

- The lack of coordination between manual contact tracing efforts and exposure notifications from the app complicated the provision of timely responses, resulting in disjointed actions.

- Users found it difficult to obtain direct medical advice or treatment options after they had received alert notifications, as interoperability had not been adequately established.

Systems Theory underscores the need to embed digital health tools within traditional healthcare structures to prevent inefficiencies. Future initiatives should create clear links among various elements to strengthen public health responses rather than complicating them with new technological solutions.

Structuration Theory: The Evolution of Digital Health Policies

The Structuration doctrine explores how the interactions between institutional leaders (concerning privacy regulations) and grassroots civic movements shape the development of digital health policies, which in turn influence user behaviours over time.

A pertinent example is the NHS COVID-19 app's rollout. Trust-related issues about data privacy significantly influenced community perceptions and required the adaptability of

regulations, which subsequently affected risk assessment across various societal groups.

- Initial worries regarding privacy were crucial in influencing data tracking standards, prompting changes in the app's default data-sharing settings, which underwent public examination and regulatory validation.

Misinformation campaigns impacted the government's communication strategies, ultimately enhancing public acceptance as media coverage shaped individuals' understanding of organisational directives.

-The app promoted user participation within a self-adapting digital landscape, offering insights into technology-based policies' governance dynamics.

Structuration Theory emphasises the interconnected nature of digital adaptation processes. It indicates that business management philosophies, alongside responses from everyday individuals, play a significant role in shaping policy development and implementation. The focus remains on the responsiveness of local governance as a critical element in helping organisations stay relevant in the continually changing digital health landscape.

Sociomateriality: Understanding Public Trust and Data Privacy Concerns

Sociomateriality is crucial for examining public attitudes toward data privacy and the effects of regulatory supervision and compliance efforts.

- Efforts focused on establishing trust, such as independent audits and transparency reports, boosted user assurance regarding data protection.

- Regulations aimed at safeguarding personal data and GDPR adherence affect public perceptions of health applications that are managed by regulatory agencies.

How apps are designed, including their user interfaces, consent acquisition methods, and anonymisation techniques, significantly influences perceptions of security and control over personal data.

These insights suggest that trust is shaped not only by technological aspects but also by societal narratives, government assurances, and regular users' experiences.

8.2.2. Practical Contributions

The study offers actionable insights into public health policy and digital health practice,

specifically in trust development, data management, and user involvement.

Table 10. Table showing Practical Contributions and Recommendations

Practical Contribution Area	Recommendations
Policy Integration: Embedding Digital Health into Crisis Management	Digital health tools should be developed in parallel with broad public health strategies so that they become integral components of public health infrastructure rather than isolated initiatives. Governments should proactively integrate digital contact tracing, epidemiological surveillance systems, and clinical care pathways to maximise public health benefits.
Transparency in Data Usage: Enhancing Public Trust	Clear, transparent communication about data collection, storage, and usage policies should be prioritised to build public trust. Regularly updated public accountability measures and independent oversight mechanisms (audits) must be implemented to reassure users and encourage continued engagement.
Equitable Access: Addressing Digital Disparities	Digital health solutions must be inclusive and ensure equitable access to marginalised or digitally excluded communities. Community-driven education programmes should be established to increase digital health literacy and equitable technology use. Multi-language notifications and alternative communication channels (e.g., SMS alerts) must be deployed to improve accessibility.
Collaboration Between Tech Companies and Healthcare Providers	Early and ongoing collaboration between technology developers, healthcare providers, and epidemiologists is essential to align digital health tools with practical clinical and public health needs. Multidisciplinary teams should collaborate in the designs of digital health solutions in order to ensure usability, analytical clarity, and effective integration within healthcare infrastructures. Joint efforts should facilitate continuous evaluation and iterative improvement of digital health tools.
User-Centric Design and Usability	Digital health apps must be user-friendly, with intuitive interfaces and simplified navigation to enhance user experience and sustain engagement. Multidisciplinary collaboration in design and usability testing is crucial to ensure the creation of digital health tools that are responsive to user feedback, culturally sensitive, and adaptable to diverse demographic needs.

Source: Author

This study offers significant contributions to understanding digital platform adoption and its practical implications over time. It highlights the need to understand technological, institutional, and social factors and to support practical knowledge through the

frameworks of ANT, Systems Theory, and structural mechanisms.

Moreover, it offers a broad lens through which to examine the limitations of the NHS COVID-19 app; it has identified the potential for technology collaborations to improve transparency and governance, ultimately fostering better user engagement and system integration.

8.3. Limitations of the Study

Several intrinsic constraints defined the boundaries of this research and some areas that warranted further exploration. The following section highlights three significant limitations of this study:

1) over-dependence on document analysis;

2) adoption of a single-case approach; and

3) context-specific results.

8.3.1: Reliance on Document Analysis as the primary data collection method (Bowen, 2009; Scott, 1990)

A primary limitation of this study was the significant dependence on the analysis of documents that may not have reflected user experiences adequately. Although comprehensive insights into the uptake of the NHS COVID app were gathered from policy documents, academic articles, government reports, and media publications, these sources did not include direct user perspectives (Campbell et al., 2014).

To overcome this limitation, the use of qualitative methods such as interviews, focus groups, and surveys could provide responses that capture user opinions, views, and experiences concerning the app. Such an approach could illuminate the factors that influenced user choices regarding the app, including concerns about privacy, accessibility, and trust.

Also, feedback from stakeholders in the healthcare and technology realms—such as professionals, policymakers, and advisers—could yield valuable information on the operational difficulties and strategic choices that were faced during the app's development and rollout. This knowledge could improve our understanding of the dynamics that shape mobile app design and usage.

Future investigators should consider the use of a mixed-methods approach that combines document analysis with qualitative data gathering. This would facilitate a more thorough understanding of the elements affecting the NHS COVID-19 app's influence on public health and user adoption.

8.3.2. Limitations of using a Single-Case Study Approach

(Baxter and Jack, 2015; Yin, 2018)

This research centres exclusively on the NHS COVID-19 app, treating it as a sole case for thorough investigation. This methodology might restrict the applicability of the conclusions reached. Examination of individual cases can yield profound insights but may miss broader patterns that could be relevant to various digital health projects.

The creation and deployment of the NHS COVID-19 app took place amid a unique combination of public health concerns, technology usage, and regulatory frameworks. Elements such as the UK's governance structure, privacy laws enforced by authorities, public perceptions regarding technology use, and government involvement greatly affected the app's acceptance among users. These context-driven factors may not transfer to other apps focused on digitised healthcare in different nations or health systems(Borrego-Díaz et al., 2016).

To broaden the relevance of the insights gained from this study, a comparative analysis of multiple apps that tackle aspects of digital wellness in varied contexts could be conducted. These could:

- examine differences in adoption rates and user privacy concerns in various countries, such as Germany, South Korea, and Singapore, especially regarding national contact tracing apps;

- contrast platforms that provide specific COVID-19 tracking capabilities with wider digital health platforms, including telemedicine and electronic health record features, to evaluate public trust and user experience; and

- investigate initiatives from the private sector compared to those backed by the public sector, focusing on government-driven projects to improve the public’s well-being through digitisation.

Research that included multiple cases would allow for more effective evaluations of the trends that influence the uptake of digital wellness solutions and the identification of practical methods and potential obstacles that might affect the success of implementation efforts.

8.3.3. Context-Specific Findings

(Arsalan Nazir and Saleem Khan, 2023; Vogl, 2020; Yin, 2018)

The study's limitations include its concentration on the UK's management of COVID-19. Various factors such as policies, culture, and institutions that affect the adaptation to digital health might differ in other regions. Multiple factors, including GDPR compliance regulations, NHS-administered healthcare facilities, and public attitudes toward government-directed digital initiatives, influenced app usage patterns in the UK. These factors may not be applicable in all situations.

Further research is recommended to explore differences across sociopolitical contexts or in response to specific health crises regarding the implementation of advanced digitally integrated medical technologies. Several factors deserve additional investigation:

• regulatory and legal differences: The influence of data protection laws in various nations on trust in digital medicine could be considerable. A comparative study between areas with stringent data protection laws, such as the EU, and regions with more relaxed regulations may uncover differing levels of public confidence;

• technological perspectives in different cultures: Community acceptance of digital health resources may differ due to factors such as varying degrees of trust in technology, historical interactions with automated governance systems, and perceived risks of adoption of new technologies;

• healthcare system structures: a country's method of consolidating healthcare services, such as through NHS management, versus a decentralised approach that includes both public and private sectors, like that used in the USA, has a direct impact on the ability to incorporate advanced technologies into routine healthcare; and

• crisis-specific adoption trends: In scenarios that require specialised strategies to respond to crises, the public's willingness to adopt treatment methods powered by AI and machine learning may differ compared with non-emergency situations that demand ongoing disease management and preventive care.

Gaining insight into how local factors influence the implementation of next-generation virtual wellness solutions could enable authorities, research groups, and developers to create tailored interventions for specific populations while improving the current healthcare frameworks.

8.3.4. Ethical and Equity Considerations in Digital Health

This study did not specifically investigate ethical issues or concerns about fairness. These factors should be considered in future research. The NHS COVID-19 app sparked conversations regarding data privacy, monitoring practices, and digital isolation, especially for at-risk populations.

Some key ethical concerns are listed here.

