Supporting pharmacists and prescribers in paediatrics: explorations of current practice and electronic systems for medicine related decision support

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Thesis summary

There is a lack of published literature describing resource and support needs of paediatric prescribers and pharmacists. In order to understand how to support this group of healthcare professionals it is first necessary to identify their current use of resources when prescribing and providing pharmacy services in paediatrics.

The methods used in this thesis were mixed. They included: focus groups with prescribers, self-completed questionnaires with paediatric pharmacy staff and paediatric prescribers, interviews with electronic prescribing leaders and documentary analysis of board meeting minutes from paediatric hospitals in England.

The resource reported to be used most frequently and most useful by both pharmacists and prescribers was the British National Formulary for Children. The BNFc was reported to be useful due to its current information and ease of use. Pharmacist and prescriber participants reported using a wide range of resources suggesting that there is no single resource that meets their information needs when working in paediatrics. There was general agreement that the current poor availability of some paediatric prescribing information could have an adverse effect on the care of patients. Pharmacy staff reported that an electronic medicines management system improved the supply of medication to inpatients, but described a need for additional development of the system for it to be suitable for all medication supply. Paediatric hospital board minutes reported a range of interventions to improve prescribing, but few reported outcomes.

To conclude: this thesis describes the extensive resource needs of both paediatric pharmacists and prescribers. The choice of resource is not affected by the status of its accreditation with NICE, raising a question of the value of this accreditation process. The lack of collaboration between paediatric hospitals regarding strategies used to improve paediatric prescribing is not acceptable and may lead to duplication of work or investment in poor support solutions.

Keywords: paediatrics, electronic prescribing, clinical decision support, pharmacy.

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1. Introduction

The major research question addressed in this thesis is: what are the current practices of decision support for healthcare professionals supplying and prescribing medication for paediatric inpatients? Medication errors in paediatric inpatients are reported at all stages of the medication supply process; from prescribing to administration. There are numerous published interventions demonstrating how to reduce these errors. In order to enable further progress in the reduction of medication errors in paediatrics it would be useful to understand what healthcare professionals working in the areas of prescribing and supply of medication use to support their work in this area. Without an understanding of healthcare professionals' current use of information sources in paediatrics it will be difficult to make an evidence based decision on the appropriate decision support to be implemented and/or included in electronic prescribing systems for paediatrics. It is also necessary to understand the interventions and support currently provided by paediatric hospitals and if they are reported to be successful.

There have been many studies demonstrating the effectiveness of electronic prescribing in reducing medication errors. It is important to note that these are largely single site case studies rather than controlled trials. Therefore the strength of the existing evidence is limited. However, not all hospitals that have introduced electronic prescribing have reported the same successes. Therefore understanding what the leaders in electronic prescribing and the companies that provide this software believe to be the factors critical for success could provide valuable insight for hospitals that have yet to implement an electronic prescribing system. There is the potential to develop more appropriate solutions to reduce paediatric medication errors if a better understanding of resource use and support provided to healthcare professionals is recorded.

> *"Clearly articulating the needs of paediatric care providers is critical in the use of information technology in paediatrics."* [1]

The aim of this research programme was to determine current practice regarding healthcare professionals' resource use to support their decision making when prescribing and providing pharmacy services to paediatric patients. In addition to determine the current prescribing and medication supply support provided by hospitals and companies for paediatric inpatients in England.

Electronic medicines management is designed to replace the paper based systems used by pharmacy departments to record patients' drug histories and make requests for medication supplies. There is limited published information on how to implement such a system and the benefits and disadvantages of using an electronic medicines management system. This study will

enable other hospitals to develop an evidence based plan for the implementation of an electronic clinical system.

Current practice regarding information resource use by paediatric prescribers when prescribing for paediatric inpatients is not well understood. It is not known what information resources paediatric prescribers use or how often they use them when prescribing for children in hospital. Understanding the information needs of paediatric prescribers should provide evidence of the type of decision support required in electronic prescribing systems to be used in paediatrics. Similarly the current practice regarding information resource use by pharmacists providing pharmacy services to paediatric inpatients is also not well understood. This study data will provide further evidence of the type of decision support required in an electronic clinical system.

Paediatric hospitals in England are anecdotally reported to have interventions in place to reduce medication errors and improve prescribing practice. By analysing the board minute meetings of the independent paediatric hospitals in England this thesis will enable identification of the current interventions being used. This will demonstrate the range of interventions being trialled in this area and the importance of medication errors and prescribing practice to the highest decision making entity in paediatric hospitals. Finally, the reported success of electronic prescribing has varied between hospitals. The final part of this research programme has identified the opinions of leaders in electronic prescribing and what they believe to be the actions required for successful use of electronic prescribing.

1.1 Literature review

The literature relevant to this research area is mainly derived from research methods that would be described as providing a lower quality of evidence; non-randomised intervention groups and case studies. The highest quality of evidence is found in randomised controlled trials as they minimise bias within their study design. [2] The quality of evidence determines how certain the researcher can be that the effect reported is a true measure. [2]

Study methods such as case studies provide a lower quality of evidence as sources of bias are not minimised and there is not sufficient statistical precision on the effect measured. When a study uses a method that does not exclude bias and provides data with low statistical precision the result of the study cannot be confirmed as being caused by the intervention implemented. Study designs such as case studies may provide data that demonstrates correlation of an intervention with a result, but due to the reasons described above this correlation of the result and intervention should not be presented as a causative relationship. Therefore cautious interpretation of the studies presented in this review is recommended.

There have been many interventions trialled to reduce medication errors. The current focus of these is electronic prescribing and decision support software. There has been evidence that electronic prescribing can reduce medication errors, but there are also reports of difficulties in adapting this technology and its decision support for the paediatric market. [3] Paediatric prescribing is characterised by the necessity to calculate individual medication doses for each patient and often using medication off label or outside of its licensed indications/doses. [4] Determining the type and level of decision support to include in a paediatric electronic prescribing system is difficult, particularly when current literature describes practices such as 'alert fatigue' and the number of alerts ignored by prescribers. Alert fatigue occurs when a user is frequently presented with information alerts on an electronic system. After using the system for a period of time the user is less likely to acknowledge the content of the alert and more likely to continue past the alert without reading its contents. Designing an appropriate decision support system for paediatrics is made more challenging by the lack of available information on the current practice of prescribers is their choice of information resources to support their decision making. The literature summarised in the following sections clearly demonstrates the lack of understanding of this area of prescribing practice. This research programme aims to add a substantial contribution to knowledge to this area, alongside research focussed on supporting the pharmacy and supply services of the medication process in a hospital.

1.1.1 Paediatric medication errors

The number of medication errors present in paediatric hospitals is difficult to estimate accurately due to the various methods, populations and definitions of medication error employed during studies. [5] Therefore it is not possible to present an accurate picture of the current level of prescribing errors in paediatric hospital practice. A typical prescribing error definition is:

> *"A clinically meaningful prescribing error occurs when, as a result of a prescribing decision or prescription writing process, there is an unintentional significant (1) reduction in the probability of treatment being timely and effective or (2) increase in the risk of harm when compared with generally accepted practice."* [6]

This definition was developed by a Delphi panel of experts. In a later study a paediatric Delphi panel also agreed that this was an acceptable definition for a prescribing error in paediatrics. [7] A review on paediatric medication errors published in 2007 reported that 5-27% of medication orders for paediatric patients contain an error at some point in the medication process. [8] Dosing errors are the most common type of medication error reported in paediatric patients. [5, 9, 10] This suggests that paediatric prescribers may require support when prescribing in order to minimise the number of errors made during the prescribing process.

In England there were approximately 2 million hospital admissions for children (0-14 years) in 2012/13. [11] Extrapolating figures using the lowest medication error rate from UK studies on medication errors (see Table 1) indicates that approximately 3,000 paediatric admissions in England may be affected by a medication error each year. This research programme will provide information that could help reduce the number of paediatric patients affected by a medication error.

The quality of the UK studies on paediatric medication errors is low as the most commonly used study method is a single site case study. One study by Ghaleb et al had a slightly higher quality from using a multi-site study method. Each study used a different definition of a medication error, with some studies including administration errors and some not. The range of definitions used means that it is not possible to directly compare the results of each study and the range of error rates reported is wide. The differences in error definition meant that some types of error may have been counted in one study but not in another study. For example, in the Ross, Paton and Wallace study a prescription that did not include an allergy status would not count as an error, but it would have counted as an error in the Bolt et al study.

Three studies employed a manual method of data collection that was usually conducted by pharmacists or nurses. However, the study by Ross, Paton and Wallace relied on self-reported medication error reports. The use of self-reporting rather than active data collection may have led to a lower error rate being reported due to the reliance on staff reporting errors as part of their job rather than the deliberate efforts of the research team.

The analysis of the errors was usually conducted by a member of pharmacy staff; however, Bolt et al used medical staff to conduct the analysis. It is not possible to determine from the published papers if using a different healthcare professional to complete the analysis has an effect on their likelihood to include a data point as an error or not.

Without an accurate estimation of the frequency of paediatric prescribing errors it is difficult to coordinate and develop an appropriate intervention to reduce them.

Table 1: Summary of UK paediatric medication error studies

Year	Authors	Measure	Method	Result
2000	Ross, Paton and Wallace. [12]	Medication errors	Retrospective review of reports	0.15% of admissions
2007	Conroy et al. [13]	Medication errors	Pharmacists and nurse interventions, drug chart review and observation.	139 interventions in six weeks, 1.2% administration errors observed
2010	Ghaleb et al. [14]	Prescribing errors	Prospective drug chart review	13.2%
2014	Bolt et al. [15]	Assessed prescribing standard vs hospital standard	Retrospective evaluation of drug charts	13% of drug charts contained errors

It has often been purported that prescribing errors in children are more likely because prescribing for children is more difficult. One of the reasons for this is that there are more calculation steps involved. [16] Wong et al found that if fewer calculations were required when writing a prescription then there was a lower risk of errors. [5] The lack of commercial formulations available for paediatric patients also generates chances for dosing errors through dilutions and manipulations of adult formulations before administration. [5] The difficulty of prescribing for children has also been identified by the National Patient Safety Agency (NPSA). The NPSA report on patient safety for children and young people stated that paediatric patients are a group where safe use of medicines is challenging. [17]

1.1.2 Reducing paediatric medication errors

The most frequently published research on reducing paediatric medication errors concerns the use of electronic prescribing with or without clinical decision support. [9] Studies have been published that demonstrate electronic prescribing can be effective at reducing medication errors

with or without clinical decision support. Electronic prescribing can also produce new types of errors and there may be difficulties in developing electronic prescribing systems that meet the needs of paediatric prescriptions. [18, 19] There is also evidence to support the use of interventions that are not information technology focussed. For example, some success at reducing paediatric medication errors has been reported through the use of prescriber education, clinical pharmacy services and medication dose calculators. [20]

The quality of this data is low for reasons similar the studies on paediatric medication errors in that these studies are also likely to be case studies rather than a higher level of evidence. It is important to acknowledge that each study is based at a different hospital with a different patient population and will have employed a different clinical system. This range in method and population makes comparison of study results challenging. Therefore it is not recommended that one relies on the results of a single study to support implementation of a particular clinical system or method to reduce paediatric prescribing errors.

1.1.2.1 Electronic prescribing and clinical decision support in paediatrics

NHS Connecting for Health has described electronic prescribing as

> *"the utilisation of electronic systems to facilitate and enhance the communication of a prescription of medicine order, aiding the choice, administration and supply of a medicine through knowledge and decision support and providing a robust audit trail for the entire medicines use process."* [21]

The following information is summarised from published research studies that are mainly case studies or reviews of multiple case studies. Therefore the quality of evidence is not near the top of the hierarchy of evidence. As such the benefits described below should be interpreted with caution as the correlation of the intervention and results presented may not be a causative relationship. The study methods employed are unlikely to provide a result free from bias and with sufficient statistical precision to be a true effect. [2]

As a simple benefit electronic prescribing can ensure legible and complete prescriptions. [3, 21-23] Clarity and quality of prescriptions can be ensured by included compulsory fields such as frequency and dose. [3, 24]

There are a wide range of features in electronic prescribing systems that are designed to support the decision making of prescribers and those supplying and administering medication (i.e. pharmacists and nurses). Electronic prescribing can be used to inform prescribers if the weight for the paediatric patient is outside the usual range for a child's age or if the weight was not current. [25] It can be used to force the entry of important information for patient safety; for example, confirmation of allergy status. [26] Access to up to date prescribing information to support

prescribers and pharmacists can be provided in electronic prescribing systems via links to summaries of product characteristics, websites or local information. [26] The data from electronic prescribing systems can be used for a range of purposes. It can be used to monitor quality, facilitate audits and observe prescribing practice. [27] In addition, electronic prescribing can help those administering medication to reduce the number of missed doses. [22] Finally it can also improve compliance with formularies. [3, 23]

Electronic prescribing can reduce prescribing errors in paediatrics with or without the inclusion of clinical decision support. [22, 25, 28-35] This reduction was observed in a range of specialties ranging from the paediatric intensive care unit to a renal outpatient clinic. One article also reported a reduction in mortality in a USA children's hospital after the introduction of electronic prescribing. [36]

Electronic prescribing can contribute to improved patient outcomes through the use of clinical decision support. [26] Clinical decision support provides advice and guidance to support prescribers and pharmacists when they are making medicines related decisions. It can be provided actively requiring the prescriber to respond to information alerts or passively where the prescriber is not required to respond to the information or is invisibly guided towards the correct medication choice, for example by making the recommended treatments the easiest to prescribe in an electronic system. In order to ensure a successful clinical decision support system four factors have been identified that are essential for success. These are: automatic provision of decision support; provision of advice rather than assessments; provision of decision support at the time and location of decision making; and computerised decision support. [37]

The varying anatomy and physiology of paediatric patients combined with off label and unlicensed use of medicines in this population can make design of paediatric decision support challenging. [4] With the addition of weight based medication calculations for individual patients; a meticulous approach is required when designing paediatric clinical decision support systems. [9, 38] An existing system designed for use in adult patients may need a paediatric drug dictionary writing before it is suitable for use in the paediatric setting. This can be difficult and time consuming. [39]

There have been two relevant Cochrane systematic reviews concerning clinical decision support in paediatrics. The first Cochrane review on on-screen computer reminders concluded:

> *"Further research must identify design features and contextual factors consistently associated with larger improvements in provider behaviour if computer reminders are to succeed on more than a trial and error basis."* [40]

The second Cochrane review concluded that there is not enough evidence to assess the effectiveness of clinical decision support in neonatal care, and the related benefits or harm cannot be determined. [41]

1.1.2.2 Features of clinical decision support systems

There are a range of alerts utilised in clinical decision support systems. Duplication alerts inform the prescriber when there is more than one of the same medicine is prescribed. This could prevent the patient receiving unsafe duplications of medication. This can be challenging if the clinical system does not have the functionality to prescribe different doses at different times of the day or if it cannot distinguish between the same medicine prescribed as two different formulations. [4, 33] Allergy alerts inform the prescriber if they have selected a medication that the patient has a recorded allergy to. Allergy alerts were the most frequently overridden alert type in one study. [42] This suggests that the information that triggered the alert was either incorrect or not clinically relevant. Maintaining an accurate allergy status on the patient record should increase the relevance of allergy alerts. Interaction alerts inform the prescriber when they have selected a medication that interacts with the patient's current medication or condition. For example, this type of alert could be used to inform prescribers if a medication may worsen a condition such as myasthenia gravis.

Dosing calculators provide an appropriate dose based on the patient information recorded and the drug dictionary embedded in the clinical decision support system. Dosing calculators have been shown to reduce errors in calculations of paediatric doses. [43-45] However, adding weight based doses and dosing limits for all medication can demand a large amount of time and money, with further costs incurred for checking the information. [26] Dose rounding is used to ensure the prescriber prescribes a dose that is measurable and suitable for administration. For example, if a dose was calculated to be 5.9mL dose rounding might recommend a dose of 6mL to ensure the administration of the drug was practical for the nurse.