• Striking a balance between public health protection and individual privacy - how can authorities effectively manage the implementation of electronic contact tracing systems while addressing worries about surveillance and data misuse?

• Algorithmic bias and barriers to accessibility - Did specific groups face exclusion from using this tool due to language barriers, lack of technological knowledge, or incompatibility with particular devices?

• The socioeconomic digital divide - what actions can emerging health-tech initiatives take to ensure equal access to all demographic groups and avoid worsening healthcare inequalities? Future research should investigate how equity-focused measures (such as technology tutoring programmes, community-driven health-tech models, and alternative access methods) could improve integration within diverse social groups.

Exploration of these elements could offer guidance for creating digital health solutions that foster inclusivity, trust, and credibility.

Although this study offers valuable insights into the adoption of the NHS COVID-19 app, its limitations highlight the necessity for future studies, particularly those that compare different contexts and user engagement levels.

Addressing these gaps through interdisciplinary collaboration could create more effective, ethically inclusive e-health solutions. Acknowledging stakeholder viewpoints and incorporating systemic and sociocultural factors will be essential in order to design and implement universally relevant telecare initiatives that are backed by evidence-based best practices.

Table 11. Recommendations for future research.

Recommendations for Future Research	Key Research Areas for Further Exploration
Longitudinal Studies on Digital Health Adoption	- Investigate long-term user engagement versus app abandonment (Kaiser, Wiens and Schultmann, 2021). - Assess factors leading to digital fatigue and declining participation and identify mitigating strategies (Torous et al., 2018). - Examine changes in user interactions and learning patterns over time. - Study long-term health outcomes associated with sustained digital health engagement (Pratap et al., 2020).
Sociocultural Factors in Digital Health Implementation	- Analyse how cultural attitudes and trust in institutions influence digital health adoption. - Explore the roles of community organisations, religious groups, and local leadership in promoting or resisting digital health interventions. - Study language, literacy, and accessibility barriers that impact adoption. - Identify barriers to digital adoption that marginalised or digitally excluded communities face.
Integration with Healthcare Systems	- Identify best practices for embedding digital health tools into healthcare infrastructure, such as hospitals and primary care networks. - Evaluate strategies for improving interoperability among various healthcare technologies and systems. - Investigate the roles of AI and machine learning in enhancing public health responses. - Examine how policy frameworks can ensure cohesive integration rather than fragmented implementations.
Ethical and Legal Considerations in Digital Health	- Explore strategies for balancing innovation with ethical responsibilities, particularly regarding privacy and surveillance. - Study regulatory frameworks (e.g., GDPR) to enhance data security and privacy protection. - Assess ethical implications of algorithmic biases and digital exclusion. - Examine public attitudes toward digital health interventions and privacy-security trade-offs.
Multi-Sector Collaboration for Digital Health Solutions	- Examine effective models of collaboration between the public and private sectors. - Research regulatory oversight and governance structures for digital health innovations. - Assess the influence of funding mechanisms (governmental vs. private) on digital health tool development. - Study international cooperation for developing interoperable digital health systems to enhance global pandemic resilience.

Source: Author

8.5. Final Remarks

This study has investigated the use of digital health tools to manage crises. It has focused on the NHS COVID-19 app and analysed its development and use from a sociotechnical perspective. By applying ANT, Systems Theory, and Structuration Theory, the research underscores that the success of e-health applications depends on technological aspects, the dynamics among diverse stakeholders, and the integration of systems while preserving public confidence. It points out that positive health outcomes are shaped not just by technological innovations but also by the framework of regulatory policies and public involvement.

A key point in the study is the realisation that digital technologies, such as the NHS COVID-19 app, function within a large societal framework that encompasses political and healthcare systems. The examination uncovers a complicated network of various entities that participated in the programme's rollout: government agencies create legislative guidelines for data privacy while promotional activities bolster marketing efforts. Additionally, policymakers have a crucial role in guiding these initiatives.

Private firms add value by designing the technology and providing essential technical knowledge, ensuring adherence to privacy regulations while aiming for user-friendly interfaces. Institutions incorporate these technologies into their current clinical practices, enhancing their contribution to patient care rather than viewing them strictly as technological tools. After the introduction of the NHS COVID-19 app, public attitudes, behavioural patterns, and levels of digital literacy significantly impacted its acceptance and ongoing use.

Nonetheless, the research suggests that achieving meaningful results extends beyond having advanced technological features, like Bluetooth, for contact tracing. Major obstacles surfaced during the rollout of the NHS app in response to the COVID-19 emergency, mainly due to concerns over privacy, communication gaps, and inequalities in digital access. Concerns about the potential misuse of personal data ignited public discussions, which illustrated the intricate relationship of trust amid the tension between technology and societal anxieties. Factors that shape the future direction of the app encompass its features and data management practices, along with public perceptions influenced by misinformation and privacy-related concerns.

The examination of the NHS COVID-19 app underscores the importance of negotiation meetings with diverse stakeholders, such as policymakers, healthcare executives, technology companies, and the general public, in influencing the app's design and public

perception. These engagements emphasise the necessity of continuous dialogue, collaboration, and modifications to govern digital health technologies successfully.

Systems Theory adds to this discussion by proposing that the incorporation of technological innovations into existing community health response frameworks is usually more advantageous than allowing them to function in isolation. An analysis of the NHS COVID-19 app exemplifies this notion; it has shown that optimal efficiency significantly depended on the alignment of the app with existing healthcare delivery mechanisms, including testing protocols and quarantine strategies.

Structuration Theory further enhances the understanding of this subject by highlighting how frameworks—including policy structures, institutional arrangements, and societal norms—impact public participation while being perpetually modified through user feedback. This principle is evident in the iterative enhancement processes that were employed by the teams responsible for developing the NHS COVID-19 app, where modifications were made based on public input.

Future initiatives in digital health technology should emphasise adaptability, openness, and user engagement to build trust and maximise advantages. Ethical considerations are essential, focused on collaboration across various levels and the promotion of flexible regulatory frameworks that ensure explicit data privacy protections. Healthcare practitioners are encouraged to promote the comprehensive integration of traditional clinical practices with modern technological solutions. Software developers are urged to establish methodologies that cater to the diverse needs of different cultural communities.

This leadership perspective offers insights into governance discussions regarding ethics, particularly those related to balancing the adoption of new technologies with the safeguarding of privacy rights. Moreover, the analysis indicates that addressing digital inequalities could enhance access to resources for different demographic groups.

This study emphasises the significance of addressing sociotechnical elements effectively in the integration of digital health during public emergencies. The example of the NHS's COVID-19 app demonstrates that the efficacy of digital health solutions heavily depends on the alignment of technological innovations, strong policy frameworks, and public confidence. As the deployment of these technologies for addressing public health crises expands, upcoming strategies must adopt a holistic sociotechnical perspective that recognises the interconnected roles of technology, institutions, and community members. This perspective seeks to enhance the advantages of digitised mediation to contribute to advancements in healthcare delivery

and crisis management while ensuring ethical and equitable practices.

8.6. Chapter Conclusion

The research indicates that the successful implementation of digital health tools, particularly the NHS COVID-19 app during the pandemic, hinges on technological capabilities, institutional strategies, and public confidence. By employing theories such as Actor-Network, Systems, and Structuration, the study highlights the intricacies of incorporating digital interventions into healthcare, which necessitates collaboration among various stakeholders and robust governance frameworks rooted in societal trust.

A significant finding is that technology alone does not ensure notable enhancements in public health results. Although sophisticated applications such as the NHS COVID-19 app can effectively address crises, their success depends on alignment with pre-existing medical infrastructures, coherent policies, and meaningful community involvement.

Utilising ANT, the research analyses the relationships among various stakeholders, including government bodies and private tech companies, and how these relationships impact user experiences, privacy protections, and, ultimately, the adoption rates of these technologies.

Systems Theory emphasises the importance of integrating advanced solutions aimed at public welfare into the larger public health systems. This integration should span the entire lifecycle of healthcare initiatives, starting with thoughtful design and moving towards smooth incorporation into current frameworks.

Structuration Theory provides insight into the governance structures that oversee digital healthcare, demonstrating the development of protocols and institutional guidelines that influence public perceptions. The study notes a transition towards viewing digital health technologies as essential rather than optional, and this highlights the necessity of adaptability and ongoing feedback to enhance these systems.

Ultimately, the conclusion is that a compassionate and responsive strategy is vital as societies embrace digital health technologies. Collaboration and open communication are required among all stakeholders engaged in public health.

The study focused application of Sociomateriality in addressing trust and transparency issues emphasises crucial elements in how the public perceives digital health solutions. People’s opinions regarding these technologies are shaped by the technology's tangible characteristics—such as data encryption, secure storage mechanisms, and

decentralised systems—and societal debates surrounding privacy, transparency, and data protection. The experience with the NHS COVID-19 app demonstrates that effective communication and trust-building efforts are vital to overcome initial doubts and sustain user involvement.

This analysis offers practical recommendations for policymakers, healthcare practitioners, and technology developers. Policymakers should strive to establish inclusive governance frameworks while clearly outlining ethical standards and ensuring that regulations prioritise user trust and data protection. Healthcare providers must incorporate new technologies to complement existing clinical workflows, enhancing rather than disrupting established healthcare practices.