Patient test results or observation alerts can inform the prescriber when a patient factor has changed that could mean a prescription needs reviewing. For example, the display of relevant laboratory results for medication that relies on certain drug plasma levels or good renal function. [26] Adverse events may be more easily detected by using an alert to inform prescribers that a patient's International Normalised Ratio (a measure of the clotting ability of the blood and an indirect measure of the effect of an anticoagulant - INR) is above a certain level. [46] Patient observations can also be used to guide treatment choice. For example, an acute respiratory infection in children template provided recommendations for management and led to a reduction in the use of antibiotics. [47]

Order sets inform the prescriber of the appropriate choice of medication(s) for an indication or condition. For example, guiding the prescriber to the most suitable medications to be used as post-operative analgesia or to treat an asthma exacerbation. Order sets can be used to improve compliance to guidelines or formularies. [4, 26] Advanced order sets will take patient specific factors into account when providing recommendations. [26]

Weight checks inform the prescriber if the patient is within the usual weight range for their age and if the current recorded weight is 'out of date'. Provision of a weight check alert within an electronic prescribing system contributed to a reduction in inappropriate doses in a renal paediatric clinic. [33]

1.1.2.3 Disadvantages and new errors associated with electronic prescribing and decision support

Despite the positive experiences reported in the previous section there have been less beneficial experiences reported in some hospitals including increased mortality rates and no reduction in medication errors. [26, 48-50] New types of errors associated with electronic prescribing systems have been reported and few studies have reported improvements in patient outcomes from using clinical decision support. [18, 19] It is important to note that computerised systems for prescribing cannot prevent all medication errors or adverse drug events. [23, 24]

Drop down menus can cause selection errors, particularly if the menu that the end user is selecting from is long. [26, 50, 51] However, this type of error can be reduced by using shorter drop down menus. [26] Free text entry sections can be associated with prescribing errors. [24, 50, 51] Free text entry allows prescribers to make errors typically seen with hand written prescriptions such as spelling errors and unclear instructions. Technical slips in log on and log off procedures may also lead to prescribing errors. [48, 51] A technical slip can lead to medication being ordered for the wrong patient if the prescriber inadvertently uses the electronic prescribing system when another prescriber is logged in. [48] Duplication errors can occur when the electronic system does not allow an individual to write the prescription as it would normally appear on a paper chart. [50]

The user interface of electronic prescribing and clinical decision support systems can be poorly designed. For example, it could be easy to select the wrong patient if the font is small and patient names don't appear on all screens of the system. [48] Selecting the correct item or information can be made more difficult if differing typefaces and colours are used for the same type of information. [48] It can be difficult to see all of a patient's medication on a single screen. This can

lead to a variety of errors including: failing to order a medication, selecting the wrong medication, and not viewing 'when needed or PRN' medication. [48]

A review published in 2006 reported that between 49-96% of drug safety alerts are overridden. [52] The setup of the alerts in an electronic prescribing system may create scenarios where medication errors are more likely. This could occur when alerts lack: specificity; sensitivity; clear information or seamless integration with the prescriber's workflow. [51, 52] Repeated ineffective alerts can result in prescribers failing to acknowledge the alert or misunderstanding or incorrectly responding to an alert. [52] This is known as alert fatigue. Alert fatigue develops when alerts are irrelevant, not serious or are shown repeatedly. [53] Alert fatigue can be used to describe the mental state of the prescriber affected by too many alerts that use up time and mental energy; critically it may lead to important alerts being ignored. [52]

Hospitals may need to rely on their system provider to respond to suggestions for improvements to the prescribing software. [26] For example, in the UK if you had chosen an American based electronic prescribing system you could find yourself disadvantaged if the majority of updates and developments focus on the needs of the American market. Many hospitals may also not have the resources to improve their own system. [54] The market of system providers is continually changing; providers can go out of business or merge. This requires hospitals to have a strategy to manage these risks.

There is a lack of literature describing if the same disadvantages and errors are associated with the use of electronic prescribing and decision support in the paediatric environment. An understanding of the effect of such systems in paediatrics is required to enable an evidence based decision on their regarding their implementation in paediatrics.

1.1.2.4 Further methods of reducing paediatric medication errors

The quality of paediatric prescribing can be increased by many approaches. [20] This section describes some approaches that do not rely on hospital wide information systems to improve paediatric prescribing and reduce paediatric medication errors.

Prescriber education is the most commonly referred to intervention used to reduce medication errors after electronic prescribing and clinical decision support. Education programmes in a number of paediatric hospital environments have been shown to improve prescribing practice or reduce prescribing errors. [9, 55-60] Prescribing education in hospitals is often led by pharmacists during induction programmes for doctors. [59, 60] Pharmacist led education may include: how to complete prescriptions correctly, induction packs (containing further information) and information on common prescribing errors. [60] Some education programmes may also include an

assessment of prescribing skills. [57, 60] Better undergraduate and postgraduate prescribing education have been recommended to prevent prescribing errors. [61, 62]

In addition to providing prescriber education as described in the above section pharmacists are also effective at intercepting paediatric prescribing errors. [54, 63, 64] Pharmacists can then provide feedback and teaching to prescribers on these errors. This can be done in real time. Feedback on prescribing errors is valued and wanted by junior doctors, particularly when the feedback is personalised and regular. [65] Group feedback to prescribers by pharmacists on common or serious errors was also beneficial. [65] Daily feedback on prescribing errors to prescribers alongside a zero tolerance prescribing policy (designed to eliminate distractions and interruptions) on a paediatric intensive care unit (PICU) in England correlated to a fall in prescribing errors. [66] Further research on the use and effectiveness of provision of feedback to prescribers in paediatrics is required to determine if this can be attributed as the causal factor in a reduction in prescribing errors.

Other technologies used include smart infusion pumps, unit dose dispensing and drug dose calculators. In a comprehensive review of strategies to reduce medication errors in paediatrics smart infusion pumps and unit dose dispensing systems showed reductions in dosing errors in paediatric patients. [9] Online or computer based calculators have been shown to reduce calculation errors for a limited number of medicines. [9] For example, the use of an online total parenteral nutrition (TPN) calculator led to a reduction of errors in TPN orders. [45] The TPN calculator ensured calculations were correct and reduced the number of orders with osmolarity outside of the recommended range. [45] However, dosing calculators may be discontinued as they become built into clinical decision support or electronic prescribing systems. [9] Dosing calculators can introduce risks or errors if they are not built securely or tested sufficiently. An Excel spreadsheet used to calculate doses in a paediatric emergency department was determined to be the cause of an error in drug calculation. The reason was that the cells of the pre-programmed Excel document could not be locked and one of the formulae had been inadvertently changed leading to the incorrect drug calculation. [67] More widespread use of drug dose calculators cannot be recommended currently due to the lack of high quality evidence to support their effectiveness.

Hospitals may also introduce reminder tools or display guidelines prominently to improve prescribing practice. A consultant-led ward round checklist on paediatric wards in a London hospital led to improvements in the quality of prescription writing, but had no effect on clinical errors. [68] A similar strategy in oral and maxillofacial surgery in Sheffield included a credit card sized ‘aid-memoir’ with prescribing doses. [15] There was no report on the success or effect of

this intervention. A bedside prescribing guideline was introduced onto a paediatric unit of a general hospital in the UK. The bedside guideline contained information on the 22 most frequently prescribed medicines on the children's unit. [69] Unfortunately, there was no report on the success of this intervention or a similar intervention at Alder Hey Children's Hospital. [70] The robust evaluation of such interventions would be valuable to improve the quality of evidence regarding their use.

Paediatric medication errors can also occur at the dispensing (pharmacy) stage of the medication process within a hospital. The pharmacy team are responsible for clinically screening medicines as well as ensuring their safe and efficient supply. New electronic systems are now available to support the pharmacy team to accurately record medication histories and medication supply. However, the experiences of pharmacy staff when implementing an electronic medicines management system and the effect of such a system in a paediatric hospital have yet to be investigated. The initial study of the thesis will aim to contribute knowledge to this new and developing area of pharmacy clinical system technology.

1.1.3 Resource or reference use to support decision making in paediatric prescribing

There is very limited evidence on the resources or sources of information used by prescribers to support decision making when prescribing for paediatric patients. The available evidence can be split into two distinct groups: evidence from outside the UK and evidence from within the UK.

The majority of published research on resource use when prescribing for paediatric patients has involved participants from the USA. The most recent study, 2011, reported that Lexi Comp was used frequently by hospital based doctors and nurse practitioners. [71] Respondents in this study were generally satisfied with the available resources but reported that a tool that could provide individualised patient dosing would be valuable. [71] This study confirmed that resources are important for providing dosing information for paediatric patients. A small study (20 participants) from 2005 reported that colleagues, paediatric texts, drug formularies, government/professional organisation websites and medical portals were the preferred sources of information for primary care paediatric doctors. [72] This demonstrated that prescribers may have needed to refer to different information sources to support their prescribing for paediatric patients. Finally, a USA report on access to paediatric prescribing information noted that there was no indication of increased access to paediatric prescribing information in the Physician's Desk Reference in the period studied (1998-2007) [73] Over the period studied the number of medications licensed for children reduced by a third and there was a decrease in the number of formulations suitable for

children. [73] It is important to note that the PDR is a voluntary listing and charges a fee, which may have deterred manufacturers from including their medicines. It is also important to note that the healthcare system in the USA is very different to that in the UK and therefore the results of these studies may not be directly applicable to UK healthcare.

A study conducted in Canada published in 2003 reported that the most common reference source used by family physicians was the "Compendium of pharmaceuticals and specialties" when looking for paediatric drug information. [74] Available sources of paediatric prescribing information were thought not to be adequate by 40% of the 261 respondents and not readily available by 27%. [74] The study concluded further work was needed on provision of paediatric prescribing information. [74] Other sources of information used by respondents included: community pharmacists, children's hospital dosing manuals, paediatric textbooks and drug companies; again demonstrating that the information needs of paediatric prescribers were not met by a single resource. The number of respondents in this study is unlikely to reflect the total physician population of Canada; therefore these results may not be generalisable to all Canadian physicians.

In the UK the British National Formulary (BNF) for Children provides information on medication for children. After the first edition of the BNF for children (BNFc) was published in 2005 research was conducted to determine how well it was meeting the needs of its users. Information regarding dosage was considered the most important information in the BNFc and the top reason for referring to the BNFc. [75] When referring to medicines information the highest priorities were how fast and easy the information was to access and the reliability of the information. [75] The BNFc was praised for its clinical advice and the logical order of medicines (grouped by body system) as well as for having the level of information right for most users. [75] BNFc producers responded to users' needs for easy access to dosing information by displaying this information in tinted panels in future editions. [75] This study had over 1200 responses supported by further work with focus groups. Despite its focus on a single resource; it is the strongest evidence currently available on the resource use of healthcare professionals in the UK. There is no further literature on the use of other resources by doctors or pharmacists that provide information to support decision making in paediatric prescribing.

A small study on the resources used by doctors when making decisions in one UK neonatal intensive care unit reported that the most common sources of information were observations of the child and information from computerised monitors when respondents self-reported their use of resources. [76] However, on observation, information from colleagues also played an

important role in supporting decision making. [76] This study provides some evidence that more than one source of information is used by doctors to support decision making in paediatrics.

1.1.4 The National Health Service in England

Health services in the UK are devolved to the separate governments of England, Northern Ireland, Scotland and Wales. In England, the area of this research programme, health services are run by NHS England. NHS England splits the country into four regions that have oversight and leadership of the NHS in each region. Within each region hospital services are provided by organisations called acute NHS Trusts. Paediatric hospital services may be provided as part of an acute NHS Trust that also provides adult health services or as separate standalone paediatric NHS Trusts. There are four NHS Trusts that provide solely paediatric health services. These are: Alder Hey Children's NHS Foundation Trust; Birmingham Children's Hospital NHS Foundation Trust; Great Ormond Street Hospital for Children NHS Foundation Trust and Sheffield Children's NHS Foundation Trust. The four standalone paediatric acute NHS Trusts alongside the other 156 acute NHS Trusts provide paediatric hospital services to the paediatric population of England. [77]

The estimated population of persons aged between 0 and 19 years old in England in 2012 was 12.7 million. [78] Approximately one in 10-15 children will be admitted to hospital each year in England and one in 11 will be referred to a hospital outpatient clinic each year in England. [79]

1.1.4.1 The current status of electronic prescribing in hospitals in the National Health Service

Currently the use of electronic prescribing by general practitioners (GPs) is widespread and embedded in their current practice. [21, 80] However, the use electronic prescribing in the hospital sector is less widely implemented than in the primary care sector, despite considerable interest in electronic prescribing systems being reported. [81] There are few hospitals that use electronic prescribing comprehensively. [80] The leaders in hospital based electronic prescribing in England, such as Burton and Arrowe Park (Wirral), have had this type of system in use for more than fifteen years, yet many UK hospitals are yet to make the move to implement electronic prescribing.

A recent study of electronic prescribing in English NHS hospitals in 2013 concluded that 69% of hospitals had an electronic prescribing system in place and more than half of these had more than one electronic prescribing system in use. [82] Only 13% of hospitals in this study reported using electronic prescribing across all adult medical and surgical wards and of these hospitals just one did not require any additional paper drug charts to be used. [82]

An earlier study published in 2010 reported that 82% of English NHS hospitals (n=56) were considering implementing or in the process of implementing electronic prescribing. [81] The functions that had the most reported interest were: knowledge and decision support and links within the system to other areas of the patient record. [81] All respondents reported that they would procure an existing system and the two most popular electronic prescribing system choices were Ascribe and JAC. [81]

1.1.4.2 National information technology projects designed to drive the use of technology and improve patient safety in the NHS

The UK government has run several projects to drive the use of technology in the NHS with the aim of improving patient safety and efficiency. The first of these projects to drive the use of technology in the NHS was the National Programme for IT. It was launched in 2002. [83] Its aim was to reform the way the NHS in England uses information. The project suffered many delays and was eventually dismantled in 2011.[83] The project should have implemented the RiO, Lorenzo (in the midlands, east and north) or Fujitsu (in the south) care records system nationwide. [83] A nationwide electronic record system may have had significant benefits in the areas of efficiency and patient outcomes. The failure and delays of the national project for IT may have made it harder to obtain financial backing for separate electronic prescribing projects. [80]

The next government led project was NHS Connecting for Health.

> *"NHS Connecting for Health is part of the Department of Health Informatics Directorate. Our role is to maintain and develop the NHS national IT infrastructure."* [84]

Earlier tasks included providing guidance on electronic prescribing and its implementation. It started services such as the Electronic Prescription Service in primary care and the development of Summary Care Records to be used across care interfaces. [84] The Connecting for Health organisation ceased to exist from March 31st 2013 and these tasks were taken over by the Health and Social Care Information Centre. [84]

In 2009 Connecting for health issued an information resource designed to support the implementation of electronic prescribing. It presented the current challenges and lessons learnt so far. The document provided information on electronic prescribing systems; lessons learned; planning and managing electronic prescribing; technologies involved in electronic prescribing and integrating electronic prescribing into systems and practice. [21] The key points of information it provided to organisations are summarised in Table 2 below.

Table 2: Key information from 'Electronic Prescribing: Challenges and Lesson Learned'

Key information from 'Electronic Prescribing: Challenges and Lessons Learned'
Electronic prescribing must be thought of through the whole medicines process and not just in the context of prescribing. Administration and supply are important features.
Electronic prescribing is used in various forms in the NHS; from standalone systems to integrated whole hospital clinical systems.
The initial benefit of electronic prescribing is legible and complete prescriptions.
Electronic prescribing systems can provide varying levels of clinical decision support.
A major motivational factor for implementing electronic prescribing is the safer use of medicines.
End users will need to understand the overall vision of the system and where it will benefit them.
The implementing team should be multidisciplinary with senior management support.
Implementing electronic prescribing is not a quick process and the time taken to go live should not be underestimated.
The team should be open with progress made and invite participation from end users.
The order and speed of roll out requires careful planning.
The project does not end once the roll out is completed.
Electronic prescribing systems require constant management and development.
"*Electronic prescribing will change how people work*".
Staff will find their own 'workarounds' for the system, which may or may not be useful or harmful.
Electronic prescribing needs to be seen as part of the overall information strategy for the hospital and be useful to all healthcare professionals working with patient information.

Table reference 'Electronic Prescribing in Hospitals: Challenges and Lessons Learned'. [21]

The Connecting for Health group also provided specific information regarding: allergy checking, dose checking, tall man lettering, miss-selection of opioids and hazard review; all in relation to electronic prescribing. The Health & Social Care Information Centre is the current national provider of information, data and IT systems for health and social care. The Health and Social Care Information Centre is responsible for collecting data from the health and social care system. Their aim is:

> *"We support the delivery of IT infrastructure, information systems and standards to ensure information flows efficiently and securely across the health and social care system, to improve patient outcomes. We are committed to putting the needs of patients and the public at the heart of everything we do."* [85]

The Safer Hospitals, Safer Wards Technology Fund was established in 2013 to encourage and provide financial resources for the use of technology in healthcare. There was initially £260 million available for NHS hospitals and other care providers to bid for which then increased to over £500 million. [86]The stated purpose of the fund is as follows:

> *"The Technology Fund is available to NHS Trusts, including Foundation Trusts, to support the rapid progression from paper-based systems for patient notes and prescriptions to integrated digital care records (IDCRs) and the development of ePrescribing and eReferral systems."* [86]

It is too early to confirm if this information technology project will prove succesful in implementing technology that improves medication safety and access to patient information in the NHS.