Technology developers are encouraged to create user-centred designs guided by thorough usability assessments that are responsive to the varied needs of different communities. This can enhance overall public satisfaction.

During ongoing digital transformations related to public health emergencies, it is essential to prioritise inclusivity and implement ethically sound approaches. Given the varying levels of internet access within different communities, strategies that promote fair online access are crucial. Collaborative efforts across government agencies, private technology firms, healthcare institutions, and civil society organisations are vital if effective digital health systems are to be developed.

It is advantageous to perceive digital healthcare changes as technological progressions and social constructs that affect society. Adopting flexible governance and design principles that consider end-users can yield valuable insights for formulating future digital health approaches. Encouraging public trust through transparency and an adaptable strategy will better align digital health initiatives with broader healthcare objectives, ultimately equipping societies to face upcoming challenges.

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APPENDIX

WORK-IN-PROGRESS: CODING/THEMES GENERATION

Exploring the Adoption of the Digital Technology 'NHS COVID-19 App' in Managing the COVID-19 Pandemic in the UK - A Sociotechnical Perspective

Thematic Framework/Data Analysis Structure

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
Strategies adopted to mobilise a digital technology 'NHS COVID-19 App' in the UK	Research Question 1 How was a digital technology 'NHS COVID-19 app' mobilised to manage COVID-19 pandemic in the UK?	47	211
Digital Partnership approach	**Sample quote 1**: The app has been developed by the NHS and NHSX, the innovation arm of the health service, under the direction of the DHSC. There have been a number of other groups involved in the development of the app. The NHS has published a list of all the organisations involved in the app: Accenture, the Alan Turing Institute, NHS Digital, NHSx, Oxford University, VMware Pivotal Lab and Zuhlke Engineering. The UK's National Cybersecurity Centre (NCSC) has also provided technical advice to those working on the app. The app's development is being led by Gaby Appleton, a former director at academic publisher Elsevier. Appleton took over the management of the app in October and replaced former Apple executive Simon Thompson. As fact-checking organisation Full Fact has pointed out, Serco is not involved in the app. The outsourcing firm has been involved in other parts of the test and trace	16	53

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	programme but not in the creation of the app. All the source code behind the app has been made open source and is available on GitHub. There's also a privacy notice and data protection impact assessment on the government's website. These detail how the app handles information and the methods used to create it. For the first version of the app, these documents were not published until the app had already been tested. **NHS track and Trace (wired.co.uk), 22 Oct 2020** **Sample quote 2:** UK government Health and Social Care Secretary Matt Hancock said: We are at a tipping point in our efforts to control the spread of this virus. With infection rates rising we must use every tool at our disposal to prevent transmission, including the latest technology. We have worked extensively with tech companies, international partners, and privacy and medical experts – and learned from the trials – to develop an app that is secure, simple to use and will help keep our country safe. Today's launch marks an important step forward in our fight against this invisible killer and I urge everyone who can to download and use the app to protect themselves and their loved ones. From today certain businesses in England are required by law to display NHS Test and Trace QR codes so customers with the NHS COVID-19 app can use them to check-in. QR codes will help businesses meet their legal requirement to log contact details and allow public health leads to send alerts based on whether people have checked in at venues. So far, more than 160,000 businesses have already downloaded QR codes. Venues in Wales that are legally required to collect and keep a record of visitors will still need to do so **(Department of Health and Social Care, 24 Sept 2020)** **Sample quote 3***:* An app roll-out has been a long time coming. The first app was trialled on the Isle of Wight but didn't get national roll-out. Zühlke Engineering was first approached in March when NHSX asked the company to provide independent assurance and technical oversight of the first app project but concluded that it was not possible to develop a reliable app using the approach pursued the first time around and recommended a change in tack. From the third week in June, the		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	company began working on the current app and finished development in the first week of September. It is classed a medical device having received the CE mark and ISO 13485 certification. Emmerich explained the first app was similar to those designed in Singapore and France, and without the involvement of Apple and Google, which he said worked well as long as the operating system permitted Bluetooth communication. 'For very good reason Apple has decided that Bluetooth communication would not be possible for apps that run in the background or when the phone is in a sleep mode. The operating system of iOS shuts down Bluetooth communication of any apps that are in that status which effectively meant that the app would work fine if it's in the foreground, if you're looking at the user interface. But the moment the phone goes to sleep, or you choose a different app, then the Bluetooth communication would stop. 'We found on the first trial on the Isle of Wight that the iPhone app only detected a very small percentage of users, and it was decided that wasn't good enough **(Zühlke Engineering, 27th May 2021)** **Sample quote 4:** Digital technology is transforming every industry including healthcare. Digital and data have been used to redesign services, raising citizen expectations about self-service, personalisation, and convenience, and increasing workforce productivity. The pandemic has accelerated the shift to online and changed patient expectations and clinical willingness to adopt new ways of working. In addition, it facilitated new collaborations both in the centre of the NHS and wider local health and care systems. Together, these changes have enabled previously unimaginable progress in digitally enabled care pathways. **(Department of Health and Social Care 23rd November 2021)**		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
Community engagements	**Sample quote1:** The NHS has released the source code behind its coronavirus contact-tracing app. More than 40,000 people have installed the smartphone software so far. The health service is targeting the Isle of Wight only, at this stage, but it says this is the first stage of the app's rollout - not a test. Tests carried out on behalf of BBC News confirm the developers have found a way to work round restrictions Apple places on the use of Bluetooth in iPhones. In a related development, Health Secretary Matt Hancock has announced that Baroness Dido Harding will head up the wider test, track and trace programme. The appointment has surprised some given that when she was chief executive of TalkTalk, the internet provider suffered a major data breach and failed to properly notify affected customers **(BBC News 7th May 2020).** **Sample quote 2:** We have Open Sourced the code behind the new NHS COVID-19 app. In this technical blog post, Terence Eden, Head of Open Technology for NHSX, discusses the open-source offer behind the beta version of the app. Giving Feedback: We welcome technical feedback from developers and security researchers. Participation in the code development is via GitHub. We have a Code of Conduct for participants in order to create a safe and welcoming environment for all. Bug reports and performance improvement suggestions can be made by opening an issue on GitHub. We will review Pull Requests on a case-by-case basis. If you think you have found a security vulnerability, we would appreciate responsible disclosure via our secure reporting platform - http://hackerone.com/nhscovid19app. Open Source: All code is made available as Free and Open Source Software. It is released under the permissive MIT Licence - this allows you to copy and distribute the code for your own use. We are pleased	26	65

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	to be working with several international health care systems and are grateful for their advice in developing this code **(NHS England, 8 May 2020).**		
Test or Trial Phase	**Sample quote 1:** Council staff and healthcare workers on the Isle of Wight will be invited to install it on Tuesday, ahead of a wider roll-out on the island on Thursday. Project chiefs have said their so-called "centralised" approach gives them advantages over a rival scheme advocated by the US tech giants and some privacy experts. But fresh concerns have been raised. The Information Commissioner's Office has declared that "as a general rule, a decentralised approach" would better follow its principle that organisations should minimise the amount of personal data they collect. The House of Commons' Human Rights Select Committee also discussed fears about plans to extend the app to record location data. "There is an inherent risk that if you create a system that can be added to incrementally, you could do so in a way that is very privacy invasive," cautioned law professor Orla Lynskey **(BBC 4 May 2020)** **Sample quote 2:** This next phase will bring together the work done so far on the NHS COVID-19 app and the new Google/Apple framework. Following rigorous field testing and a trial on the Isle of Wight, we have identified challenges with both our app and the Google/Apple framework. This is a problem that many countries around the world, like Singapore, are facing and in many cases only discovering them after whole population roll-out. As a result of our work, we will now be taking forward a solution that brings together the work on our app and the Google/Apple solution. This is an important step, allowing us to develop an app that will bring together the functionality required to	15	38

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	carry out contact tracing, but also making it easy to order tests, and access proactive advice and guidance to aid self-isolation. NHS Test and Trace is already working to stop the spread of coronavirus and save lives. Building on our previous work, data published today (18 June) shows that tens of thousands more people who may have otherwise unwittingly spread the virus are now remaining safely at home. 3 weeks ago, we launched NHS Test and Trace as a brand new, end-to-end service, to help control the spread of COVID-19 and we are hugely grateful for the way the public have responded to protect those around them. *Joint statement from Baroness Dido Harding, Executive Chair of NHS Test and Trace and Matthew Gould, CEO, NHSX:* **(Department of Health and Social Care 18 June 2020)**		
Early Adopter phase and evaluation **Nationwide launch (promotion)**	**Sample quote 2:** The NHS COVID-19 app has been trialled in the London Borough of Newham, the Isle of Wight (IoW) and among NHS Volunteer Responders. This trial period is referred to as the early adopter phase. The NHS COVID-19 app programme commissioned a formal evaluation to ascertain perceptions of the NHS COVID-19 app and (intended) usage of its features during the early adopter phase. Quantitative online survey work was carried out among IoW residents between 25 August and 5 September 2020 and among NHS Volunteers between 27 August and 19 September 2020 by a third-party research agency, NatCen, who were commissioned by the NHS COVID-19 app programme. Telephone and online fieldwork were carried out between 12 and 27 September 2020 by another third-party research agency, IFF, who were commissioned by the NHS COVID-19 app programme. This report also includes NHS COVID-19 app analytics and NHS COVID-19 app store data covering the period of the trial as well as findings from insight work that was conducted with Newham community groups between 2 and 12 September 2020. The main findings of the evaluation are summarised below. NHS COVID-19 app downloads: Feedback obtained from users during the NHS COVID-19 app hypercare process was that users found the NHS COVID-19 app to be a useful tool to	12	55

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	keep friends and family safe and to provide good local area information. Additionally, they agreed that the NHS COVID-19 app had a 'slick' interface and that it does not drain the battery. This was a positive contrast to feedback received on the previous version of the NHS COVID-19 app, which, it was reported to drain batteries quickly. **(NHS COVID-19 app: early adopter evaluation report Department of Health and Social Care, 8 April 2021).** **Sample quote 1:** NHS COVID-19 app launches nationwide to help control COVID-19 transmission alongside national and local contact tracing. Features of the app include contact tracing using Bluetooth, risk alerts based on postcode district, QR check-in at venues, symptom checker and test booking – with user privacy and data security at its heart. Businesses are now required by law to display the official NHS QR code posters from today so people can check-in at different premises with the app. People across England and Wales are being urged to download the NHS COVID-19 app to help control the spread of coronavirus and protect themselves and their loved ones as case numbers rise.The app launches today, and after positive trials and rigorous testing is an important new tool to work alongside traditional contact tracing to help reduce the spread of the virus. It will be available to those aged 16 and over in multiple languages. It forms a central part of the NHS Test and Trace service in England and the NHS Wales Test, Trace, Protect programme – identifying contacts of those who have tested positive for coronavirus. As part of a major campaign to encourage downloads of the app a new		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	advertisement will launch on primetime TV tonight with the strapline 'Protect your loved ones. Get the app.' Today the UK's major mobile network operators, including Vodafone, Three, EE and O2, Sky and Virgin, have confirmed that all in-app activity will not come out of customers' data allowance. **(Department of Health and Social Science, 24 September 2020)** **Sample quote 2:** *More than one million people have downloaded the government's contact-tracing app for England and Wales within its first day of release*. NHS Covid-19 instructs users to self-isolate for 14 days if it detects they were nearby someone who has the virus. It also has a check-in scanner to alert owners if a venue they have visited is found to be an outbreak hotspot. Anyone aged 16 and over is being asked to install it. The government plans to give its own download tally on Monday. Media caption, Health Secretary Matt Hancock said the app "helps us to find more people who are at risk of having the virus" that human contact tracers are unable to find. "Everybody who downloads the app will be helping to protect themselves, helping to protect their loved ones, helping to protect their community because the more people who download it, the more effective it will be," he told BBC Radio 4's Today programme. The app keeps secret who receives a self-isolation alert. And there was some confusion about whether users could ignore a notification telling them to stay at home. Mr Hancock told BBC Breakfast: "That self-isolation is voluntary, unlike the mandatory self-isolation if you are called by NHS Test and Trace."Media caption, Matt Hancock said people might need to "upgrade" to access the NHS Covid-19 app. But the Department of Health had earlier said that users must obey the command and would in theory be liable for fines of £1,000 or more if they did not, while acknowledging it had no way to check. A senior source has since told the BBC that the notification is "advisory" because the authorities cannot legally enforce something that cannot be proved. (**BBC, 24 September 2020)**		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
Strategies adopted to promote a digital technology 'NHS COVID-19 App' in the UK	Research Question 2 How was a digital technology 'NHS COVID-19 App' promoted in the UK?	50	467
Promotion by prominent individuals and Society influencers	**Sample quote 1: *Queen's Speech:*** A time of disruption in the life of our country: a disruption that has brought grief to some, financial difficulties to many, and enormous changes to the daily lives of us all. I want to thank everyone on the NHS frontline, as well as care workers and those carrying out essential roles, who selflessly continue their day-to-day duties outside the home in support of us all. I am sure the nation will join me in assuring you that what you do is appreciated and every hour of your hard work brings us closer to a return to more normal times. I also want to thank those of you who are staying at home, thereby helping to protect the vulnerable and sparing many families the pain already felt by those who have lost loved ones. Together we are tackling this disease, and I want to reassure you that if we remain united and resolute, then we will overcome it. I hope in the years to come everyone will be able to take pride in how they responded to this challenge. And those who come after us will say the Britons of this generation were as strong as any. That the attributes of self-discipline, of quiet good-humoured resolve and of fellow-feeling still characterise this country. The pride in who we are is not a part of our past, it defines our present and our future. The moments when the United Kingdom has come together to applaud its care and essential workers will be remembered as an expression of our national spirit; and its symbol will be the rainbows drawn by	39	270

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	children. Across the Commonwealth and around the world, we have seen heart-warming stories of people coming together to help others, be it through delivering food parcels and medicines, checking on neighbours, or converting businesses to help the relief effort. And though self-isolating may at times be hard, many people of all faiths, and of none, are discovering that it presents an opportunity to slow down, pause and reflect, in prayer or meditation. It reminds me of the very first broadcast I made, in 1940, helped by my sister. We, as children, spoke from here at Windsor to children who had been evacuated from their homes and sent away for their own safety. Today, once again, many will feel a painful sense of separation from their loved ones. But now, as then, we know, deep down, that it is the right thing to do. While we have faced challenges before, this one is different. This time we join with all nations across the globe in a common endeavour, using the great advances of science and our instinctive compassion to heal. We will succeed - and that success will belong to every one of us. We should take comfort that while we may have more still to endure, better days will return: we will be with our friends again; we will be with our families again; we will meet again. But for now, I send my thanks and warmest good wishes to you all. **(BBC 5 April 2020)**		
	Sample quote 2: *The government paid social media influencers to promote the NHS Test and Trace service, it has confirmed.* Instagram influencers, including Love Island stars, were paid an undisclosed amount to make posts during lockdown. The social media posts were part of a wider campaign to inform the public about the programme. "Our use of social media influencers has meant over 7 million people have been reached," said	4	7

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	a spokesman for the government. "As a responsible government, we will use every means possible to keep the public informed during the pandemic and raise awareness of NHS Test and Trace. "This is just one part of a wider campaign utilising TV, radio, social, print, and other advertisements to ensure the public has the information it needs."The government said that all costs involved in the campaign would be published in due course as part of the regular transparency reports on gov.uk. Dozens of Instagram influencers including former Love Island contestants Shaughna Phillips, Chris Hughes and Josh Denzel made paid Instagram posts marked as ads, with the hashtags "#gettested" and "letsgetback". **(BBC, 31 August 2020).**		
Projected as quick fix solution to COVID-19 virus spread	**T 1Sample quote 1:** The NHS COVID-19 app is available to download for free in England and Wales. If you live in either nation and are 16 or over, you can download the app on your phone. The app includes a number of features to help you protect yourself and others, including: getting alerts to let you know if you may be at risk from coronavirus (COVID-19) symptoms checker the latest advice based on your circumstances. general information on COVID-19 entering a positive result (from an NHS or paid-for test) to alert others if they may be at risk The app will provide you with the latest information depending on where you live. Guidance may differ in England and Wales. The app will be updated from time to time with new functionality and improvements. The latest version includes up-to-date features and advice so it's important to keep it updated. The NHS COVID-19 app uses Bluetooth Low Energy (BLE) to understand the distance, over time, between app users. Typically, you'll be sent an exposure	7	12

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	notification with guidance if you've been within 2 metres of someone for 15 minutes or longer who has since tested positive for COVID-19. If a person tests positive for COVID-19, reports the result in the app, and agrees to share their random IDs, the app will calculate the risk to every app user they came into contact with in the previous few days – with this information, the app will work out whether a user should get an exposure notification **(UK Health Security Agency, 13 May 2022)** **Sample quote 2:** People should continue using the NHS Covid contact tracing app in England and Wales and isolate when asked to do so, Downing Street has said. The prime minister's spokesman said the app had been an "important tool" and Boris Johnson continued to use it. The software detects the distance between users and the length of time spent in close proximity - currently 2m or less and more than 15 minutes. It comes amid a huge rise in alerts as infections surge. The latest government figures show UK infections are continuing to rise, with 35,707 Covid cases reported on Friday - the highest daily cases figure since 22 January. A further 29 deaths within 28 days of a positive test were also recorded. Earlier Transport Secretary Grant Shapps said the app's sensitivity may need to change when the 1m-plus rule ends on 19 July. The system allows people who test positive to anonymously share their test result, triggering alerts for those detected as close contacts in the days before the test. Under current rules, those who receive an alert are asked to stay at home for up to 10 days, although the Department of Health said the app "is, and always has been, advisory" - unlike the requirement to isolate if you are contacted directly by NHS Test and Trace. **(BBC, 9 July 2021)**		
Multiple communication channels	**Sample quote 1: Sample quote 3:** The NHS App has been developed by the NHS to help people in England get more information about their health and care - and more control of how they use NHS services. Available to download on all iOS and Android devices, it allows you to book appointments at your GP surgery, manage repeat prescriptions,	7	24