1.1.5 National resources to support prescribing in England

The National Institute for Health and Social Care Excellence (NICE) provides national guidance and advice that aims to improve health and social care. [87] The guidelines cover a wide range of paediatric conditions and there are frequent reviews of existing guidelines and introductions of new guidelines. NICE also evaluates medical technologies and interventions. [87]

NICE have recently implemented a new medicines optimisation guideline. This guideline is designed to help the delivery of:

> *"the safe and effective use of medicines to enable the best possible outcomes."* [88]

The guideline has two recommendations that are particularly relevant to the studies of this thesis. The first is that hospitals should consider the implementation of clinical decision support systems. [88] The data presented later in this thesis will describe the type of information that prescribers and pharmacists report to use in current practice. Therefore this type of information should be considered to be part of future clinical decision support provided. Additionally, this thesis will also provide data that describes the information needs of pharmacists when providing pharmacy services such as medication review. Medication review is another recommendation of the NICE medicines optimisation guideline. [88] The research recommendations of this guideline include looking at process measures for using clinical decision support. [88] This might include how end users use and/or interpret clinical guidance.

The BNFc is jointly produced by the British Medical Association, the Royal College of Paediatrics and Child Health, the Royal Pharmaceutical Society, and the Neonatal and Paediatric Pharmacist Group. The BNFc aims to provide practical guidance on the use of medicines in children. A second paediatric formulary is produced by Guy's and St Thomas', King's College and University Lewisham Hospitals. This is a specialist paediatric formulary produced jointly across three hospital groups. It

provides information on paediatric dosing that may be off label or unlicensed as well as licensed paediatric doses. [89] There are no data available on the use of these resources in practice.

The National Prescribing Centre has a competency framework for all prescribers that describes the common competencies required of a prescriber. [90] The General Medical Council 'good practice in prescribing and managing medicines and devices' guideline provides guidance to all doctors on prescribing ranging from reviewing medicines to prescribing unlicensed medicines. [91] In addition to these organisations there are Royal Colleges that focus on a clinical speciality and provide guidance for it. Royal Colleges, alongside national societies, for example the British Thoracic Society, produce clinical guidelines to be used by healthcare professionals. The Meds IQ initiative is the most recent Royal College of Paediatric and Child Health project designed to collate interventions to reduce paediatric medication errors on a single website. [92] The interventions reported in the minutes of paediatric hospital board meetings could be shared as part of this projects focus on paediatric prescribing safety.

1.2 Aim and objectives of this research programme

From the gaps identified in the above literature review the following research questions were identified:

- What new errors or disadvantages are associated with using electronic prescribing in paediatrics?
- What initiatives are currently used to improve paediatric prescribing practice in the UK? For example, dose calculators or feedback on errors?
- Are initiatives designed to improve paediatric prescribing practice effectively evaluated in the UK?
- Is there a single source of comprehensive information on paediatric prescribing available to healthcare professionals in the UK?
- How do healthcare professionals use and value prescribing guidance in the UK?
- What resources are used by doctors and pharmacists in paediatrics to support prescribing decisions in the UK?
- Are current resources for paediatric prescribing effective?

The research questions guided the development of the aim of this research programme. The aim of this research programme was to identify current practice of healthcare professionals' resource use to support their prescribing and medication supply work and the current prescribing and medication supply support provided by hospitals and companies to paediatric patients in England.

The specific objectives of this research programme were:

- Identify and describe the experience of pharmacy staff of the implementation of an electronic medicines management system at Birmingham Children's Hospital;
- Identify the current practice of prescribers at Birmingham Children's Hospital concerning their resource use to support prescribing decisions for paediatric patients;
- Identify the current practice of pharmacist members of the Neonatal and Paediatric Pharmacist Group concerning their resource use to support the provision of pharmacy services for paediatric patients;
- Identify the current practice of independent English paediatric hospitals provision of paediatric prescribing support as recorded in the minutes of their board meetings;
- Identify the current views and experiences of leaders in electronic prescribing concerning current benefits/barriers/issues, and their advice for hospitals to ensure successful implementation.

These objectives will allow for a substantial original contribution to the field of pharmacy practice research as there is minimal published research available on the above research objectives. The results of this research will ensure there is data available on the resources used by both prescribers and pharmacists in the supply and prescribing of medication to paediatric inpatients. It will also provide information on strategies used by English paediatric hospitals on improving prescribing practice and reducing medication errors. The research will also provide evidence regarding the use of electronic medicines management to support the supply of medication within a paediatric hospital. Finally, it will bring together advice and expertise from a range of leaders in electronic prescribing that could serve as guidance for paediatric hospitals that have yet to implement electronic prescribing and decision support.

1.2.1 The theoretical perspective of this PhD

1.2.1.1 Epistemology and theoretical perspectives

Deciding on an appropriate paradigm for a mixed methods study is difficult as there appears to be large theoretical differences between the paradigms in which each type of research is usually grounded. Typically quantitative research will be based in the positivist paradigm, whereas qualitative work may be interpretive or constructionist in paradigm. To understand what paradigm is best suited to this study it is important have an understanding of each paradigm before judging which will best suit the aim of this research.

Positivism assumes there is a stable actuality 'out there' and that phenomena (e.g. health) are present whether we detect them or not and that they are present in the same way whether we comprehend them or not. [93] Our comprehension of phenomena may be incorrect, but there is a 'correct' understanding that we will get nearer to defining. [93] Research in the positivist paradigm has a focus on empiricism; collecting data directly from the phenomena being studied. Another focus is 'unity of method'; this is a concept that all sciences and research will use identical methods. [93] The final important aspect is that science is separate from society and is rational, free from bias and objective thus ensuring that 'knowledge' gained from scientific methods is impartial and 'true' for all periods and locations. [93] Positivism may lean towards deductive reasoning; linking premises with a definite conclusion. [94]

From the interpretative perspective the most important research is not about the stable actuality 'out there' but people's understandings of it. [93] The interpretative paradigm focusses on the meaning of phenomena and its aim is to comprehend the world from the perspective of people rather than to define a cause and effect relationship or laws for the phenomena. [93] It uses inductive reasoning where the premises give evidence for the likely conclusion.

Constructionism queries whether there is a single stable actuality that pre-exists and instead suggests it is socially constructed. [93] Instead of defining things through our knowledge from scientific methods, constructionist researchers focus on how these things are constructed via the outcome of social, political and historical processes. [93] Constructivist views may allow for the definition of more than one reality as knowledge is socially constructed.

Finally there is the pragmatic approach. This has neither a qualitative or quantitative focus; instead it has the aim of using the most appropriate method for the research objectives. Pragmatism is the result of decades of debate concerning whether qualitative and quantitative methods can be used together under one paradigm. Before the mid-1980s the two approaches were divided and people would argue for the greatness of one over the other. [95] By the late 1970s people started to agree that the two approaches could complement each other. [95] For example, running a qualitative focus group to explain further the statistical results. In the last 25 years it has been agreed that qualitative and quantitative methods could be combined for research under the paradigm of pragmatism. [95] Pragmatism acknowledges that quantitative work may not be free of social influences or completely impartial. For example, when conducting an experiment we use our qualitative understanding based on prior experiences, common sense and our judgement to decide if our findings are likely to be 'true'. [96] This qualitative understanding of context is also used when we trust prior research when comparing and interpreting our new data or knowledge.

1.2.1.2 Paradigm and theoretical perspective of this research

The paradigm for this research can be described as pragmatist. It is combining the best of qualitative and quantitative methods to meet the research aim. An advantage of taking a pragmatic approach is that the methods can be mixed to provide a complete answer to the research question. [95] This mix of methods is particularly useful within the development of recommendations for practice and policy (which this research aims to do) as there is a need to explore the study population as a whole as well as studying individual differences or circumstances. Pragmatism allows individual experiences and/or anomalies to be explored alongside population statistics.

A mixed method approach can give greater validity to research by allowing corroborative findings to be drawn from across several methodically diverse studies. Quantitative methods usually have high levels of internal validity whereas qualitative methods are more likely to have high levels of external validity. Quantitative methods can ensure internal validity by obtaining precise, reliable and replicable measures, samples and conditions. [97] High internal validity allows you to define causal relationships as other explanations can be removed or measured. [97] However, by having high internal validity, external validity (the degree to which the relationships/results identified are generalizable to real world circumstances) may be compromised as the controlled conditions may result in an environment that is different to the 'real world'. In contrast, qualitative research obtains and analyses data in context, usually with a reduction in control. [97] However, this allows for exploration of real life situations that may have been excluded from or not anticipated by a quantitative study. In summary, combining qualitative and quantitative research and their associated internal and external validity can be an effective way of increasing the overall validity of research.

2. Methods

This chapter contains a description of the research method used for each study.

2.1 Initial exploratory focus groups on current resource use when prescribing and thoughts on electronic prescribing

Focus groups were used to gain an insight into the research area and familiarise the researcher with the language used to describe current practice. The aim of the focus groups was to provide the researcher with a general understanding of current resource use during paediatric prescribing and prescriber opinions on electronic prescribing. The objectives were:

- Provide an insight into current paediatric prescribing practice
- Explore attitudes towards systems designed to improve paediatric prescribing practice such as electronic prescribing
- Inform the design of future studies regarding methods used to support medicines related decisions in paediatrics.

2.1.1Timing of the study

Four focus groups were held at Birmingham Children's Hospital. Focus groups one and two took place on 11th May 2012 (at an update day for non-medical prescribers). Focus groups three and four took place on 16th August 2012 (at a training day for doctors). Both sets of focus groups took place in the education centre at Birmingham Children's Hospital, which was the participant's workplace and therefore convenient for participants.

2.1.2 Ethical approval

Ethical approval for the preliminary focus group study was gained from Aston University (#328, 24/05/2012) and it was registered as an audit at Birmingham Children's Hospital (PHA32, 31/01/2012) for this study.

2.1.3 Focus group design

Table 3: Numbers of participants in preliminary focus groups

Focus group	**Number of participants**
Non-medical prescribers (1)	9
Non-medical prescribers (2)	8

Medical prescribers (3)	8
Medical prescribers (4)	5

All focus group participants were attendees at training days that were run independently from this study. The focus groups were run as one of the sessions that attendees of the training day were asked to participate in. There were no attendees at the study day that chose not to participate in the focus groups. In focus group one all non-medical prescribers were nurses; in focus group two there was one pharmacist prescriber and seven nurse prescribers. Focus groups three and four were solely made up of medical prescribers.

Before the focus group started informed written consent was obtained from each participant. The focus groups followed the topic guide developed by the researcher (see Appendix 1). The topic guide was developed by using a review of the current literature to identify areas where further research was needed as well as consultation with the Deputy Medical Director at Birmingham Children's Hospital to ensure the topic guide was compatible with local practice and met the needs of the hospital's electronic prescribing project (which this study contributed to). Minimal directions and instructions were provided to the participants during the focus group by the focus group coordinator unless they veered off the research topic and needed to regain focus on the topic of interest.

The focus groups had an audio recording taken which was transcribed by the researcher. All audio files were transcribed by the researcher using Windows Media Player and Microsoft Word. This ensured that the researcher was familiar with the data set before beginning the analysis. The transcript was then used for the qualitative analysis of the focus groups. Applied thematic analysis was used with the support of NVivo (version 9) software to analyse the focus groups. The function of applied thematic analysis is to identify themes and patterns in qualitative data. This technique identified and labelled extracts of relevance/interest to the research theme as codes. After all the transcripts had been coded they were checked for uniformity of coding. Some extracts were recoded to ensure the coding used was consistent. After the coding was completed the codes were brought together into themes. The themes were based on frequency of the code, relevance to the research theme and areas of importance to the participants.

2.1.4 Rationale for method

Focus groups were suitable as the initial research method for exploring and gaining an understanding of the research question and the context of the research in current hospital practice. The open structure of this method enabled a wide ranging discussion of the research

questions and their context in a paediatric hospital. This ensured the focus of future studies was relevant to current practice.

Disadvantages of the focus group method are that the results are unlikely to be reproducible. It is not likely that the participants will provide the same responses if the focus group was repeated, particularly if there were any changes to the membership of the focus group. It is important to note that the responses from the participants are a narrative and therefore may not be indicative of what they do in practice. [93, 94]

The advantages of the focus group method are it is a quick and convenient method to collect data from a number of participants at the same time. [93, 98] Focus groups can allow the participants to discuss freely the research topic and take cues from other participants to trigger contributions that may not have been added otherwise. [99] Participants are free to use language they feel comfortable with and are not limited by the research method in the length or detail of their response. Participants can also emphasise the areas that are most important to them. [99]

Several techniques were actively employed in this study to improve the quality of the focus group method. It is important that the researcher has a good understanding of the language used by the participants. [93] This was assured in this study as the researcher was a hospital pharmacist with a good understanding of the research area gained during prior hospital work experience. The location of the study is also important and it is thought that it is best to conduct the focus groups in a place that the participants feels is 'theirs'. [93, 99] This advice was heeded in this study as the focus groups were conducted at the participants' place of work. Finally to encourage the participants to speak freely and provide complete answers the researcher running the focus group must be receptive. [93] This can be achieved by not interrupting the participants and recognising the participants answers by nodding or saying "mm". [93]

2.2 Questionnaire studies

This section describes an oversight of the methods used for all the questionnaire based studies within this thesis followed by the specific methods of each study (sections 2.3 to 2.5). The three questionnaire studies were retrospective self-completed questionnaires (see Appendices 2 to 4). Questionnaire study 1 was paper based. Questionnaire studies 2 and 3 were electronic. The details unique to each individual study follow this information that is common to the three studies.

2.2.1 Ethical approval

Questionnaire study 1: Experience of pharmacy staff from moving from a paper based to an electronic medicines management system was approved as a service evaluation audit by Birmingham Children's Hospital Clinical Governance team (audit number 682, 09/10/2012) and Aston University Ethics Committee (#416, 15/03/2013).

Questionnaire study 2: Resource use during prescribing decisions by prescribers at Birmingham Children's Hospital was approved as a service evaluation audit at Birmingham Children's Hospital (PHA32, 31/01/2012) and by the Aston University LHS Ethics Committee (#455, approved 26/09/2013).

Questionnaire study 3: Resource use during paediatric pharmacy services provision was approved by the Aston University Ethics Committee (#486, 28/10/2013).

Information sheets were provided for each study either on paper or electronically. Consent was obtained from all participants.

2.2.2 Confidentiality

For questionnaire study 1 which was paper based; the consent forms were separated from the questionnaires to ensure confidentiality and anonymity were maintained. Participants were asked to provide their email addresses if they were interested in future research; this data was stored separately from the completed questionnaire. Questionnaires and consent forms were stored in a locked cupboard that was only accessible to the researcher.

For questionnaire studies 2 and 3 the researcher did not collect or have access to any personal data during these studies as no personal data was collected. The distributors (Birmingham Children's Hospital and the Neonatal and Paediatric Pharmacist Group) of the questionnaires did not share the email addresses of the participants with the researcher. All email addresses were blind copied when each email was sent. The questionnaire data were stored on a password protected account that only the researcher had access to.

2.2.3 Data entry

The first questionnaire study was paper based; as such the data had to be entered by hand into Microsoft Excel for analysis. To ensure data entry precision, all entries were triple checked for accuracy prior to analysis. This was conducted by the researcher on separate days. Minor errors occurred due to the software spell check auto-correction and in these cases the verbatim responses were identified and the responses were returned to the original wording used by the

questionnaire respondent. Comments that had been added to closed answer questions were disregarded. Incorrectly completed questions were also disregarded.

For the online based questionnaire studies Survey Monkey (Gold survey package) was used to export the data directly into Microsoft Excel (2010) and SPSS (version 21). Transfer of the data was necessary for its analysis.

2.2.4 Data analysis

The closed answer questions in the questionnaire based studies required statistical analysis whereas the open ended questions required qualitative analysis. Microsoft Excel (2010) and SPSS (version 21) were used for quantitative analysis. Two software programmes were required as Microsoft Excel enables data to be easily manipulated and provides more flexibility in the production of graphs. It also allows easier importing of graphs into Microsoft Word compared to SPSS. SPSS enables full statistical analysis to be completed. NVivo (version 9) was used for the qualitative analysis.