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	view your GP medical records, set organ donation preferences and much more. New functions and services will also be added in the coming months. We have developed a resource pack, including posters, images for social media, a presentation, web banners, and suggested copy for bulletins and newsletters, to help communications teams raise awareness of the NHS App to the public and to your staff, so you can be part of the campaign too. We've included lots of different versions of images and other resources, so that you can use them as easily as possible within your own settings, but if you would like any of the resources in other formats or sizes, you can contact us at enquiries@nhsdigital.nhs.uk.(**Raising awareness of the NHS App - NHS Digital**) **Samplequote2: IMAGE REMOVED FOR COPYRIGHT REASONS** Web capture 'NHS COVID-19 APP - Search Images (bing.com)'		
Political class in health crisis frontline campaign	**Sample quote 1:** Health Secretary Matt Hancock said the app "helps us to find more people who are at risk of having the virus" that human contact tracers are unable to find. "Everybody who downloads the app will be helping to protect themselves, helping to protect their loved ones, helping to protect their community because the more people who download it, the more effective it will be," he told BBC Radio 4's Today programme. The app keeps secret who receives a self-isolation alert. And there was some confusion about whether users could ignore a notification telling them to stay at home. Mr Hancock told BBC Breakfast: "That self-isolation is voluntary, unlike the mandatory self-isolation if you are called by NHS Test and Trace." **(BBC, 24 Sept**	18	68

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	2020) **Sample quote 2:** ***People should continue using the NHS Covid contact tracing app in England and Wales and isolate when asked to do so, Downing Street has said.*** The prime minister's spokesman said the app had been an "important tool" and Boris Johnson continued to use it… The Welsh government has said ***people in Wales should continue to use the app even if social distancing rules differ from those in England***. No date has been given for the end of the 1m-plus rule in Wales. One possible solution could be to change the sensitivity of the app, so it would tell people to self-isolate only after closer and more prolonged contact. But sources at the app developers told the BBC they have not yet been asked to do this, although they are planning a change from 16 August when people would be able to record that they were fully vaccinated to turn off the self-isolation countdown timer. Mr Shapps told BBC Breakfast: "As our restrictions change, of course the app needs to change. Things like replacing the 1m-plus rule on 19 July might well lead to a review of the way the app itself needs to function." The most recent figures for the last week of June show an extra 300,000 downloads, bringing the total to more than 26 million, but it is not known how many people are active users. "It's in our interests as a society to carry on doing the things that protect each other," Mr Shapps said. **(BBC, 9 July 2021)**		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
Emotional and touching campaign appeals	**Sample quote 1:** As part of a major campaign to encourage downloads of the app a new advertisement will launch on primetime TV tonight with the strapline 'Protect your loved ones. Get the app.' Today the UK's major mobile network operators, including Vodafone, Three, EE and O2, Sky and Virgin, have confirmed that all in-app activity will not come out of customers' data allowance. The contact tracing element of the app works by using low-energy Bluetooth to log the amount of time you spend near other app users, and the distance between you, so it can alert you if someone you have been close to later tests positive for COVID-19 – even if you don't know each other. The app will advise you to self-isolate if you have been in close contact with a confirmed case. It will also enable you to check symptoms, book a free test if needed and get your test results. The app has been designed with user privacy in mind, so it tracks the virus, not people and uses the latest in data security technology to protect privacy. The system generates a random ID for an individual's device, which can be exchanged between devices via Bluetooth (not GPS). These unique random IDs regenerate frequently to add an extra layer of security and preserve anonymity. The app does not hold personal information such as your name, address or date of birth, and only requires the first half of your postcode to ensure local outbreaks can be managed. No personal data is shared with the government or the NHS **(Department of Health and Social Care, 24 Sept 2020)** **Sample quote 2:** *Download the NHS COVID-19 app and help protect your loved ones.* People across North East Lincolnshire are being urged to download the **NHS COVID-19 app**- external site to help control the spread of coronavirus and protect themselves and their loved ones as case numbers rise across the UK. The app launches today, and after positive trials and rigorous testing is an	30	135

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	important new tool to work alongside traditional contact tracing to help reduce the spread of the virus… Cllr Philip Jackson, leader of North East Lincolnshire Council, said: "The launch of the NHS COVID-19 app is an important part of the government's coronavirus response. The more people who download and use this app, the more it will help us to prevent the spread of COVID-19. This is a welcome step in protecting those around us." (**North East Lincolnshire Council home page, 24 Sept, 2024**) **Sample Quote: 3** IMAGE REMOVED FOR COPYRIGHT LAWS REASONS **BBC, 29 OCT 2020** **Sample Quote: 4** **IMAGE REMOVED** **(NHS Covid-19 app explainer - Search Images (bing.com) 10 Jan 2024)**		
Multilingual	**Sample quote 1:** The app launches today, and after	10	24

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
campaign/making the messages on the app clearer.	positive trials and rigorous testing is an important new tool to work alongside traditional contact tracing to help reduce the spread of the virus. It will be available to those aged 16 and over in multiple languages. It forms a central part of the NHS Test and Trace service in England and the NHS Wales Test, Trace, Protect programme – identifying contacts of those who have tested positive for coronavirus. **(North East Lincolnshire Council home page, 24 Sept, 2024)** **Sample quote 2:** **PICTURE REMOVED** **(Public Health Messaging for Communities from Different Cultural Backgrounds SPI-B, 22 July 2020)** **Sample quote 3:** The report sets out a number of stakeholder requests for action across the following domains. Research and data: to deepen our understanding of the wider socio-economic determinants, improve data recording of faith and ethnicity and greater use of community participatory research. Policy: ensuring long term sustainable change, establish cross government infrastructure to drive change, address occupational risk and act to mitigate the impact of race crime. Communications: work with community leaders to enhance the depth of reach into BAME communities ensuring guidance and media is culturally appropriate and available in different languages use different approaches to mitigate fears and encourage improved uptake of vital prevention services. Anchor institutions: scale up prevention services in a targeted and timely way, develop strategies to rebuild trust with health and care services, co-produce solutions with BAME groups and faith leaders, provide safeguards to mitigate risks for all frontline workers. In conclusion, this report provides additional information and insights on the relationship between COVID-19 and		

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vii) Partnership Campaign	BAME communities in England from a rapid review of the published literature and stakeholder engagement exercise. Although our understanding is evolving rapidly, it is difficult at this stage to provide a full explanation of the observed differences. Ethnic inequalities in health and wellbeing in the UK existed before COVID-19 and the pandemic has made these disparities more apparent and undoubtedly exacerbated them. The unequal impact of COVID-19 on BAME communities may be explained by a number of factors ranging from social and economic inequalities, racism, discrimination and stigma, occupational risk, inequalities in the prevalence of conditions that increase the severity of disease including obesity, diabetes, CVD and asthma. Unpacking the relative contributions made by different factors is challenging as they do not all act independently. The engagement sessions highlighted the BAME groups deep concern and anxiety that if lessons are not learnt from this initial phase of the epidemic, future waves of the disease could again have severe and disproportionate impacts. All were united in the commitment that urgent, collaborative and decisive action is required to avoid a repeat of this in the future. **(Beyond the Data: Understanding the Impact of COVID-19 on BAME Communities (publishing.service.gov.uk), June 2020)** **Sample quote 1: Businesses urged to prepare for NHS COVID-19 app:** Pubs, restaurants, hairdressers, cinemas and other venues across England and Wales are being urged to download QR codes to prepare for public rollout of new app. IMAGE REVOVED The NHS COVID-19 app is currently being trialled and will launch on Thursday 24 September in England and Wales, including QR check-in at venues. QR codes will be an important way for NHS Test and Trace in England and NHS Test, Trace, Protect in Wales to contact multiple people if coronavirus outbreaks are identified in venues. Businesses across England and Wales like pubs, restaurants, hairdressers and cinemas are being urged to ensure they have NHS QR code posters		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	visible on entry so customers who have downloaded the new NHS COVID-19 app can use their smartphones to easily check-in. The move comes ahead of a national launch of the NHS COVID-19 app across England and Wales on Thursday 24 September. The government will be supporting businesses and venues to display the QR codes, which can be downloaded via a website to display as posters in premises. Following the launch of the new COVID-19 app, customers and visitors in England will be able to check-in on entry with their phone instead of filling out a check-in book or tool specific to a business. This will allow NHS Test and Trace to contact customers with public health advice should there be a COVID-19 outbreak. In England, using QR codes will help businesses meet the new legal requirement to record the contact details of customers, visitors and staff on their premises. With coronavirus cases rising in the UK in the last few weeks it is essential businesses capitalise on the benefits QR codes can bring to protect themselves and their customers. **(Department of Health and Social Care, 11 Sept 2020)**		
A digital technology 'NHS COVID-19 App' shaping response of COVID-19 pandemic in the UK	Research question 3 How a digital technology 'NHS COVID-19 App' helped shape the COVID-19 pandemic response in the UK?	35	197
Creation of 'digital healthcare'	**Sample quote 1:** *Matt Hancock (Secretary of State for Health and Social Care):* Remote consultations, for instance, have supported thousands of patients to stay safely at home and get the healthcare they need. 99% of practices can now offer video consultations,	13	44

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	up from 3% at the start of the year, and the feedback from both patients and clinicians is overwhelmingly positive. 111 online has also been amazing and will get stronger and stronger. Much of NHS Test and Trace is already online. You can book a test and get advice online, while of course the telephone service is available for all those who need it. And throughout the lockdown we've supported care homes to introduce modern digital tools; whether online check-ins with local GPs, getting care homes onto NHSmail or the over 2000 tablets we've given to care settings to allow residents to stay in close touch with loved ones, something that's so important for people's wellbeing. There is no going back on these improvements, and it's not just the front-end patient-facing services that have been transformed, it's the digital back-end too. Getting our data infrastructure into shape has been a vital part of the NHS response to the pandemic.**(How technology helped shape the pandemic response - NHS Transformation Directorate (england.nhs.uk), 30 July 20** **Sample quote 2:** The contact tracing element of the app works by using low-energy Bluetooth to log the amount of time you spend near other app users, and the distance between you, so it can alert you if someone you have been close to later tests positive for COVID-19 – even if you don't know each other. The app will advise you to self-isolate if you have been in close contact with a confirmed case. It will also enable you to check symptoms, book a free test if needed and get your test results…As well as contact tracing, the app has a range of additional, enhanced features that will help to reduce personal and public risk from COVID-19 as part of the wider testing and contact tracing service: Alert: letting users know the level of coronavirus risk in their postcode district QR check-in: enabling users to check-in at a venue and alerting them if they have recently visited somewhere they may have come into contact with someone who later tests positive for COVID-19 Symptoms: allowing users to check if they have coronavirus symptoms and see if they need to order		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	a free test Test: helping users book a free test through the app and get results to know whether they have COVID-19 Isolate: if a user is told to self-isolate, a timer feature will help count down that period and access will be provided to relevant advice **(NHS COVID-19 app - COVID-19 response - NHS Transformation Directorate (england.nhs.uk) 1 July 2020)** **Sample quote 3:** *Digital revolution to bust COVID backlogs and deliver more tailored care for patients.* People across the country will benefit from faster, more personalised healthcare, following a digital revolution to make the health and social care system fit for the 21st century. Rapid expansion of use of technology – including remote monitoring and virtual wards – to drive efficiency, free up hospital space and clinician time, and bust the COVID backlogs NHS App to be updated with new features offering more personalised care from home, such as increasing patients' access to their records and enabling notifications directly from their GP Digital reforms to deliver benefits over the next decade that could save billions in taxpayers' money while also promoting economic growth and private investment People across the country will benefit from faster, more personalised healthcare, following a digital revolution to make the health and social care system fit for the 21st century. The plan for digital health and social care, published today (Wednesday 29 June), sets out the government's ambitious vision for transforming health and care with digital technology – which give patients access to quicker and more effective care at their fingertips and will save the health and care systems time and money. The plan sets out how we will improve access to information for people and their care teams through the NHS App		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	and NHS website – resulting in faster, more personalised treatment. This includes bringing information together into the app and enabling people to view and manage hospital appointments, have virtual consultations, and see notifications from their GP. It also outlines the acceleration of the use of digital technology across the NHS and social care to improve efficiency and free up frontline workers' time, helping to bust the COVID backlogs. By increasing the availability of remote monitoring – where patients can use technology to keep an eye on their condition from home – a further 500,000 people could be better supported by March 2023. Over 280,000 people already used remote monitoring at home and in care homes for long-term conditions in the last year, freeing up hospital beds and saving clinicians' valuable time. This has resulted in improvements in patient outcomes – with problems picked up earlier, shorter stays in hospital, and fewer admissions in the first place.**(Department of Health and Social Care and The Rt Hon Sajid Javid MP, 29 June 2022)**		
Provision of a virtual 'health passport'	**Sample quote 1:** Following its September 2020 launch, the NHS COVID app soon became integral to British pandemic life - it was needed to board flights, enter bars and restaurants, and store essential COVID vaccine information. But its end does not mean the pandemic is over. For more than two years, the NHS COVID App dictated the lives of those living in the UK - it told us which counties were safe to travel into, who people could spend Christmas with, and how close the public could get to their loved ones. But on Thursday, it is being switched off for the final time. No more "getting **pinged**", or needing a bar code to enter a restaurant. The app is **estimated to have saved thousands of lives** and stopped millions of infections but now the fight against the virus enters a new phase and it is no longer needed.**(SKY News, 26 April 2023)** **Sample quote 2:** *Transport secretary Grant Shapps appeared to confirm in a recent interview that England's NHS app extension of NHS COVID-19 App*	9	21

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	would be used as a vaccine passport. Travel restrictions are due to ease on 17 May, after which foreign travel can resume. However a government source told the BBC the app would not be ready "imminently". It is connected to GP services in England and linked to personal health data. People can use the NHS app to request repeat prescriptions, message their doctor and organise online consultations. It is completely separate from the NHS Covid-19 app, which is used for contact-tracing. The NHS app is already able to display vaccine statuses, including Covid-19 jabs - but this must be enabled by GPs, and while some seem to do this by default, other surgeries ask patients to request it. Vaccines Minister Nadhim Zahawi told BBC Breakfast that work was under way on preparing it to act as a passport - this could involve it having access to not only vaccine status, but also to most recent test results. "NHSx [the NHS's digital division]...are working on making that operationally possible for the 17th of May," he said.But in a statement, the Department of Health and Social Care said only that the app was "being considered as part of the digital route".**(BBC, 29 April 2021)**		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	Sample quote 3: PICTURE REMOVED (What your NHS COVID Pass letter tells you (easy read) 21 May 2021 (publishing.service.gov.uk)		
Generation of valuable real-time and infectious rate	**Sample quote 1:** Secure reliable data from the NHS COVID-19 data store has ensured that those leading the response to the virus in both the NHS and government have the data we need to manage the response in real-time. We also issued simple guidance endorsed by the ICO and the National Data Guardian to ensure data can be shared and can get to where it's needed, and that, crucially, data-sharing rules do not get in the way of looking after patients. The easy-to-use guidance we've published means that staff on the frontline can feel confident that they're doing the right thing when they're using patient information. We will not be going backward on this approach either but will continue to make it easy to use data properly to deliver care and save lives. None of this would have been possible without the remarkable, can-do attitude to tech that has characterised the NHS's response to the pandemic, across the frontline. People simply refused to accept that something was too difficult to do, or that it would take years rather than weeks. All of this is a huge tribute to the work of so many, right across our health and care system: the CIOs, CCIOs and CNIOs who've driven these innovations; the frontline staff who've thrown themselves in to new ways of working; and the patients themselves who've been amazingly willing to embrace new ways of accessing the NHS.	5	10

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	This has been a truly national effort. The old argument about whether it's right to prioritise modern technology in the NHS and our care sector is over. The pandemic has proven beyond doubt that better tech is vital for the future success of our health and care service. **How technology helped shape the pandemic response - NHS Transformation Directorate (england.nhs.uk), 30 July 2020** **Sample quote 2:** Health and Social Care Secretary Matt Hancock said: As we move to the next stage of our fight against coronavirus, we will be able to replace national lockdowns with individual isolation and, if necessary, local action where there are outbreaks. NHS Test and Trace will be vital to stopping the spread of the virus. It is how we will be able to protect our friends and family from infection and protect our NHS. This new system will help us keep this virus under control while carefully and safely lifting the lockdown nationally. NHS Test and Trace brings together 4 tools to control the virus: test: increasing availability and speed of testing will underpin NHS Test and Trace. trace: when someone tests positive for coronavirus the NHS Test and Trace service will use dedicated contact tracing staff, online services and local public health experts to identify any close recent contacts they've had and alert those most at risk of having the virus who need to self-isolate. This will be complemented by the rollout of the NHS COVID-19 App in the coming weeks. **(Government launches NHS Test and Trace service - GOV.UK (www.gov.uk) 27 May 2020)**		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
Merger of medical science and a digital technology	**Sample quote 1:** This next phase will bring together the work done so far on the NHS COVID-19 app and the new Google/Apple framework. Following rigorous field testing and a trial on the Isle of Wight, we have identified challenges with both our app and the Google/Apple framework. This is a problem that many countries around the world, like Singapore, are facing and in many cases only discovering them after whole population roll-out. As a result of our work, we will now be taking forward a solution that brings together the work on our app and the Google/Apple solution. This is an important step, allowing us to develop an app that will bring together the functionality required to carry out contact tracing, but also making it easy to order tests, and access proactive advice and guidance to aid self-isolation. NHS Test and Trace is already working to stop the spread of coronavirus and save lives. Building on our previous work, data published today (18 June) shows that tens of thousands more people who may have otherwise unwittingly spread the virus are now remaining safely at home. Joint statement from Baroness Dido Harding, Executive Chair of NHS Test and Trace and Matthew Gould, CEO, NHSX: 3 weeks ago we launched NHS Test and Trace as a brand new, end-to-end service, to help control the spread of COVID-19 and we are hugely grateful for the way the public have responded to protect those around them. Our ambition is to develop an app which will enable anyone with a smartphone to engage with every aspect of the NHS Test and Trace service, from ordering a test through to accessing the right guidance and advice. This will support our vision of helping more people get back to the most normal life possible at the lowest risk. **(Next phase of NHS coronavirus (COVID-19) app announced - GOV.UK (www.gov.uk), 18 June 2020)** **Sample quote 1:** The NHS COVID-19 app is available to download for free in England and Wales. If you live in either nation and are 16 or over, you can download the app on your phone. The app includes a number of features to help you protect yourself and	1	1