2.2.4.1 Qualitative analysis of open ended questions

The chosen method of analysis was applied thematic analysis. The following table summarises the processes undertaken to conduct the analysis.

Table 4: Steps of applied thematic analysis used

Step 1. Acquainted oneself with the data	Transcribed data, read and re-read through the data, wrote down initial ideas.
Step 2. Produced initial codes	Coded thought-provoking data in a systematic manner across the data set.
Step 3. Explored for themes	Brought codes together into themes.
Step 4. Evaluated themes	Did the themes work in relation to extracts and entire data set?
Step 5. Defined and named themes	Determined the specifics of each theme, each had a clear definition and name.
Step 6. Wrote up	Selected appropriate examples of extracts, related back to research question and current literature, produced report/article of the study.

Table 4 is adapted from 'Table 1 Phases of analysis' in 'Using thematic analysis in psychology'. [100]

Counts of frequency of codes were used to help define themes and to decide if there was enough evidence to support a theme. However, the main evidence for each theme was determined by the content of each extract rather than the quantity of codes that fitted to that theme.

2.2.4.2 Quantitative analysis of closed answer questions

In the questionnaire studies the two independent variables identified that may influence responses to the questions are profession (e.g. is the respondent a pharmacist or a doctor?) and experience (e.g. how many years of experience at Birmingham Children's Hospital does the respondent have). The demographics of the participants were described. This recorded how many participants from each profession completed the studies and their years of experience. In each study descriptive statistics of the participants overall and for each profession were also recorded. Some comparisons between the professions were able to be made at that stage. The null hypothesis was that profession or experience would not affect the use of resources by the participants. Table 5 describes the most appropriate measures of central tendency to be used in questionnaire study one. The mean will only be computed for experience as the other variables have ordinal data. For ordinal data the mode would be the most appropriate measure of central tendency.

Table 5: Appropriate measures of central tendency for medicines management data

Variable	**Most appropriate measure of central tendency**
Experience	Mean
Level of satisfaction with training	Mode
Level of satisfaction with implementation	Mode
Attitude to change before	Mode
Attitude to change after	Mode

The variability of experience was recorded using the range (i.e. the most years of experience minus the least years of experience). This was recorded overall and for both groups within the profession variable. With the exception of years of experience, all data collected was of ordinal data type (i.e. there is a natural scale to the data but there is not an equal difference between each point of the scale). Because of this non-parametric statistical tests were used for data analysis. For ordinal data (e.g. profession vs level of satisfaction with training) the Mann-Whitney U test was used. The Mann-Whitney U test compares mean rank differences between two independent groups. [101] It is the non-parametric alternative to the independent t-test. Assumptions of normality and homogeneity of variance do not apply to this test, but observations must be independent of each other. [101] In questionnaire study one this test was used to see if

there were any differences between the pharmacist and non-pharmacist groups in terms of: level of satisfaction with training, level of satisfaction with implementation, attitude to change before electronic medicines management and attitude to change after electronic medicines management. In questionnaire study two this test was used to test the null hypothesis that there is no difference between medical and non-medical prescribers and their reported frequency of use of each information source.

The Wilcoxon test is used to compare mean rank differences between related groups (i.e. repeated measures). [101] It is the non-parametric equivalent of the paired t-test. Assumptions of normality and homogeneity of variance do not apply to this test, but the observations must be independent of each other. [101] In questionnaire study one this test was used to compare attitudes to change before implementation of electronic medicines management with attitudes to change after electronic medicines management. The details of the tests to be carried for questionnaire study one are described in Table 6. The null hypotheses were that there would be no difference between the professions when the following were considered: training satisfaction, implementation satisfaction, attitude to change before and attitude to change after. The final null hypothesis was there would be no difference in the attitude to change of participants before or after the study.

Within the prescribers at Birmingham Children's Hospital there will be medical and non-medical prescribers (nurses and pharmacists). To determine if there is any difference between the years of experience of these two groups the Kruskall-Wallis test will be used. The Kruskall-Wallis test is used with non-parametric data to test if three or more samples have the same distribution. [101] The null hypothesis stated that there would be no difference in the distribution of years of experience of medical and non-medical prescribers.

Table 6: Statistical tests used in pharmacy staff experiences of the change from paper to electronic medicines management systems study

Data to be tested	**Selected test**
Profession vs training satisfaction	Mann-Whitney U
Profession vs implementation satisfaction	Mann-Whitney U
Profession vs attitude to change before	Mann-Whitney U
Profession vs attitude to change after	Mann-Whitney U
Attitude to change before vs attitude to change after	Wilcoxon

2.2.5 Rationale for method

The chosen method for these studies was a paper or electronic self-completed questionnaire. The versatility of the questionnaire and the low costs of a self-completed questionnaire were important advantages of this method choice. [94] The data collected is more easily generalizable to the chosen study population compared to if a smaller sample was used via interviews or focus groups. [94] The respondents invited to participate in these studies did not have spare time at work to enable interviews to be conducted, although it is acknowledged they may have provided richer data on the experiences of staff.

The choice of a self-completed questionnaire allowed a large quantity of data to be gathered efficiently and in a timely manner with minimal costs. It was important in these baseline studies that respondents had an opportunity to comment on their current practice as these studies may have implications on the development of electronic clinical system design and that could ultimately affect all healthcare staff using such a system. Therefore it was important to gain opinions from as many people as possible within the population rather than fewer rich descriptions from targeted interviews or observations. The questionnaire studies have provided data that can be easily compared if the study is repeated after the introduction of an electronic clinical system or if the study is conducted at another paediatric centre.

Satisfaction questions employed a five point Likert-style scale to enable opinions to be quickly identified. These closed questions ensured responses were clear and unambiguous. The accompanying open ended questions ensured experiences and reasoning were also provided, enabling a rich data set that has been used to assist in the explanation of the quantitative results.

Challenges with this method include the possibility that the responses may not reflect the participants practice in reality. [94] However, this problem would also be encountered if the study had an interview or focus group method.

Methods to improve the response rates in these studies were employed due to the known difficulties in recruiting healthcare professionals into questionnaire based studies. This included careful design of the questionnaire to ensure the length was minimised and the number of open questions was minimised. [102] It has been reported that lower response rates may be found when using open questions in comparison to closed questions. [102] Therefore in this study only essential open questions were asked. Further ‘design incentives’ included dissemination of the study to participants by direct email from a medical or pharmacy peer (a medical/pharmacy director at the hospital) and organisational endorsement of the study by a professional organisation such as the Neonatal and Paediatric Pharmacist Group. These ‘design incentives’

have been previously recognised as one way of improving response rates of doctors by Van Geest et al. [102]

Although earlier research has suggested that web based questionnaires may offer a lower response rate than mail based questionnaires, more recent studies have indicated this may no longer be the case. [103] It is reasonable to use web based questionnaires with employees that are IT literate and have access to the internet in their work; both criteria would be met by the staff at BCH and members of the NPPG indicating that a web based questionnaire was a reasonable choice. [103]

2.2.6 Rationale for qualitative analysis method

The analysis type for this qualitative study was thematic content analysis following the principles described by Braun and Clarke. This is the most common approach to qualitative analysis. [93] The main advantage of using thematic analysis is that it is not tied to one particular theoretical framework. [100] It is therefore flexible to the data available and does not require detailed technical knowledge and as such is a practicable choice of analysis. The disadvantage of this technique is that context can be lost when categorising themes. [100] However, this can be avoided during the evaluation of themes stage of the analysis process. By evaluating the themes, the researcher will be able to see which themes are supported with data and if they reflect the meaning found in the data set.

2.3 Experiences of pharmacy staff when moving from a paper based to an electronic medicines management system

The aim of this study was to explore the opinions and experiences of pharmacy staff at Birmingham Children's Hospital after they switched from using a paper based medicines management system to an electronic medicines management system. The study collected data on: advantages and disadvantages of each system; training for the electronic system; implementation of the electronic system and staff recommendations for improvements.

2.3.1 Timing of the study

The study was conducted as soon as practically possible after the implementation of the new electronic medicines management system. Delays in the ethics process meant the intended start of one month after the system roll out was not met. The questionnaire was intended to be disseminated to participants in January 2013. However, the questionnaire was subsequently available to participants from 4th April 2013 until 30th June 2013. Participants were told they could complete the questionnaire during working hours as the questionnaire was also a registered audit at the hospital.

2.3.2 Sample size

The eligible population was pharmacy staff who had used both the old paper based medicines management system and the new electronic medicines management system. This totalled 54. The aim was to recruit 35 respondents to achieve a confidence interval of ± 10 and a 95% confidence level.

2.3.3 Questionnaire design

The questionnaire design was based on a discussion with two non-pharmacist staff members, one pharmacist and one pre-registration pharmacist; four participants in total. The participants were encouraged to draw the medicines management process as a flowchart both for paper based system and for the new electronic system. The participants were asked to label and describe the advantages and disadvantages for each process. Finally, they recorded the timeline as they remembered it for the training and implementation periods. This discussion was not audio recorded, but the flowcharts and timelines drawn by the participants were used to inform the questionnaire design.

The software used for the questionnaire design and production was SNAP (version 10). This was chosen due to existing experience of using this programme in the pharmacy practice research office at Aston University and the availability of a licence for the researcher. The original intention was to have an electronic online questionnaire; however it proved too time consuming to arrange the setup of this with the necessary information technology teams within the university. The software was used to develop and print the questionnaires. A paper based format was determined to be manageable for this study. The first reason for this was the study population was small and the resulting data entry would be manageable. Secondly, using a paper questionnaire would ensure the participants could complete it without the need to access a computer. Thirdly, the pharmacy department was not required to share the email address data of its staff. To avoid unnecessary delays to the data collection in this study the choice was made to switch to paper. To prevent a participant completing more than one copy of the questionnaire an administrator ensured only one copy was received from each participant.

See Appendix 2 for final version of the questionnaire.

2.3.4 Pilot of questionnaire

The questionnaire was piloted with one pharmacist and one non-pharmacist member of staff from the pharmacy department at Birmingham Children's Hospital. Due to the small numbers of staff in the team at the study hospital further pilot participants were not selected so as not to impact on the potential sample number. The pilot helped determine the face validity of this study

as the researcher could be sure the questions were measuring the concept they were intended to measure. Comments from the pilot were positive and the participants stated the questionnaire was understandable to them and relevant to the systems being evaluated. Two additions were made to the questions about the perceived advantages/disadvantages of the systems. The disadvantages added were: pharmacists use Ascribe (pharmacy dispensing and medicines management software) less often so it takes them time to put the medications onto it and pharmacy technicians are able to resupply a medication for a repeat when it may have not been approved by the pharmacist.

2.3.5 Distribution of the questionnaire

The study was introduced to the pharmacy department at the regular departmental meeting for all staff and at the same meeting an initial distribution of the questionnaire was made to all eligible participants present by the researcher. Not all staff attended this meeting so this meeting was followed up with further introductions to the study and distributions of the questionnaire by the researcher at pharmacy technician and pharmacist meetings. Copies of the questionnaire were handed out personally to individual members of staff. Further distributions, email reminders and visits to the department were also made to encourage a higher response rate.

Table 7: Timetable of reminders for medicines management questionnaire

Date	**Activity**
04/04/2013	Questionnaire launched at pharmacy department meeting
09/04/2013	Completed questionnaires collected and email reminder sent to pharmacy staff
16/04/2013	Email reminder sent by pharmacy team leader to pharmacy staff. Completed questionnaires collected, verbal reminders provided to pharmacy staff
18/04/2013	Attended pharmacists meeting to introduce the questionnaire and hand out to eligible pharmacists
23/04/2013	Completed questionnaire collected and verbal reminders provided to pharmacy staff by researcher
30/04/2013	Attended pharmacy technician meeting to introduce the questionnaire and hand out to

	eligible pharmacy technicians by researcher
08/05/2013	Email reminder sent to pharmacy staff. Completed questionnaires collected and verbal reminders provided to pharmacy staff by researcher
13/05/2013	Completed questionnaires collected and verbal reminders provided to staff by researcher
22/05/2013	Delivered further copies of questionnaire to pharmacy department and gave verbal reminders to pharmacy staff by researcher
06/06/2013	Pharmacy team leader to chase non-completers of study (audit is part of contract for NHS staff) via email and in person
08/07/2013	New pharmacy audit lead sent email reminders to pharmacy staff

2.4 Resource use during prescribing decisions by prescribers at Birmingham Children's Hospital

The aim of this study was to determine the usual practice of resource use during prescribing by prescribers at Birmingham Children's Hospital. Resource use refers to the use of any source of information during the process of prescribing that aids the prescribing process. The study collected data on: prescriber details (profession, level of experience, frequency of prescribing habit); resource use (frequency, what resources, which resources are preferred) and availability of prescribing information for children. The chosen method for this study was an electronic questionnaire distributed to participants via email. The questionnaire provided both quantitative and qualitative data on current practice of resource use when prescribing.

2.4.1 Sample size

The number of prescribers at Birmingham Children's Hospital at the time of the study was 423. That included: consultants, medical trainees and non-medical prescribers. Inclusion criterion for this study was that the individual was a prescriber at Birmingham Children's Hospital NHS Trust. The aim was to have a sample of at least 202 respondents resulting in a confidence interval of ±5 with a confidence level of 95%.

2.4.2 Timing of this study

This study was launched at the end of 2013 when Birmingham Children's Hospital was in the early stages of procuring an electronic prescribing system. At the time of the study the provider for the electronic prescribing system had not been confirmed. The predicted launch of electronic prescribing is now summer 2016 so it is anticipated that data from this study will inform the development of this system.

2.4.3 Questionnaire design

Design of the questionnaire was informed by the initial exploratory focus groups held early on in this research programme in addition to the available research literature. These were held with both medical and non-medical prescribers, who were the population to be targeted by this study. Therefore the selection of participants for the focus groups was adequate to inform the development of this study.

The list of potential resources for inclusion in the questionnaire was drawn from the focus group discussions and the acquired knowledge of the researcher. The researcher acquired knowledge through prior work as a healthcare professional and being a member of the multidisciplinary team that was developing an electronic prescribing and decision support system at Birmingham Children's Hospital. This information led to the development of questions on how often a resource is used when prescribing, which resources are used and how often a specific resource is used. The focus groups also discussed that there was a lack of paediatric advice in certain paediatric areas at the time of the study, for example, information regarding renal and hepatic doses. This prompted the researcher to ask the questionnaire respondents whether there was a lack of paediatric prescribing information in general as well as for specific clinical areas. Participants in the focus groups also commented that certain resources were easier to use than others for a variety of reasons. Consequently questions were developed to cover the reasons why resources would be considered useful or not.

Originally it was intended to employ the Snap Surveys software (version 10) for the questionnaire design and distribution of the questionnaire. However, there were considerably difficulties getting the same version of the software available at both the university and hospital sites. This was a problem as the questionnaire was designed in Snap version 10 and this was incompatible with the earlier version of Snap software used in the hospital. The hospital did not want to have staff email addresses released to be used in the university's version of Snap, but it was also unable to upgrade its version of Snap to be compatible with the questionnaire developed at the university. An agreement regarding the distribution of the questionnaire online and compatibility of Snap software at the two sites was not available in a timeframe that enabled the research programme

to continue at a reasonable pace. In order to launch the questionnaire in a timely manner another option was developed. The option chosen was the Survey Monkey Gold plan. This version of Survey Monkey had the necessary question and response designs needed for this study alongside advanced routing features. The Survey Monkey Gold Plan version also came with SPSS integration which would be valuable for the statistical analysis. Neither the university nor Birmingham Children's Hospital raised any ethical concerns about the change of survey software.

A copy of the questionnaire can be found in Appendix 3.

2.4.4 Pilot of questionnaire

The questionnaire was piloted by a group of medical and non-medical prescribers at Birmingham Children's Hospital. There were six participants, two non-medical prescribers and four medical prescribers. Participants were asked to complete the questionnaire and comment on the ease of completion and clarity of the questionnaire. Participants in the pilot were also asked to time themselves completing the questionnaire so that the information sheet and email requests would contain accurate time commitments required from participants.

Several small changes were made to the questionnaire as a result of the pilot study, but no major changes were required. This may be because a combined team of a doctor, pharmacist and non-medical prescriber had provided pre-pilot comments on the face validity of the questionnaire. The non-medical prescriber pilot participants had fewer comments than the medical prescriber participants. The non-medical prescriber participants had "*no real issues*" with the questionnaire and found it to be "*thought provoking*". Medical prescribers commented on the clarity and comprehensiveness of the questionnaire. One participant stated it was difficult to rank some areas of the questionnaire as they all were equally important, but no other participants mentioned this difficulty therefore the ranking questions were not altered. The instructions for the ranking questions differed slightly in the pilot to see if there was any preference for either style of questioning. One participant (who commented that English was not his/her first language) noted that the second set of instructions was clearer and easier to follow. For the final version of the questionnaire both ranking questions were altered to use the second set of instructions.

Another participant commented that the questionnaire was useful for staff members to feel involved in the design of the new prescribing process for the hospital. This participant felt that if this was the case it could help ensure the resulting system was user friendly and it will facilitate the change process.

The pilot was also useful for determining how the questionnaire functioned on smaller screened devices such as smart phones. One participant reported that he had completed the questionnaire on his smart phone with no problems.

2.4.5 Questionnaire distribution

The researcher could not gain access to the email addresses of the prescribers at Birmingham Children's Hospital so the questionnaire was distributed by a member of staff at the hospital instead of directly from the survey software. This improved the anonymity of the potential participants as the researcher did not have their email address at any point in the study. The questionnaire was hosted by Survey Monkey and a direct link to the questionnaire was sent to participants. The researcher and participants were blind copied into all emails sent by the hospital staff member. This enabled the researcher to confirm the email had been sent as requested without revealing the email addresses of the potential participants.

The questionnaire email and two subsequent reminder emails were sent from the account of the Deputy Medical Director at the hospital who was a clinical supervisor on the research study. However, the researcher remained in charge of the timing of the reminders and tracking the number of respondents. For a reminder to be sent the researcher had to request this be done by the Deputy Medical Director, who would then send the required email out to participants. Without access to the participants email addresses there was no method for the researcher to track who had completed the questionnaire. Therefore targeted reminders to solely non-respondents could not be sent and as such they went to all potential participants. Table 8 shows the timetable of emails sent to potential participants.

Table 8: Timetable of reminders for prescriber resource use questionnaire

Date	**Activity**
28/10/2013	Initial questionnaire email sent to consultants
04/11/2013	Initial questionnaire email sent to trainees
05/11/2013	Initial questionnaire email sent to non-medical prescribers
21/11/2013	Reminder email sent to trainees
24/11/2013	Reminder email sent to consultants
17/11/2013	Reminder email sent to non-medical prescribers
20/12/2013	Reminder email sent to consultants
14/01/2014	Reminder sent to trainees

2.5 Resource use during paediatric pharmacy services provision

The aim of this study was to determine current practice of decision support resource use when providing clinical pharmacy services to paediatric patients. Pharmacy services were defined by the researcher as services provided by pharmacists working in a hospital environment. This could include, but was not limited to: supplying medication, clinically screening medication, answering medication queries and medication reviews.

The study collected data on:

- Pharmacist details (level of experience, frequency of paediatric pharmacy services);
- resource use (frequency, what resources, which resources are preferred);
- availability of prescribing information for children.

The chosen method for this study was an electronic questionnaire distributed to participants via email. The questionnaire provided both quantitative and qualitative data on current practice of resource use when prescribing.

2.5.1 Sample size

The questionnaire was delivered to members of the Neonatal and Paediatric Pharmacists Group (NPPG) the UK's leading group for paediatric pharmacists based on membership numbers. It was sent to 280 potential participants (i.e. all members with an email address). The aim was to have a sample size of 167 and therefore have a confidence interval of ±5 and a confidence level of 95%.

2.5.2 Questionnaire design

The questions of this questionnaire were designed to provide a direct comparison to the prescribers' questionnaire run at Birmingham Children's Hospital. Therefore the questions remained almost identical so this purpose could be met. The wording of the questions was amended to reflect the new audience. For example, instead of referring to prescribing or prescribers the questionnaire now refers to paediatric pharmacy services or pharmacists. The questionnaire continued to use Survey Monkey as the design tool and host.

A copy of the questionnaire can be found in Appendix 4.

2.5.3 Pilot

This questionnaire was not piloted as it was the same questionnaire as conducted at the Birmingham Children's Hospital prescribers' questionnaire. There was no change in questions or profession completing the questionnaire so it was not deemed necessary to conduct a second pilot as there were pharmacist participants in the pilot of the initial study.

2.5.4 Questionnaire distribution

The questionnaire was distributed by the NPPG via email using their database of contact details of members. Potential participants were asked to provide their membership number in the questionnaire so the researcher could validate all responses were legitimate. The researcher contacted the Secretary of the NPPG each time a reminder needed to be sent out. On sending of the reminders the researcher was copied into the email to confirm the reminder had been sent as requested. Reminders were sent to all potential participants as there was no method of determining who had completed the questionnaire as the researcher was not permitted to access the email addresses of the potential participants.

Table 9: Timetable of reminders for NPPG questionnaire study

Date	Activity
15/11/2013	Initial email regarding questionnaire sent to NPPG members
06/12/2013	Reminder email sent to NPPG members
09/01/2014	Reminder email sent to NPPG members

2.6 Analysis of documents: support for prescribers: what is discussed at hospital board level?

The aim of this study was to determine the extent and content of paediatric prescribing support discussions at board meetings of NHS paediatric hospitals. The chosen method for this study was qualitative analysis of documentary sources. The documentary sources to be analysed were publically available minutes and papers from board meetings of NHS Trusts.

2.6.1 Sample size

There are four independent paediatric NHS Trusts in the UK. To include other NHS Trusts that have paediatric hospitals within them was deemed inappropriate as it may not have been possible to tell if references in the minutes referred to the adult or paediatric site within that trust. Therefore only the four paediatric NHS Trusts were included in order that the researcher could be certain that any reference to improving prescribing were aimed at those prescribing for paediatric patients.

2.6.2 Period of study

The chosen period of study was three complete calendar years from January 2010 to December 2012. This period of time was chosen as it was recognised that in recent years there has been an

increased focus on medication safety in hospitals and as such the minutes from this period should reflect this. A study period of three years was selected because it is recognised that in the NHS it can take many months for projects to be approved, make the transition to being live and for results to be reported back to the board.

Initially a period of two years was selected but after preliminary examination of the data it was determined that an extra year of data was needed in order to fully represent current practice in the study data set. Previous experience of the researcher regarding NHS projects confirmed that it would be prudent to add another year to the study period.

2.6.3 Ethical approval

No ethical approval was required from the university for this study as the data used was available in the public domain.

2.6.4 Data collection

The data for this study was publically available. Therefore the researcher needed to download the required minutes from each of the study sites NHS Trust website or request the required minutes via the freedom of information request manager. A total of four freedom of information requests were made. Each request was made via email and all study sites supplied the required data via email. One freedom of information request was required for Birmingham Children's Hospital because there were three board meetings that did not have papers available to download from the website. One freedom of information request was sent to Sheffield Children's Hospital because due to broken links on their website a full data set could not be downloaded. One freedom of information request was sent to Great Ormond Street Hospital because there were ten sets of minutes that were not available on the website. One freedom of information request was sent to Alder Hey Children's because the minutes for 2010 and 2011 were not available to download from their website. The average number of board meetings per year at each hospital was 10.

2.6.5 Data entry

Data for analysis was entered into NVivo (version 9). This piece of software was valuable in this study due to the large volumes of data that needed to be managed. It did not manage the large PDF documents that contained the board meeting minutes. Therefore data needed to be modified before importing it into NVivo. This resulted in cutting the minutes/papers documents into smaller files that the NVivo software could manage. As a significant proportion of each meeting's documentation was dedicated to issues not related to prescribing, for example financial and

human resources reports, these sections were removed. Only sections related to prescribing support and medication safety were imported into NVivo.

2.6.6 Data analysis

The chosen method of analysis was applied thematic analysis. Please see section 2.2.4 to refer to the exact procedure followed.

2.6.7 Rationale for method

The analysis of documents is an established method in qualitative research and this method is a valuable way of exploring what is happening within an organisation. [93] It was more efficient to collect the minutes from prior board meetings rather than to observe current meetings or processes over a similar period of time. The organisations in this study have a far greater capacity for producing this data than an individual researcher so it was more efficient to make use of the data freely available. Public records, such as board meeting minutes, have been considered one way of indicating what is important to an organisation at that time. [93] Therefore the amount of data regarding paediatric prescribing support and prescribing errors may be indicative of the importance attached to these issues by each of the hospitals. Authenticity of the information is likely as these are public documents that are required to be an accurate reflection of the meeting. [94]

2.7 Interviews with selected leaders in paediatric electronic prescribing

The aim of this final study was to collect experiences and advice from the selected leaders in electronic prescribing and decision support. Data was collected on: advantages and disadvantages of electronic prescribing/decision support; future developments of electronic prescribing/decision support and advice for organisations yet to implement electronic prescribing. The chosen method for this study was semi-structured interviews.

2.7.1 Sample size

The experts in electronic prescribing needed to be identified. Prior knowledge indicated there were two hospitals that each had over ten years of electronic prescribing experience, which led to their selection as a source for participants. These hospitals also had experience of using electronic prescribing in paediatric populations. The participants selected were individuals who were leading the electronic prescribing programme at the hospital. Commercial awareness and company staff availability led to the selection of two UK based providers of electronic prescribing software, who were also leading suppliers of this technology. Further participants were selected from

independent UK paediatric NHS Trusts to explore the paediatric perspective in this research area. These participants were leading on the development of electronic prescribing within each hospital. Birmingham Children's Hospital was excluded due current involvement in their electronic prescribing initiative. It was felt that this long term commitment of work on the electronic prescribing initiative may bias the reporting of data from this hospital, hence its exclusion from the study.

Selection of a suitable participant from each location relied in part on the organisation and the judgement of the researcher. Ideally the hospital participants were part of the team leading the implementation or management of electronic prescribing so they have the necessary experiences to provide an overview of electronic prescribing at that hospital. The researcher did not have a choice of participant with the companies as they determined who would be available to participate in the study. The possible influences of participant selection on the findings are discussed in the analysis of the study in chapter 7.

2.7.2 Ethical approval

This study was approved by Aston University Ethics Board (#546, approved 24/10/2013).

Gaining ethical approval for this study from the university was a particularly challenging process. There was a delay of several months between the initial approval subject to amendments and the approval of the amendments sent through. Interviews with companies were approved and could go ahead, but interviews with any NHS staff member would require the university ethics committee to see an approval from each trust involved in the study. This meant that individual approval had to be sought from each NHS trust and added to the university's approval before the interview could take place. The ethics committee also determined that participants must be able to review and amend their transcript after the interview if they chose to. It was agreed that seven days was a suitable period of time for them to do this.

2.7.3 Development of the interview guide

The design of the interview guide was directed by the emerging themes from the earlier studies and current literature. The importance of implementation was noted in the literature and as such questions regarding the implementation process were asked. The primary focus of the two previous questionnaire studies had been the resources used to support prescribing decisions, so questions regarding prescribing support offered by the system in question were included in the interview guide. Much of the published research in this area describes improvements attributed to electronic prescribing (for example, legibility of prescriptions) or new areas of concern that have arisen as a consequence of electronic prescribing. Therefore both these topics were included

in the interview guide. During the initial focus group study participants were very optimistic about the functions that could be included in electronic prescribing systems in the future. As a result of this, interviewees were asked to reflect on where their prescribing systems might be in five or ten years time. Finally, recent conferences such as "Electronic Prescribing in Hospitals: Moving Forward" contained case reports of advice from hospitals, but much of this data has not been published elsewhere. Therefore participants who had implemented electronic prescribing or were part way through the process were asked what advice they would give to hospitals that have yet to take this step. During the interview process the topic of training came up several times (it was also mentioned often in the "Electronic Prescribing in Hospitals: Moving Forward" conference) so this was added to the interview guide for the later interviews.

Please refer to Appendix 5 for the interview guide.

2.7.4 Data collection

The majority of data was collected by audio recording the interviews at a location of the participant's choice. These were largely at their places of work, but there was an interview held in a hotel's meeting area at the request of the participant. Written informed consent was gained prior to commencing each interview and this was reconfirmed verbally also. Participants received an information sheet to read through before the interview and were told the topic of the interview was electronic prescribing and prescribing support. Participants had seven days to review their transcript (required by the university ethics board). Here there was a final confirmation of consent when the participant approved the transcript. One company was unable to provide a participant to complete the interview, but instead completed the interview via email. The audio recording device failed at one interview, so the transcript was created from the researcher's notes.

2.7.5 Data entry

All audio files were transcribed by the researcher using Windows Media Player and Microsoft Word. This was a timely process with each hour of audio taking up to ten hours to transcribe. However, it did ensure that the researcher was familiar with the data set before beginning the analysis.

2.7.6 Data analysis

The chosen method of analysis was applied thematic analysis. Please see the previous table in section 2.2.9 to refer to the exact procedure followed.

2.7.7 Rationale for method

Interviews were a suitable method for this aim as it is not possible to gain rich data on experiences and opinions using quantitative methods. The results were a valid record of the participants' experiences and views. The quality of the data set gained has been improved through the use of purposive sampling. Purposive sampling is the selection of participants by the researcher to ensure a representative sample is participating; it is particularly useful when different perspectives are required from a limited population of experts. [99] Each participant was chosen for their prior experience in the research area or their knowledge in the more specialist field of paediatrics and electronic prescribing. The semi-structured interview allowed the researcher to provide focus on a wide ranging topic area.

Disadvantages of the semi-structured interview method are that the results are unlikely to be reproducible. It is not likely that the participant will provide the same responses if the interview was repeated. It is also important to note that the responses from the participants are a narrative and therefore may not be indicative of what they actually do. [93, 94]

Several techniques were actively employed in this study to improve the quality of the interview method. It is important that the interviewer has a good understanding of the language used by the participants. [93, 94] This was assured in this study as the researcher is a hospital pharmacist with a good understanding of the research area gained during the earlier years of the PhD programme. The location of the interview is also important and it is thought that it is best to conduct the interview in a place that the participant feels is 'theirs'. [93] This advice was heeded in this study as participants were interviewed at their place of work or in one case a location of their choosing that was more convenient for them. Finally to encourage the participant to speak freely and provide complete answers to questions, the interviewer must be receptive. [93] This can be achieved by: not interrupting the participant; recognising the participants answers by nodding or saying "mm"; and finally when the participant finishes speaking leaving a slightly longer silence than usual to allow them to add any extra details if they choose to. [93]

2.8 Use of software to support data collection and data analysis

Use of software in these studies has ensured effective use of time by the researcher. A variety of software has been used to maximise the reliability and validity of the data collection and data analysis. The software that has proved to be valuable in this research is:

- Survey Monkey (Gold survey package),
- SNAP (version 10),
- Microsoft Excel (2010),

- Microsoft Word (2010),
- Adobe Reader (version XI),
- SPSS (version 21),
- NVivo (version 9),
- Windows Media Player (Windows 7).

Microsoft Word was useful for recording the transcriptions of the interviews and focus groups. It has also been useful for formatting qualitative question answers before copying them into NVivo for analysis.

NVivo has enabled a systematic and thorough thematic analysis to be done more efficiently that if it had been done by hand. It is easier to view everything coded under a single code on a page together to ensure coding consistency. Viewing everything under one code on a computer also ensures everything under than code is seen by the researcher. This cannot be guaranteed if the analysis is completed by hand. Although there were some problems importing large PDF files into NVivo no further problems were experienced. It ensured there was a high level of rigour applied to all qualitative analysis throughout this PhD.

The researcher completed a one day course at Aston University on using NVivo for qualitative analysis alongside a two day course at Oxford University on methods of qualitative analysis. Specific software training for SPSS was provided by Aston University.

3. Initial exploratory focus groups

The purpose of this study was to explore the current practice of paediatric prescribers and pharmacists regarding resources used when making medicines related decisions for children. It also investigated attitudes towards systems such as electronic prescribing that have been designed to improve prescribing practice. Data were collected from four focus groups at Birmingham Children's Hospital (BCH) in 2012. Details of the method can be found on page 32. The objectives were to:

- Provide an insight into current paediatric prescribing practice
- Explore attitudes towards systems designed to improve paediatric prescribing practice such as electronic prescribing
- Inform the design of future studies regarding methods used to support medicines related decisions in paediatrics.

3.1 Context of this study

Alongside analysis of the current literature this study was required to develop the further studies presented in this thesis regarding supporting medicines related decisions in paediatrics. The four focus groups were conducted early in the research programme at BCH with both medical and non-medical prescribers. Prescribers with a range of experience participated, including non-medical prescribers in training and consultants with over ten years of experience in paediatrics. The discussion points of the focus groups were designed using the available literature and prior hospital experience of the researcher.