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	others, including: getting alerts to let you know if you may be at risk from coronavirus (COVID-19) a symptoms checker the latest advice based on your circumstances general information on COVID-19 entering a positive result (from an NHS or paid-for test) to alert others if they may be at risk The app will provide you with the latest information depending on where you live. Guidance may differ in England and Wales. The app will be updated from time to time with new functionality and improvements. The latest version includes up-to-date features and advice so it's important to keep it updated.**(NHS COVID-19 app - GOV.UK (www.gov.uk), 13 May 2022)**		
Community participation to curb the virus's spread	**Sample quote 1:** Please install the app, and use it. Digital contact tracing is new and no-one's done it at scale before. Using Bluetooth to measure distance in the real world hasn't been done at this scale before. Interoperating between massive numbers of different devices in ways that weren't originally conceived hasn't been done before. And we've not battled a pandemic like this before. So, we're all learning simultaneously across the disciplines of epidemiology, socio-technical interaction, engineering, modelling and privacy and security. We've chosen to make the NHS app simple and robust against some of the problems we think we'll face in deployment. As our understanding of the virus evolves, so will our response, including how the app works. It may turn out that one of the other models proposed actually helps manage the virus better. No-one knows today, but the UK is responding based on the best scientific advice available today. If that advice means the app has to change, we'll evolve the design. But the NHS will always be transparent about what the app does and how. The coronavirus pandemic requires a public health led strategic response and the NHS app is one small, but important and visible, part of that. The design of the app must	11	24

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	be led by the epidemiological needs of that response and the security and privacy models have to fit around that. An app that provides fantastic provable privacy but doesn't help stop the spread of the disease isn't a useful tool. The NHSX team developing this app is diverse, multi-disciplined, science and evidence led and working flat out to build a product that protects the public. **(The security behind the NHS contact tracing app - NCSC.GOV.UK, 4 May 2020)** **Sample quote 2:** *NHS COVID-19 app launches to help control coronavirus (COVID-19) transmission.* NHS COVID-19 app launches nationwide to help control COVID-19 transmission alongside national and local contact tracing Features of the app include contact tracing using Bluetooth, risk alerts based on postcode district, QR check-in at venues, symptom checker and test booking – with user privacy and data security at its heart Businesses are now required by law to display the official NHS QR code posters from today so people can check-in at different premises with the app People across England and Wales are being urged to download the NHS COVID-19 app to help control the spread of coronavirus and protect themselves and their loved ones as case numbers rise. The app launches today, and after positive trials and rigorous testing is an important new tool to work alongside traditional contact tracing to help reduce the spread of the virus. It will be available to those aged 16 and over in multiple languages. It forms a central part of the NHS Test and Trace service in England and the NHS Wales Test, Trace, Protect programme – identifying contacts of those who have tested positive for coronavirus.**(NHS COVID-19 app launches across England and Wales - GOV.UK (www.gov.uk) 24 Sept 2020)**		
Leveraging of Bluetooth technology	**Sample quote 1:** The contact tracing element of the app works by using low-energy Bluetooth to log the amount of time you spend near other app users, and	3	5

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
for contact tracing	the distance between you, so it can alert you if someone you have been close to later tests positive for COVID-19 – even if you don't know each other. The app will advise you to self-isolate if you have been in close contact with a confirmed case. It will also enable you to check symptoms, book a free test if needed and get your test results. The app has been designed with user privacy in mind, so it tracks the virus not people, and uses the latest in data security technology to protect privacy. The system generates a random ID for an individual's device, which can be exchanged between devices via Bluetooth (not GPS). These unique random IDs regenerate frequently to add an extra layer of security and preserve anonymity. The app does not hold personal information such as your name, address or date of birth, and only requires the first half of your postcode to ensure local outbreaks can be managed. No personal data is shared with the government or the NHS. **(NHS COVID-19 app - COVID-19 response - NHS Transformation Directorate (england.nhs.uk), 1 July 2020)** **Sample quote 2:** Every day, your device generates a random elliptic curve key pair and encrypts your installation ID (and some other administrative stuff like time periods) with it in a way that only the NHS server can recover, giving you a daily, random-looking, encrypted 'blob'. Now, your phone advertises a contact service over Bluetooth Low Energy (BLE) – the same mechanism that your phone uses to talk to your step tracker or smart watch. When another app user comes close enough to be seen over BLE, the devices connect to each other's contact service and exchange a package containing their current encrypted blobs, the time and the transmission power used for the BLE connection, all signed using the device authentication key. While the phones can see each other, the app samples and records the Bluetooth signal strength every few seconds. Signal strength is a proxy for distance, so this record represents something about the physical encounter. Every time this happens, the record (date and time, package received over BLE, sampled signal strength, total duration of encounter) is securely stored on your phone. If nothing happens, each record is deleted		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	after 28 days. At this point, nothing has been sent back to the NHS.(**The security behind the NHS contact tracing app - NCSC.GOV.UK, 4 May 2020)**		
Simplification of the contact tracing process	**Sample quote 1:** NHS COVID-19 app: preventing 600,000 cases of COVID-19. NHS Test and Trace (NHSTT) is a central part of the government's COVID-19 recovery strategy. Testing to identify cases and tracing those who may have contracted COVID-19 through social contact is essential to control the spread of the virus. The NHS COVID-19 app complements NHS Test and Trace processes by extending the speed, reach and precision of contact tracing. It allows close contacts unknown to the individual who has tested positive, for example strangers on public transport, to be notified to self isolate, if they are also an app user. (**NHS COVID-19 app: preventing 600,000 cases of COVID-19 - Improving health and care services for everyone - NHS Transformation Directorate (england.nhs.uk)** **Sample quote 2:** As well as contact tracing, the app has a range of additional, enhanced features that will help to reduce personal and public risk from COVID-19 as part of the wider testing and contact tracing service: Alert: letting users know the level of coronavirus risk in their postcode district QR check-in: enabling users to check-in at a venue and alerting them if they have recently visited somewhere they may have come into contact with someone who later tests positive for COVID-19 Symptoms: allowing users to check if they have coronavirus symptoms and see if they need to order a free test Test: helping users book a free test through the app and get results to know whether they have COVID-19 Isolate: if a user is told to self-isolate, a timer feature will help count down that period and access will be provided to relevant advice (**NHS COVID-19 app - COVID-19 response - NHS Transformation Directorate (england.nhs.uk), 1**	5	7

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	July 2020)		
As a sign of hope to tackle the crisis	**Sample quote 1:** More than one million people have downloaded the government's contact-tracing app for England and Wales within its first day of release. NHS Covid-19 instructs users to self-isolate for 14 days if it detects they were nearby someone who has the virus. It also has a check-in scanner to alert owners if a venue they have visited is found to be an outbreak hotspot. Anyone aged 16 and over is being asked to install it. The government plans to give its own download tally on Monday. Media caption, Health Secretary Matt Hancock said the app "helps us to find more people who are at risk of having the virus" that human contact tracers are unable to find. "Everybody who downloads the app will be helping to protect themselves, helping to protect their loved ones, helping to protect their community because the more people who download it, the more effective it will be," he told BBC Radio 4's Today programme. The app keeps secret who receives a self-isolation alert. And there was some confusion about whether users could ignore a notification telling them to stay at home. Mr Hancock told BBC Breakfast: "That self-isolation is voluntary, unlike the mandatory self-isolation if you are called by NHS Test and Trace." **(BBC 24 Sept 2020)**	19	43
Challenges faced by a digital technology 'NHS COVID-19 App'	**Research Question 4** What were the challenges encountered by adopting a digital technology NHS COVID-19 App to manage COVID-19 pandemic in the UK?	34	47

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
Data Privacy Concerns	**Sample quote 1:** Wide-ranging security flaws have been flagged in the Covid-19 contact-tracing app being piloted in the Isle of Wight. The security researchers involved have warned the problems pose risks to users' privacy and could be abused to prevent contagion alerts being sent. GCHQ's National Cyber Security Centre (NCSC) told the BBC it was already aware of most of the issues raised and is in the process of addressing them. But the researchers suggest a more fundamental rethink is required. Specifically, they call for new legal protections to prevent officials using the data for purposes other than identifying those at risk of being infected, or holding on to it indefinitely. In addition, they suggest the NHS considers shifting from its current "centralised" model - where contact-matching happens on a computer server - to a "decentralised" version - where the matching instead happens on people's phones. "There can still be bugs and security vulnerabilities in either the decentralised or the centralised models," said Thinking Cybersecurity chief executive Dr Vanessa Teague. "But the big difference is that a decentralised solution wouldn't have a central server with the recent face-to-face contacts of every infected person. "So there's a much lower risk of that database being leaked or abused."Health Secretary Matt Hancock said on Monday a new law "is not needed because the Data Protection Act will do the job". And NHSX - the health service's digital innovation unit - has said using the centralised model will both make it easier to improve the app over time and trigger alerts based on people's self-diagnosed symptoms rather than just medical test results. **(BBC, 9 May 2020)**	7	20

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	Sample quote 2: *An update to England and Wales's contact tracing app has been blocked for breaking the terms of an agreement made with Apple and Google*. The plan had been to ask users to upload logs of venue check-ins - carried out via poster barcode scans - if they tested positive for the virus. This could be used to warn others. The update had been timed to coincide with the relaxation of lockdown rules. But the two firms had explicitly banned such a function from the start. Under the terms that all health authorities signed up to in order to use Apple and Google's privacy-centric contact-tracing tech, they had to agree not to collect any location data via the software. As a result, Apple and Google refused to make the update available for download from their app stores last week, and have instead kept the old version live. When questioned, the Department of Health declined to discuss how this misstep had occurred. (**BBC, 12 April 2021)**		
False and Excessive Alerts	**Sample quote 1:** *The NHS Covid-19 app will be altered to send out fewer isolation alerts, the BBC has learned.* The team behind the contact tracing app for England and Wales has been told to adjust the measurements which trigger the alerts, a source has confirmed. The time frame for the change is not yet known. Transport Secretary Grant Shapps had suggested that the app might need to change for the planned lifting of restrictions in England on 19 July. The app has so far been downloaded nearly 26m times in England and Wales. But businesses and individuals have raised concerns that too many people were being advised to self-isolate for up to 10	6	15

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	days, following close contact with a device that later reported a positive Covid test result. A requirement to self-isolate if people have had both vaccine doses will only stop on 16 August, raising fears that millions would be asked to self-isolate this summer as they mixed more after 19 July, and cases rise. The UK is experiencing a marked increase in Covid infections, according to the Office for National Statistics, with the latest data suggesting one in every 160 people has the virus. That is up from one in every 250 in the previous week and an estimated 400,000 people are thought to have been positive in the week to 3 July. **(BBC, 9 July 2021)** **Sample quote 2:** The app was fraught with challenges. At one point its algorithm had to be tweaked after tens of thousands of people were receiving alerts every day telling them to self-isolate in case they were infected. This period was dubbed the "pingdemic", and in one week in December 2021 the app sent nearly 700,000 notifications. It worked by using Bluetooth to identify other devices nearby which also had it installed. If someone around you later used their app to report a positive Covid test and you had been within two metres of them for longer than 15 minutes, you would be alerted that you had been in close contact with the virus. All the data was anonymised, so the owners of the devices were never identifiable. Because of this, the recommendation to self-isolate could not be legally enforced, leading to complaints that it was not effective enough.**(BBC, 30 April 2023)** **Sample quote 3:** **PICTURE REMOVED**		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	(BBC, 16 July 2021)		
The App's Algorithmic Bias **Age-related digital divides**	**Sample quote 1:** ***Fairness is a highly prized human value.*** *Societies* in which individuals can flourish need to be held together by practices and institutions that are regarded as fair. What it means to be fair has been much debated throughout history, rarely more so than in recent months. Issues such as the global Black Lives Matter movement, the "levelling up" of regional inequalities within the UK, and the many complex questions of fairness raised by the COVID-19 pandemic have kept fairness and equality at the centre of public debate. Inequality and unfairness have complex causes, but bias in the decisions that organisations make about individuals is often a key aspect. The impact of efforts to address unfair bias in decision-making have often either gone unmeasured or have been painfully slow to take effect. However, decision-making is currently going through a period of change. Use of data and automation has existed in some sectors for many years, but it is currently expanding rapidly due to an explosion in the volumes of available data, and the increasing sophistication and accessibility of machine learning algorithms. Data gives us a powerful weapon to see where bias is occurring and measure whether our efforts to combat it are effective; if an organisation has hard data about differences in how it treats people, it can build insight into what is driving those differences and seek to address them. However, data can also make things worse. New forms of decision-making have surfaced numerous examples where algorithms have entrenched or amplified historic biases; or even created new forms of bias or unfairness. Active steps to anticipate risks and measure outcomes are required to avoid this. **(Independent report: Review into bias in algorithmic decision-making Published 27 November 2020)** **Sample quote 1:** *Lack of access to the internet has left elderly people feeling "lonely" and "inadequate" during the pandemic.* According to Age UK, elderly people across the West are being discriminated	6	7

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
Misinformation/Fake News	against because they do not have access to a digital device. Without the internet, many have been unable to attend virtual classes or even book a table at the local pub as lockdown restrictions eased. The charity has launched a scheme to help people learn digital skills. Ray, 82, whose art classes were cancelled when lockdown began, recalled: "You tend to feel a bit lonely. I didn't go out, well I couldn't at the time cause of Covid... and I was sat here and all I had to do was watch the television." He was able to benefit from Age UK's Think Digital programme. It paired him with a digital champion who delivered remote support sessions and taught him how to use a laptop to connect with others online. He is now able to continue his painting classes remotely and said: "I feel now that the world is my oyster." PICTURE REMOVED [For Copy Wright Reason] Image caption, Brenda said she felt "inadequate" when she was unable to look at the menu on an app on her phone. The pandemic has seen a rise in the use of digital services but the latest figures from Ofcom show only 55% of over 65-year-olds use a smartphone. While 46% percent of over 75-year-olds have not used the internet recently, 39% of those have never used it before. Although Brenda, from Bristol, has a tablet she was gifted, she is reluctant to use it and go online. "I don't use it, I can't now, our brains don't work like that. We've never had this when we were kids, first time I've ever had it and I'm 86. " She said she felt "inadequate" when she visited a local pub and was unable to access the menu, which is viewed via an app in the dark. For those millions who can't, the lockdown has meant being literally cut off from the world and essential services—leading to loneliness and social isolation." (**BBC, 25 June 2021)** **Sample quote1:** In February, the World Health Organisation warned that, alongside the outbreak of COVID-19, the world faced an 'infodemic', an		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	unprecedented overabundance of information—both accurate and false—that prevented people from accessing authoritative, reliable guidance about the virus. The infodemic has allowed for harmful misinformation, disinformation, scams and cybercrime to spread. False narratives have resulted in people harming themselves by resorting to dangerous hoax cures or forgoing medical treatment altogether. There have been attacks on frontline workers and critical national infrastructure as a result of alarmist conspiracy theories. The UK Government is currently developing proposals for 'online harms' legislation that would impose a duty of care on tech companies. Whilst not a silver bullet in addressing harmful content, this legislation is expected to give a new online harms regulator the power to investigate and sanction tech companies. Even so, legislation has been delayed. As yet, the Government has not produced the final response to its consultation (which closed over a year ago), voluntary interim codes of practice, or a media literacy strategy. Moreover, there are concerns that the proposed legislation will not address the harms caused by misinformation and disinformation and will not contain necessary sanctions for tech companies who fail in their duty of care We have conducted an inquiry into the impact of misinformation about COVID-19, and the efforts of tech companies and relevant public sector bodies to tackle it. This has presented an opportunity to scrutinise how online harms proposals might work in practice. Whilst tech companies have introduced new ways of tackling misinformation through the introduction of warning labels and tools to correct the record, these innovations have been applied inconsistently, particularly in the case of high-profile accounts. Platform policies have been also been too slow to adapt, while automated content moderation at the expense of human review and user reporting has had limited effectiveness. The business models of tech companies themselves disincentivise action against misinformation while affording opportunities to bad actors to monetise misleading content. At least until well-drafted, robust legislation is brought forward, the public is reliant on the goodwill of tech companies, or the bad press they attract, to compel them to act. **(House of Commons Digital, Culture,**		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	Media and Sport Committee Misinformation in the COVID-19 Infodemic Second Report of Session 2019–21, 16 July 2020) **Sample quote 2:** ***The NHS has today unveiled a package of measures in the battle against coronavirus fake news – working with Google, Twitter, Instagram and Facebook – to help the public get easy access to accurate NHS information and avoid myths and misinformation.*** The measures include Google providing easy access to verified NHS guidance when someone searches for coronavirus. As well as helping to promote good advice, the NHS has been fighting bad advice and misinformation about the virus in the media and online, working with Twitter to suspend a false account posing as a hospital and putting out inaccurate information about the number of coronavirus cases; and publicly condemning homeopaths promoting false treatments. The NHS is also working with Twitter, Instagram and Facebook to verify or 'blue tick' over 800 accounts belonging to NHS organisations including hospital trusts and local commissioning groups. And following months of work, the NHS and Google will this week introduce new Knowledge Panels – prominent pop out boxes of information – as part of Google search on mobile, to ensure it provides the public in the UK with easy access to NHS information about more than 250 health conditions, including coronavirus. Both Twitter and Facebook are directing users to the NHS website if they search for coronavirus. The announcement comes alongside the government's action to crack down on fake news, including a cross-government team to engage with social media firms to monitor the internet for scams. **Sir Simon Stevens, NHS chief executive** said: "Ensuring the public has easy access to accurate NHS advice however they search for it, not only will support people to take the right action but will also help the country's response to coronavirus. "The NHS has already been battling coronavirus fake news, from working to take down false Twitter accounts to speaking out against misleading treatments being promoted by homeopaths online.		

Themes/Subthemes	Research Question & Sample quote from data to support the theme	No. of Files	References
	"It's right that social media platforms and search engines take any action so they can help ensure the public are directed to NHS advice first. "I would also like to personally thank all those NHS staff who are doing an incredible job caring for patients, testing thousands of worried people and taking calls from thousands more." **Health Secretary Matt Hancock** said: "Today's actions are another important step so members of the public can access reliable, accurate health information, which is more crucial than ever as we continue our response to coronavirus. "These changes will ensure the latest trusted NHS guidance sits at the very top of Google search lists, so people can be reassured they are reading official, up-to-date Government advice. "Public safety is our top priority and we are harnessing digital tools to reach millions of people on more than 250 conditions they are searching for – including coronavirus – helping tackle misinformation and ensuring the public is well informed to take control of their health."**(NHS takes action against coronavirus fake news online, 10 March 2020)**		

End