3.2 Results and discussion

3.2.1 Resource use in paediatrics

The use of various resources was the theme with the most data points in both the medical and non-medical prescribers focus groups (n=33 and n=30). Paediatric prescribers reported to use a range of resources to support their work. This included: BNFc, trust guidelines, Frank Shan (a specialist paediatric intensive care prescribing guide), local standard infusions card, pharmacy staff and other colleagues. Participants often used the BNFc and trust guidelines to support decisions regarding doses. However, information about other aspects of prescribing such as interactions and administration was less frequently referred to. There were no clear differences between the resources used by medical or non-medical prescribers.

3.2.2 Current difficulties with available paediatric resources

Both medical and non-medical prescribers reported difficulties with the currently available paediatric prescribing resources (n=8 and n=15). Non-medical prescribers reported more difficulties than medical prescribers. Non-medical prescribers were more likely to refer to a lack of access to certain types of patient information. In particular, they had difficulty accessing patient information that was either held in the clinical notes or on the pharmacy dispensing system (Ascribe). In contrast, medical prescribers referred to a lack of specialist paediatric prescribing information within specialties such as liver or renal impairment. Non-medical prescribers also referred to a lack of specialist paediatric prescribing information, but less frequently than their medical peers did. Medical prescribers reported a frustration that they could not access the specialist pharmacists out of hours.

> *"The pharmacists are a fantastic resource we use all the time but then at the weekend they're not there, which I find quite bizarre."*

3.2.3 Decision support expected in electronic prescribing for paediatrics

Both medical and non-medical prescribers agreed that dosing support should be a key function in an electronic prescribing system for use in paediatrics. The participants expected a paediatric electronic prescribing system to be able to calculate doses using individual patient factors such as: weight, age and body surface area. This is in line with currently available functionality as reported by Stultz and Nahata. [4] Both medical and non-medical prescribers expected prescribing to be part of a wider electronic patient record that included test results and images. The reported reason for this was to minimise the time spent moving between electronic systems.

> *"I want it to be interactive, particularly with results systems. So I don't have to log out of that."*

3.2.4 Current concerns and potential benefits regarding using electronic prescribing in paediatrics

Both medical and non-medical prescribers could anticipate many potential benefits from the introduction of electronic prescribing (n=56 and n=36). One benefit identified, by both medical and non-medical prescribers, was the ability to be able to see from any location with access to the system if a patient had received the medication the participant had prescribed. A second benefit identified by both professional groups was that electronic prescribing systems had the potential to improve the speed and accuracy of supply of medicines to the patient.

> *"It will be safer and quicker once you've learnt to use it."*

Non-medical prescribers also identified that easier access to the patient's medical and drug history would be one of the most significant benefits to them. Improved access to patient history

would remove one of the difficulties non-medical prescribers reported having currently. Finally, a further benefit to non-medical prescribers, which was not reported by medical prescribers, was the ability to more easily monitor their own practice and to identify trends in their prescribing habits. Medical prescribers reported that it would be beneficial to be able to see a snapshot of a patient without having to find or be in the same location as the paper patient notes.

However each focus group also had several concerns about using electronic prescribing (medics n=33, non-medical n=32). The majority of participant's concerns focussed on the provision of suitable information technology infrastructure/hardware. All participants were concerned that the current infrastructure/hardware could not support an electronic prescribing system. Participants were concerned that there was not sufficient numbers of computers available in clinical areas and that IT support was too *"relaxed"*. The security of the IT system was discussed by both groups as an important issue that needed to be addressed without causing lengthy log on procedures and slow access.

Non-IT related concerns focussed on staff training, the handling of alerts in an electronic system and testing the system to ensure it fitted with current workflows and practices.

3.2.5 Alerts in clinical systems

The non-medical prescribers focus groups had extensive discussions about the use of alerts in clinical systems (n=17). However medical prescribers were less focussed on this topic (n=6). Both professions of participants agreed that the same alerts should be displayed to the prescriber regardless of experience or specialist clinical area. Each group discussed the optimum way that healthcare professionals would be expected to interact with alerts. Some participants reported that if you were to override an alert then you should be expected to comment as to why you took that action. In line with current literature that has stated the alerts could be presented according to their severity, participants agreed that alerts should be triaged. Each type of alert should then require a different response from the user depending on its level of severity. [104, 105]

3.3 Impact on study development

These focus groups alongside the existing literature provided valuable information regarding the development of the studies in this research programme.

The focus groups provided initial data on the resources currently used to support paediatric prescribing. The resources referred to above, along with the information in the introduction and the researcher's prior knowledge were used to populate the questions on resources put to respondents at BCH and from the NPPG.

Information was provided on current prescribing practice. This suggested that information such as type of healthcare professional, years of prescribing experience and frequency of prescribing may influence the way in which healthcare professionals use resources to support prescribing in paediatrics.

The discussions regarding alerts demonstrated that the accuracy and relevance of these alerts was important to the participants of the focus groups. In order to produce alerts in a clinical system that are accurate and relevant to the user the system developers first need to understand the information that they value. Therefore further questions on the type of information used by prescribers and pharmacists were included in the questionnaires.

The references to a lack of available literature in these focus groups supported some information reported in the previous literature that current resources may not be adequate to support prescribing in paediatrics. This prompted the researcher to include questions to pharmacists and prescribers to determine if they thought there was a lack of paediatric prescribing information; if so what information was lacking and did this lack of information have an effect on patient care.

Pharmacists and pharmacy systems were referred to in all focus groups as an important source of information and support when prescribing for children. Pharmacists were valued for their specialist knowledge and their interpretation of specialist paediatric prescribing information. As pharmacists would also be a key user of an electronic prescribing system it was also important to determine what their resource needs were. Hence a study with a pharmacist population was also conducted. In addition, pharmacy electronic systems were referred to as a useful source of information. As pharmacy systems are used to record and manage the supply of medicines, a vital part of the medicine process in hospitals, a study detailing how the supply of medicines can be managed electronically was also conducted.

Throughout the focus groups there were references to other interventions designed to support paediatric prescribing. For example: paediatric prescriptions for infusion card. These references in combination with the variety of interventions reported in the literature formed the basis of the study on the paediatric prescribing improvement initiatives reported by paediatric hospitals in England.

A large proportion of the discussion within the focus groups was based around the potential benefits and concerns of electronic prescribing in paediatrics. The current literature in this area is largely derived from studies based in the USA, where the healthcare system is set up differently to the UK. Therefore benefits and disadvantages of electronic prescribing, alongside

recommendations from experienced users, were prioritised as key interview topics with selected leaders and/or experts in electronic prescribing.

4. Electronic Medicines Management

The purpose of this study was to explore staff experiences of the implementation, training and functionality of a new electronic medicines management system that was introduced in the Pharmacy Department at Birmingham Children's Hospital (BCH) in 2012. Data was collected using a retrospective self-completed questionnaire by Pharmacy Department staff at BCH. Details of the method can be found on page 34. The objectives were to:

- identify attitudes to change before and after the introduction of electronic medicines management
- assess satisfaction with training for electronic medicines management
- assess satisfaction with the implementation process for electronic medicines management
- identify advantages and disadvantages, according to pharmacy staff, of paper and electronic medicines management systems
- identify pharmacy staff opinions on how to improve the electronic medicines management system.

4.1 Context of this study

Prior to the introduction of the electronic medicines management system, Birmingham Children's Hospital operated a paper based system for the medicines management process run by the Pharmacy Department. This system was only used by pharmacy staff. During this process pharmacy technicians would visit the wards to assess each patient's drug history; whether they had brought their own medication onto the wards (patient's own drugs – PODs) and whether any medication needed to be supplied from pharmacy. The pharmacy technician would also create or update the patient profile on the pharmacy dispensing computer system (Ascribe). The paper system involved the pharmacy technicians leaving handwritten notes for the relevant ward pharmacist regarding any apparent discrepancies with the patient's medication or other queries relating to the supply of medication. The pharmacy technician would complete paper order forms for medicines that were not stocked on the wards and then take these orders down to the dispensary for dispensing when he/she had completed their ward visit. After each order had been approved by the pharmacist it could then be supplied to the ward. The paper medicines management process was used across all 15 wards in the hospital.

The electronic medicines management system implemented to pharmacy staff only was an extension of the existing pharmacy dispensing computer system – Ascribe. Several iterations of

the electronic medicines management system were tried in conjunction with software developers at Ascribe and the multidisciplinary operational group of pharmacy staff, starting in June 2012, before an agreement was made that it was suitable to be used for inpatient medication supply in January 2013. The new electronic medicines management functions of Ascribe allowed the pharmacy staff to record medication histories electronically and order inpatient medication electronically. At the same time, all outpatient medication was supplied by a separate newly opened outpatient pharmacy. The intended launch of the survey instrument for this study was one month after the roll out was completed. However this target was not met due to a delay in receipt of ethical approval and the launch of the survey instrument was commenced in April 2013. This was three months after the final iteration of the system was confirmed at the end of January 2013.

During the implementation pharmacy managers reported that training was offered to all staff. A variety of training opportunities were available that pharmacy staff were required to 'self-sign up' to. These included group training sessions for both staff groups (pharmacist and non-pharmacist) and one to one training. A multidisciplinary operation group was in place throughout the process to enable staff to participate and engage in the plans for development and implementation of the electronic medicines management system. Each ward pharmacist chose when their ward would go live. A list of wards using the electronic medicines management system was also put on display in the dispensary and a guideline was provided.

The survey instrument had five main topics. These were:

- satisfaction with the training provided for the electronic medicines management system;
- satisfaction with the implementation process of electronic medicines management
- attitude towards change;
- advantages and disadvantages of both systems;
- recommendations for future improvements.

4.2 Results

4.2.1 Response rate

The combined response rate was 48% (n=26/54). The response rate for pharmacists was 56% (n=14/25). The response rate for non-pharmacist staff was 41% (n=12/29).

4.2.2 Respondent characteristics

All respondents reported that they were aware of the change from paper based to electronic medicines management. All respondents were either pharmacists or non-pharmacist members of the Pharmacy Department team at the study site. Non-pharmacist members were: pharmacy technicians, student pharmacy technicians or dispensers. 14 respondents identified themselves as pharmacists. 12 respondents identified themselves as non-pharmacist members of pharmacy staff.

Respondents were asked to record the number of years/months they had worked at Birmingham Children's Hospital. Two respondents (one pharmacist and one non-pharmacist) did not provide a clear answer to this question as there was no unit of time alongside their response. The range of time worked at BCH was 2 years to 27 years. The median and the mode were both 7 years. The mean was 9.5 years. There was no significant difference between the experience of pharmacists compared with non-pharmacist staff (Mann Whitney U test, z value -1.026 and p value 0.108).

4.2.3 Attitude towards change

Participants were asked to record their attitude towards change both before the introduction of electronic medicines management and after the introduction of medicines management.

Figure 1: attitudes towards change of pharmacists and non-pharmacists before the introduction of electronic medicines management.

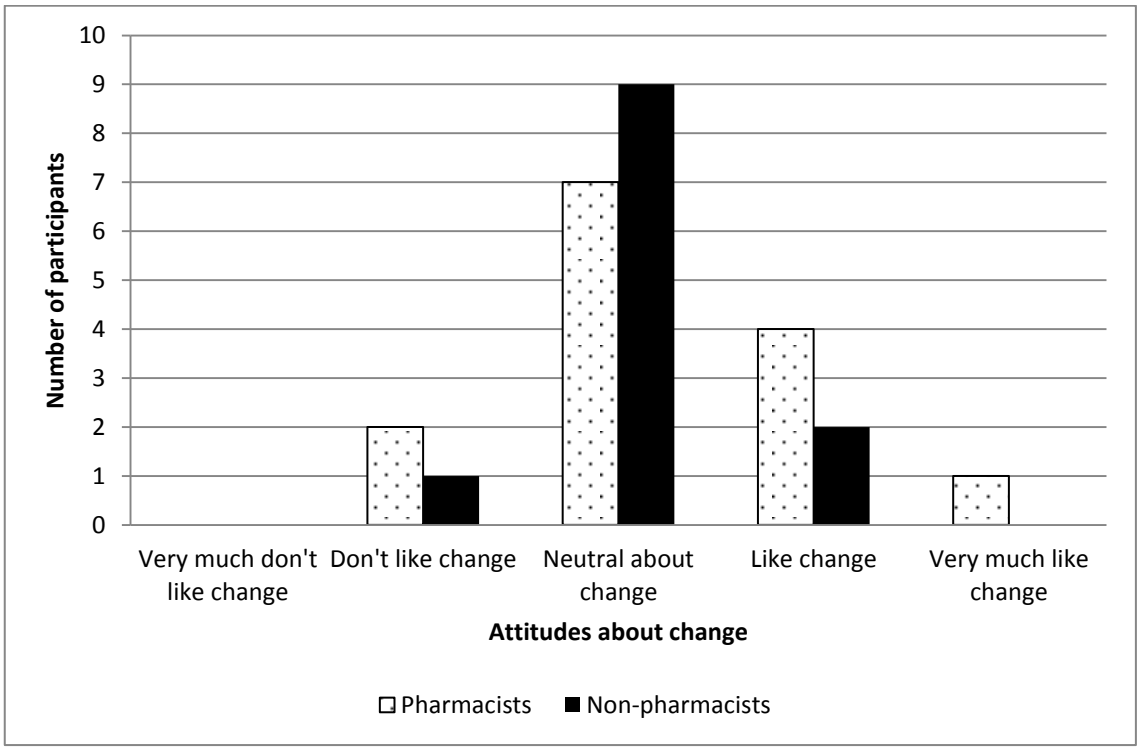


Figure 1 shows that before the introduction of electronic medicines management the majority of respondents had a neutral attitude to change. There was no apparent difference between attitudes of pharmacist or non-pharmacist staff.

Figure 2: attitudes of pharmacists and non-pharmacists towards change after the introduction of electronic medicines management

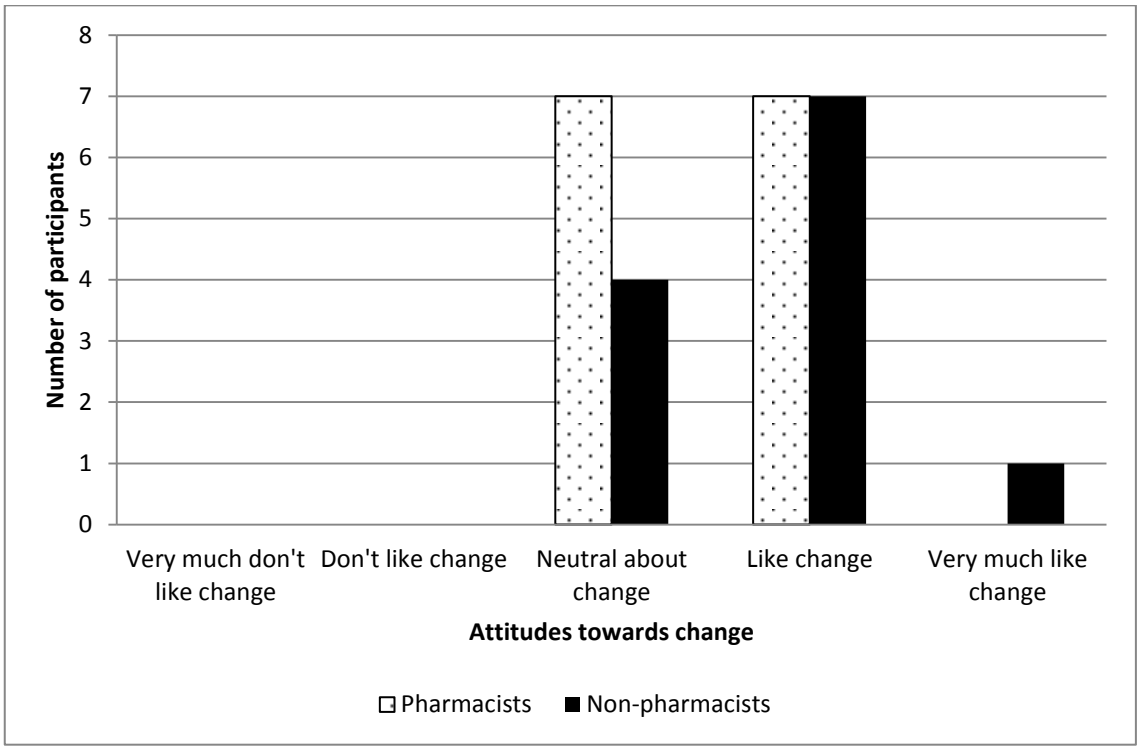


Figure 2 shows the attitudes of respondents to change after the introduction of electronic medicines management.

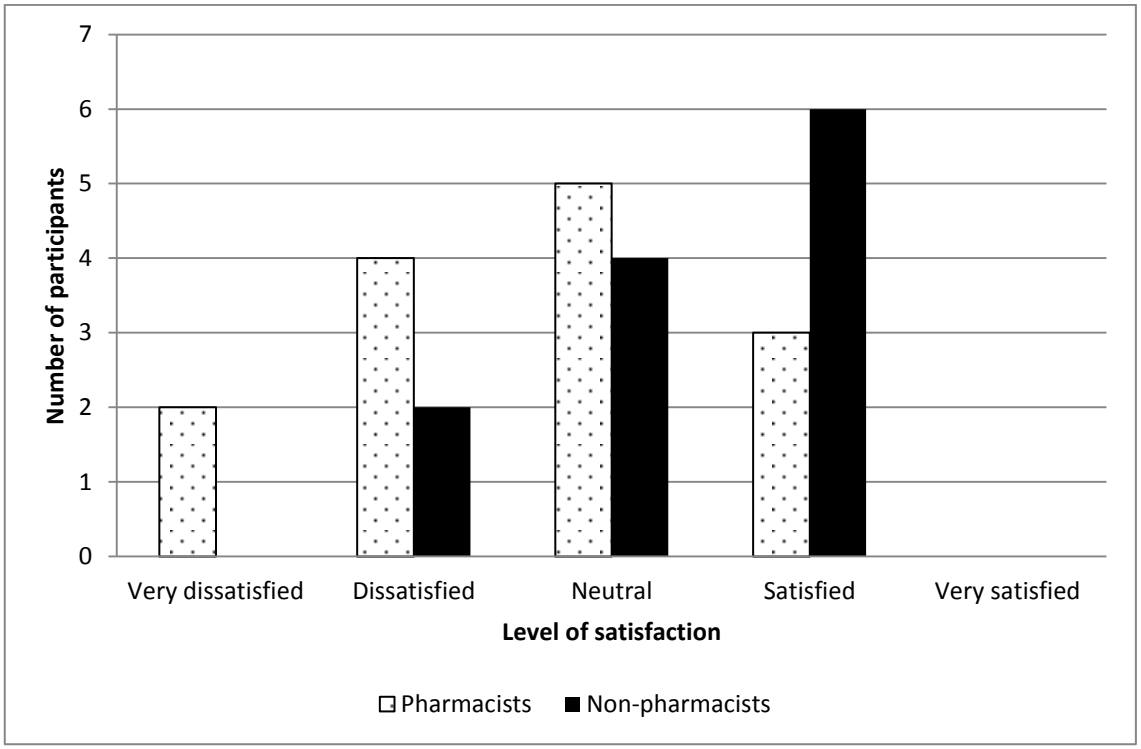
The Wilcoxon Signed Rank Test was performed to compare statistically the attitude before and after the introduction of electronic medicines management. The z value was -2.546 (p = 0.011). The r value (effect size) was 0.3 indicating a medium sized effect. This is a statistically significant result (when p = <0.05) that indicates the attitude to change after the implementation of electronic management is significantly different to the attitude before implementation.

There was no significant difference between the attitude to change of pharmacist compared with non-pharmacist respondents before and after the introduction of electronic medicines management (Mann Whitney U Test, p values 0.300 before and 0.305 after).

4.2.4 Satisfaction with training

Respondents were asked to rate their satisfaction with electronic medicines management training using a five point scale from very satisfied to very dissatisfied. Results are shown in Figure 3.

Figure 3: the satisfaction of pharmacists and non-pharmacists with electronic medicines management training



There was no statistical difference between pharmacists and non-pharmacists concerning their satisfaction with electronic medicines management training (Mann Whitney U, z value -1.784, p value 0.074). 10 of the 12 non-pharmacist respondents were either neutral or satisfied with training, with 2 reporting to have been dissatisfied. 6 of the 14 pharmacist respondents reported to have been dissatisfied or very dissatisfied with training and 8 reported to have been neutral or satisfied.

4.2.5 Satisfaction with implementation

Respondents were asked to rate their satisfaction with electronic medicines management implementation using a five point scale from very satisfied to very dissatisfied. The results are described in Table 10 below.

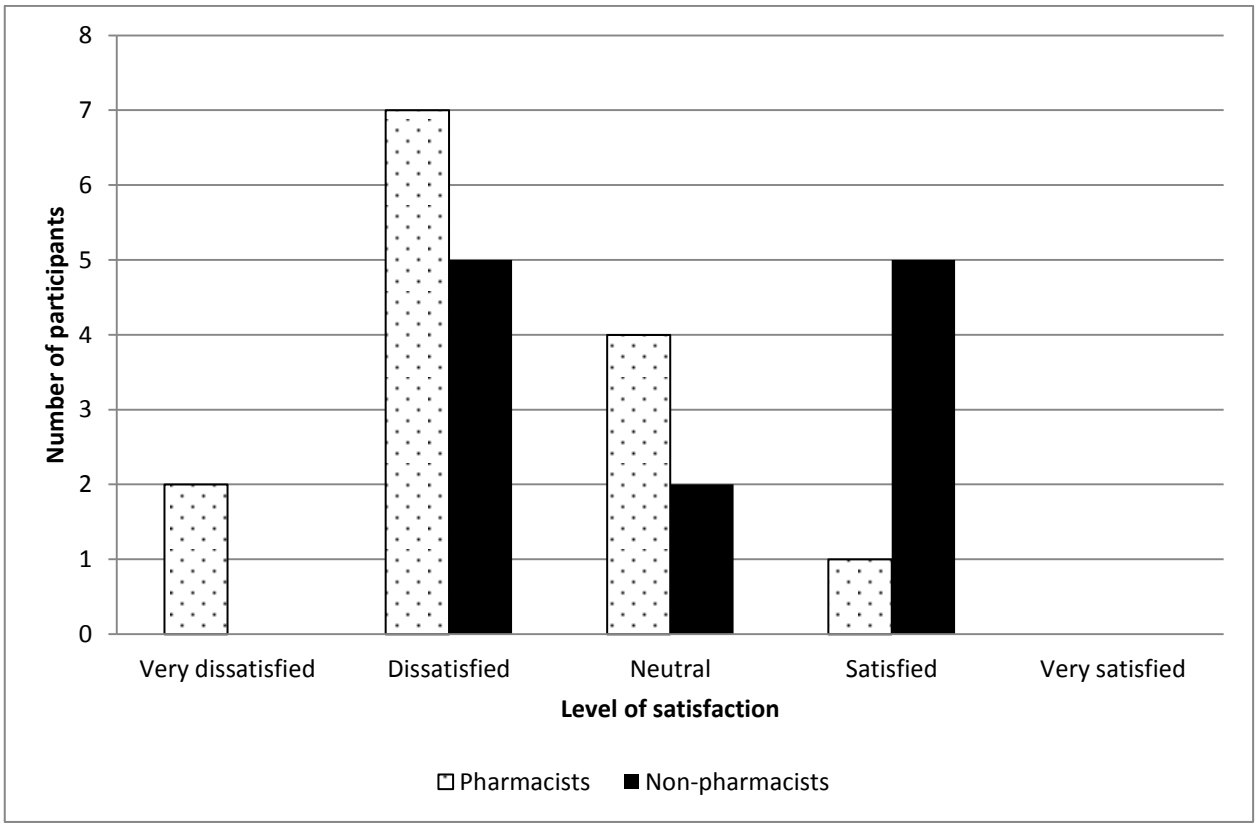
Table 10: Satisfaction with electronic medicines management implementation

Level of satisfaction	**Frequency**
Very dissatisfied	2
Dissatisfied	12
Neither	6

Satisfied	6
Total	26

The majority of respondents (14/26) were dissatisfied with the implementation of electronic medicines management (see Figure 4).

Figure 4: the satisfaction of pharmacists and non-pharmacists with the implementation of electronic medicines management



There was no statistical difference between the satisfaction of pharmacists and non-pharmacists with the implementation of electronic medicines management (Mann Whitney U, z value -1.811, p value of 0.070).

4.2.6 Thematic analysis of open ended questions

Eight open ended questions were asked in the survey instrument; these are represented by an italic font in each section. This section of the chapter describes the themes developed from using applied thematic analysis. The themes are sections 3.2.6.1 to 3.2.6.5 below.

4.2.6.1 Training needs to be structured and coordinated with implementation

This theme was supported by responses from the questions: Please describe how you prepared for the change to eMedMan; Please describe how you feel the training could have been improved.

Just half of the respondents (n=13) stated they had attended a training session in preparation for the implementation of electronic medicines management. There was a variety of experiences described in relation to training undertaken; suggesting that not everyone attended a training session with the same "eMedMan champion" (a member of pharmacy staff who had the role of championing the new system or being involved in a pilot or providing training).

- 13 respondents stated they attended a training session.
- Three respondents stated they did not receive training.
- Three respondents were 'eMedMan champions' who provided training.
- One respondent stated they received "training by eMedMan designated champion"
- One responded reported "I had no ward based training at all".
- One respondent described their training experience as "…observing someone for 5 minutes then working along and asking questions when needed"
- One respondent described their training experience as "looked at templates on Ascribe".
- One respondent who had attended a training session described the training provided as "brief"
- One respondent described their training as "half an hour… that was all"
- One respondent referred to the training session as a "demo".

The most frequent complaint about training referred to the timing of the training in relation to the implementation of the electronic medicines management system (n=16). Examples regarding overall planning included: "I think training could have been planned and improved" and "…allocated time dedicated to practical training instead of just fitting it in". Regarding the timing of the training; comments included "implementation of a training schedule earlier" and training provided in advance". The result of the training schedule provided at BCH was that respondents felt they should have been "given more time to know what to do" and that "everybody needed to be fully prepared before going live". These comments and the low number of positive comments (n=2) regarding the training provided suggest that not everyone considered themselves appropriately trained before the roll out began.

Two respondents recommended that training needed to be more structured and that competency should be signed off to formalise the training. "More structured, formalised and standardised so everyone had the same level of training". Comments such as "more trainers to disseminate

training" and "more trainers to go to for help" indicated the need for further use of trainers. Although some described their own self-motivated training plans (for example, speaking with dispensary staff who had used the system) as satisfactory one respondent was not happy that he/she had not been able to attend an 'official' training session as they were on annual leave for their allocated session.

The overall subject emerging was that training should have been of better quality and better timed so respondents were ready to use the system before it went live at Birmingham Children's Hospital.

4.2.6.2 Project status and changes need to be clearly communicated

This theme is supported by answers from the following questions: Please describe your experiences during the changeover process: what do you think went well or less well during the changeover process? Please describe what do you feel could have been done to improve the implementation of the eMedMan system.

In this study staff were confused as to which wards were using electronic medicines management and which were using the old paper based system. Individual respondents commented that the implementation should have had "less ambiguity" and there was "confusion which wards were fully eMedMan". One respondent stated that it "was confusing on when to use it [electronic medicines management] and when not to" and another respondent commented they had received "confusing and conflicting advice". Respondents intimated that they needed to know which wards were using the new system and when wards were moving to the new system.

From the description of the implementation process it can be seen that many changes or issues were raised and these would have required clear and accessible communications to all staff using the system. Respondents felt the processes for use of the new system needed to be "well defined and clear" and "uniform" accompanied by "SOPs" or "clear guidelines". It could be suggested that had this taken place during this implementation staff may have found it easier to understand when to use the new system and when to continue with the paper based system. Suggestions for improving the implementation process included the development of SOPs before the system goes live that have been tested and are therefore usable in practice. The SOPs available during the implementation of electronic medicines management "weren't fit for purpose" according to one respondent and needed to have been "checked and validated before distribution" by another.

The overall theme was that the development of the project and stages of implementation needed to be clearly communicated to staff and supported by SOPs at Birmingham Children's Hospital.

4.2.6.3 Staff involvement or input is require at all stages of the project

This theme is supported by answers from the following questions: Please describe your experiences during the changeover process: what do you think went well or less well during the changeover process? Please describe what do you feel could have been done to improve the implementation of the eMedMan system.

Five respondents felt that end users and staff expertise were not as involved in the project development and roll out as they should have been. Comments from individual respondents included: "involve practitioners in the development of the system"; "engagement with staff in the implementation stage and before", include "input from staff who work in clinical areas" and "ask for input from staff".

Respondents wanted those who would be using the system to have had more input into its design so the end result would have been more suitable for purpose. Respondents' comments suggested that the changes to workload and workflow had not been anticipated by the development team, but respondents suggested these could have been had the development team sought further input from the potential users of the electronic system. "Staff were not asked about the practicalities or how it could be done".

The overall view was that had staff been more involved from the beginning of the process electronic medicines management at Birmingham Children's Hospital would have been more successful and a better fit for purpose.

4.2.6.4 System compatibility with current practice needs to be carefully considered

This theme is supported by answers from the following questions: Please describe any further advantages or disadvantages of eMedMan that are not mentioned above. Please list any improvements that could be made to the eMedMan system.

Many comments from the respondents stated that the system was not suitable for use for its intended tasks (n=5), particularly for 'to take out' (TTOs – prescriptions issued on discharge) or outpatient prescriptions. Staff were frustrated that the new system was more time consuming than the old system (n=4) and did not have the necessary drug templates built into it (n=4). Drug templates are forms that enable pharmacy staff to record the drug and full details of its prescription. For example: a drug template would contain boxes in which the dose, frequency, route and other relevant information regarding its prescription to be recorded. It also required extra effort as checks on both the paper copy and electronic copy needed to be made for TTOs and outpatient prescriptions: "The dispensing and checking process was longer for TTOs". Respondents described the new system as "time consuming" on a number of occasions for a

variety of tasks. There were more comments about the lack of suitability of the system for TTOs than for other types of supplies made by the pharmacy. “TTO supplies using eMedMan did not work very well”. Although the TTOs were being done on the electronic system staff reported that paper copies of TTOs were also received which “seemed long winded”.

General negative comments regarding the suitability of the system were recorded such as: “lots of issues with the software” and “poor design of the system”. The main issue with the new medicines management system was with regard to the templates built into the system. Templates were a feature that existed in Ascribe prior to the use of the electronic medicines management module. Drug templates were prefilled items that described the usual route, frequency, dose of the drug. The overall use of the electronic system could have been made more time consuming by the lack of suitable templates, but this was a problem that existed prior to this change. Comments such as “templates were a big issue as many unfit for purpose” and “templates are a mess” indicated the lack of suitable templates in the electronic medicines management module on Ascribe. Templates were also described as “frustrating”. Templates were an important part of the new electronic medicines management system as they ensured all necessary information about a drug was recorded to enable it be supplied accurately from the pharmacy.

Other comments on the suitability of the system related to “input errors” which were described as “dangerous”. During the roll out the old paper system continued to be used on wards until they were switched over to the new electronic medicines management system. This meant two processes for medicines management were running concurrently. The combined system of paper and electronic systems for TTOs and outpatient prescriptions “didn’t add anything”. The running of the two systems alongside each other was described as “awkward” and “…introduced extra risk”.

Finally, some comments were raised regarding clinical screening on the new system. It was noted that pharmacists spent more time inputting information onto the electronic medicines management system (Ascribe) which left them with less time for clinical checking. There was also confusion over when the medication needed to be ‘rescreened’(i.e. checked to ensure the medication remained suitable) by the pharmacist. In addition, one respondent was worried that medication could be dispensed without being clinically screened by the pharmacist. There was also a comment that inputting data onto Ascribe is a skill, and input errors would decrease as level of skill increased.

The prevalent theme was that the new system was not fit for purpose for medicines management processes for outpatient or TTO medication and further adjustments needed to be made to ensure it was less time consuming and as usable as the previous paper system at Birmingham

Children's Hospital. The new system was described as suitable for use for managing inpatient medication.

4.2.6.5 Electronic medicines management in its current format is suitable for inpatient supplies of medication

This theme is supported by answers from the following question: Please describe any further advantages or disadvantages of eMedMan that are not mentioned above.

Three individuals commented that the benefit of the electronic medicines management system was its suitability for inpatient medication supplies and the improvement it had made to speed of dispensing of inpatient medication supplies. The reasons the inpatient supply worked well included: "no paper requisitions were needed", "I could order things on the ward which were sent straight away to disp (dispensary)", " ward orders were started more quickly in disp (dispensary)", medication orders were "received quicker", "turnaround for inpatient items quicker" and the Pharmacy Department "can keep an accurate record of meds". The supply of inpatient items using electronic medicines management was purely electronic and as such the orders could be sent to the dispensary instantly where the dispensing process could begin as soon as the order was received. This was a notable improvement when compared to the paper system as pharmacy technicians or pharmacists may not have brought the orders down to dispensary until they had finished their ward round previously.

In summary, electronic medicines management enabled faster, and accurately recorded, supply of inpatient medication to the wards at Birmingham Children's Hospital.

4.2.6.6 Final comments from respondents

Question asked: please provide any final comments you have or experiences you'd like to share about the paper based or eMedMan systems you feel are important or have not been covered in the questionnaire.

The respondents were invited to provide any final comments on the electronic medicines management process that they felt may have not been covered by previous questions. The comments referred to two respondents' reservations regarding relying on electronic systems: "cannot be completely paperless – this can be dangerous as important errors such as inputting the drug can have disastrous consequences" and "when Ascribe fails the whole dispensing system fails". These two comments have been highlighted as they indicated an element of concern regarding the safety of the new medicines management system and raised the question that some staff may not believe that electronic systems are suitable in general.

4.3 Discussion

Prior to the introduction of electronic medicines management (as an extension of the pharmacy dispensing software Ascribe) the process of the paper system was well established and understood by members of the pharmacy team and other healthcare professionals at the hospital. However, there was a need to upgrade to a more efficient system as several disadvantages of the paper system had been identified. Information recorded on pieces of paper as communications between the pharmacy technician and the pharmacist could get lost meaning that important information may not be available to the pharmacist. The paper medication orders for the ward could also get lost resulting in a failure to supply the medication to the ward. Finally, delays to medication supply could occur as the paper medication orders were all submitted when the pharmacy technician returned to the pharmacy.

In order to solve the issues that had been identified in the paper system an electronic medicines management system was proposed. This is in line with the paperless NHS target to be met by 2018. [106] At the end of May 2012 the electronic medicines management module was added onto Ascribe and was ready to be used. Prior to this staff had been added to the Ascribe system so they would be able to use it once the electronic medicines management process was live. The roll out of electronic medicines management started on the 5th June 2012 and ward pharmacists chose when their ward would go live with the new system. A list of wards using the new system was displayed in the dispensary and a printed guideline describing how to use the system was available.

After roll out started the electronic medicines management system continued to be fine-tuned and improved. The week after the roll out an electronic support box for pharmacists was added where they could email the electronic medicines management team with any problems. Further changes were also made through June to December 2012. In December 2012 the use of the new system was paused and a discussion document was developed to review the suitability of the electronic medicines management system for future use. This was reviewed at the end of January 2013 when it was decided than the electronic medicines management system would be used solely for inpatient medication orders. In January 2013 a new outpatient pharmacy opened at Birmingham Children's Hospital and took responsibility for all outpatient prescriptions. This study took place in April 2013 when electronic medicines management was used for inpatient medication orders only.

An important finding from this study was that respondents reported a more positive attitude to change after changing to electronic medicines management compared to their attitude before the change to electronic medicines management. The shift to a more positive attitude to change

occurred despite the reported dissatisfaction with the implementation and training provided for electronic medicines management. It was not possible to confirm using the data from this study that the implementation of electronic medicines management was the causative factor in the shift in attitude to change. However, some potential explanations for this result could be drawn from the responses provided in the free text answers. Respondents recognised that electronic medicines management was beneficial in its current form for inpatient medication orders. It had allowed the medication orders to be processed more quickly as they were sent to the dispensary electronically. This in turn meant that the medication was available to the patient on the ward in a shorter period of time. Respondents also recognised that it was easier to find details of previous medication supplies on the electronic system and it removed the need to transcribe from the paper medication order onto Ascribe. These benefits could imply that staff felt this change was the right choice and therefore may have impacted their attitude to change. In this study the new medicines management system has allowed staff time to be better used in terms of inpatient medication ordering. For inpatients the new electronic medicines management system appears to follow the NICE recommendation that one purpose of medicines reconciliation is to

"Improve the efficiency of a service, making the best use of staff skills and time." [88]

The difference in satisfaction of pharmacist and non-pharmacist staff with electronic medicines management implementation was not significant. However, the satisfaction with implementation had the possibility of being different as the pharmacist and non-pharmacist staff used the electronic medicines management system for different purposes. Pharmacists were using the system to record and complete clinical checks of medication and record the patient's medication history. The non-pharmacist staff were using the system to dispense medication; record patient medication histories and place orders for medication. Comments from both pharmacists and non-pharmacists referred positively to the inpatient medication processes as the electronic medicines management system enabled medication orders to be dispensed quicker and ensured all instructions were legible to the dispensary staff. Non-pharmacist staff complete the majority of dispensing at Birmingham Children's Hospital. The dispensing process was one area where respondents identified an improvement in medication supply processes; therefore it could be that staff responsible for dispensing (non-pharmacist) are more likely to be satisfied with the new system. However, the small size of this study may have prevented statistical significance being identified. There were several negative comments made regarding the clinical screening process on the new electronic system by both pharmacist and non-pharmacist respondents. Clinical screening is only carried out by pharmacists. Respondents were concerned about the length that a clinical screen was valid for and the risk that a medication could be re-dispensed when the pharmacist hasn't approved a second supply. In summary, respondents identified that an area of

non-pharmacist work had seen an improvement (supply of inpatient medication) whereas an area of pharmacist work (clinical screening) had been highlighted as an area of concern within the electronic medicines management system.

The difference in satisfaction of pharmacist and non-pharmacist staff with electronic medicines management training was not significant. The responses in the free text answers provided some anecdotal evidence for this. There were five negative comments regarding the training provided; four of these comments came from pharmacist respondents. Prior to the introduction of electronic medicines management pharmacists would have used Ascribe less frequently than non-pharmacist staff as they would only have used it for recording medication histories and occasionally for dispensing medication. In contrast, non-pharmacist staff would have used it frequently for dispensing medication and recording medication histories. This difference in duties could have meant that pharmacists and non-pharmacists had different levels of familiarity and skills with the Ascribe software. Hence, it may have meant that pharmacists required different training in order to be able to use the electronic medicines management module effectively. Different training sessions were provided for the different staff groups, but if the pharmacist training sessions did not meet the needs of the pharmacists, this might partially explain why the pharmacists reported more negative comments regarding training.

Respondents reported a variety of experiences of the training process, despite all staff being offered the same training opportunity. This may be partially explained by eMedMan champions providing group and one-to-one training options. In one case training was not available to a respondent as the session offered was when the respondent was on annual leave and an alternative was not believed to have been available. Some respondents also reported training 'on the job' rather than attending a training session led by an electronic medicines management champion. This training type could refer to the one to one training reported to have been offered to pharmacy staff. Despite these differences, some respondents did identify the presence of electronic medicines management champions and were satisfied with the training provided. Education for a new system is one feature that is thought to be important in the success of clinical system implementation, so this is an area could be developed for future system implementations. [107] Appropriate training of staff conducting medicines reconciliation, in this study the pharmacy staff, is also advised by NICE. [88]

The pharmacy at Royal Cornwall Hospitals Trust has been referred to in an article with regard to its electronic medicines management processes on JAC (a pharmacy management software system that can be used for dispensing, electronic prescribing etc). [108] The benefits of their system were that it demonstrated the workload of the ward pharmacy technician and it

highlighted the areas where pharmacist services were to be targeted. [108] It is not clear whether the system at Birmingham Children's Hospital could be used to identify the same. This raises the question whether electronic tools should record information that captures the contributions of the pharmacy team to patient care. Royal Cornwall Hospitals reported that a key point regarding electronic medicines management is the electronic tool should not be "a burden to complete" and should fit into normal working patterns. [108] At the time of the study Birmingham Children's Hospital is not meeting this ideal as respondents reported that the new system took longer to use than the previous system and the drug templates on the system were not fit for purpose. However, the drug templates were part of the system that was in use prior to the extension to electronic medicines management. This suggests that this was not a new problem generated by the extended use of Ascribe. Unsuitable drug templates made it more difficult for the details of a patient's medication to be recorded compared to the paper based system as there was not an appropriate space available to record some drug information. Respondents identified improved drug templates could be developed further to ensure the system fits pharmacy working patterns in the future. Recording relevant information is an important function of a medicines management system. [88]

Recommendations from previous studies on the successful implementation of clinical systems state the importance of end users in the development process. [107, 109] This study further highlights the importance of engaging staff when developing and implementing clinical pharmacy systems as respondents commented staff should have been more involved in the development stages. This study also highlights that individual engagement of pharmacists with new electronic systems can be challenging; particularly when the pharmacist believes that the new system may take time away from patient care. However, this attitude is in contrast to that expected from the NICE guideline on medicines optimisation that highlights the importance of accurate record keeping of medication information. [88] The comments of the respondents reflected previous studies that suggest the system would have been more successful had they been able to influence its development more and ensure the new system fitted in with their usual working patterns. Another feature reported to affect the success of a system's implementation is responding to ideas for enhancement. [107] Again, this is an area where respondents in this study were not satisfied as they did not feel their ideas or issues were always responded to appropriately.

4.4 Limitations

The greatest limitation of this study was its size, influenced by the choice of study site and the response rate. The small site meant the amount of data that could be collected was limited and the quality of the data relied on obtaining a very high response rate. The choice of site could not

have been different as Birmingham Children's Hospital was the only site available to the researcher where it was known that the change process from paper to electronic medicines management could be evaluated. Access to research at this site was practicable for the researcher as an honorary contract was in place to facilitate research in conjunction with Birmingham Children's Hospital. The study was also registered as an audit at Birmingham Children's Hospital and as research is part of the normal NHS staff contract it was anticipated that response rates for this audit would match the high response rates (over 90%) for audits conducted in the pharmacy department previously. Unfortunately this was not the case. The study was introduced to staff at several meetings to ensure all staff received a personal invitation to complete the study. There were also email reminders and visits to the department to increase participation and inform people about the purpose of the study to further encourage staff to contribute. Pharmacy staff were informed that they could complete the study during work hours or in their own time. On reflection it is difficult to see what further strategies could have been employed to gain a higher response rate. Because of the lower than anticipated response rate (48%) the findings may not accurately reflect the view of all staff of the electronic medicines management process. Non-respondents were not followed up as there was no method available to do so due to the paper process involved.

Another limiting factor was the timing of the study. The unforeseen delays in ethical approval meant the study could not be launched until several months after the electronic medicines management process had been in place. The intention was that the study would be conducted after the roll out had been completed and initial issues or changes had been managed in order to ensure respondents had these processes fresh in their memory. Ideally the study would have been co-ordinated with the roll out so each staff member completed the questionnaire after using the new system for the same period of time. The delay of the study could mean that respondents are no longer able to recall the details of the changeover process or their training. This is an important limitation. The delay in launching the survey may also have affected the likelihood that respondents provided socially desirable results due to the pressure of already having to use the system and not wanting to appear difficult to managers when the results were collected.

Finally, there was a set of questions that required the advantages and disadvantages of each system to be ranked. These were not completed correctly in the study, but there were no problems detected with these questions in the pilot. This is a disadvantage of the paper based survey method. Respondents in the study either did not rank the ideas listed or gave more than one idea the same rank. Therefore it was not possible to fully analyse these questions. . The results from these questions may have identified the benefits of the paper and electronic medicines management systems that staff felt were most important as well as the disadvantages

they felt were most in need of addressing. The lack of data then available on the advantages and disadvantages of each system was therefore limited to the comments provided by respondents in the open ended questions.

This study is a case study from a single site so it is unlikely to be generalizable. The study raises issues that need to be assessed in a larger study, but this would not be easy to conduct as there are unlikely to be sites in the same stage of development of the electronic medicines management process. Other hospital sites may not use Ascribe software. However, the themes that emerged that are not related to Ascribe may be useful to other hospital pharmacies that are considering making the change to electronic medicines management, particularly as there is limited published work describing this area of pharmacy practice.

4.5 Conclusion

- In spite of the negative results for training and implementation satisfaction, after experiencing a change from paper based medicines management to electronic medicines management respondents were more likely to report a more positive attitude to change.
- This study demonstrated that despite a lack of satisfaction in the training and implementation process respondents could identify benefits of moving to electronic medicines management.
- Respondents valued the improved supply of inpatient medication that electronic medicines management has enabled.
- The study identified a number of factors that are required to ensure a smooth implementation and training process for movement to an electronic medicines management system. These included: appropriately timed and assessed training; validated SOPs for the new process and engagement of staff at all phases of developing and implementing a new medicines management process.

4.6 Recommendations for practice

- Involving staff who will be end users of the electronic medicines management system in the development and planning process is important.
- The timing and structure of training are important for training and implementation satisfaction of staff. The training should take place near the date the system goes live and should also include an SOP for staff to use after their training.
- Regular communications regarding project progress are essential.

- The suitability of the new system to fit into current working practices, whilst enabling its benefits to be supported by staff, should be carefully evaluated.

5. Information resource use by prescribers at Birmingham Children's Hospital

The purpose of this study was to examine the use of and satisfaction with prescribing resources in paediatrics by prescribers at Birmingham Children's Hospital. The study aimed to identify a base line measure of prescribing habits and use of prescribing information resources before the introduction of electronic prescribing at Birmingham Children's Hospital. The objectives were to:

- Identify the current prescribing habits reported by prescribers at Birmingham Children's Hospital in terms of prescribing frequency, prescribing experience and clinical specialty;
- Identify the prescribing information resources which prescribers at Birmingham Children's Hospital report to use most frequently;
- Identify which prescribing information resource is the most useful to prescribers at Birmingham Children's Hospital and why;
- Identify any areas of paediatric prescribing where prescribers at Birmingham Children's Hospital report a lack of available prescribing information;
- Identify the potential impact on patients of the current availability of paediatric prescribing information reported by prescribers at Birmingham Children's Hospital.

A self-completed online questionnaire was distributed to all prescribers at Birmingham Children's Hospital at the time of the study. Further details of the method can be found on page 43.

5.1 Context of this study

Little is known about how often paediatric prescribers consult a resource before making a prescribing decision or how useful these resources are to paediatric prescribers. This study took place at Birmingham Children's Hospital at a time when prescribing was undertaken by completion of handwritten charts. The exception was the use of the ChemoCare electronic prescribing tool for chemotherapy prescriptions.

There are a range of environments where a prescriber may prescribe medication within Birmingham Children's Hospital NHS Trust. These include: inpatients, outpatients, emergency department and prescriptions for use in the community on behalf of Birmingham Children's

Hospital NHS Trust. Each of these environments may have differing processes for the steps taken when making a prescribing decision and differing access to resources. In the inpatient and emergency department setting at Birmingham Children's Hospital prescribing is typically carried out by junior doctors who may or may not prescribe under the instructions or supervision of a senior colleague. In contrast outpatient prescribing is typically completed by senior doctors or consultants. Prescriptions for use in the community are written by prescribers with a range of experiences. Across all these environments there may also be prescribing by non-medical prescribers such as nurses and pharmacists.

Birmingham Children's Hospital ensures that all prescribers are provided with a copy of the British National Formulary for Children (BNFc). Currently paper copies of the BNFc are provided every twelve months; these are distributed by the Pharmacy Department to prescribers based within the hospital. Birmingham Children's Hospital prescribers also have access to a number of other prescribing information resources including pharmacy staff (including specialist pharmacists), other healthcare professional colleagues, the internet, local and national guidelines, and the adult British National Formulary (BNF).

This study aimed to provide a description of current practice of prescribing information resource use when making paediatric prescribing decisions at Birmingham Children's Hospital to inform the development of the clinical decision support features in the electronic prescribing system that was under development at the time of this study.

5.2 Results

5.2.1 Response rate

The sample size was 423. This figure does not include those whose emails were not delivered. There were 45 potential non-medical prescriber respondents and 378 potential medical prescriber respondents. There were 192 responses to this study; a response rate of 46%. The response rate for doctors was 39%, whereas the response rate for non-medical prescribers was 78%.

Two respondents declined to complete the questionnaire at the consent stage on page one and seven identified themselves as staff who did not prescribe within Birmingham Children's Hospital NHS Trust. These seven respondents were then excluded from the study. 183 prescribers began the questionnaire.

5.2.2 Profession of respondent

182 responses were received to this question. The responses are summarised in Table 11 below.

Table 11: Profession of prescriber respondents at Birmingham Children's Hospital

Profession	Frequency (% responses to this question)
Doctor	146 (80.2%)
Nurse	32 (17.6%)
Pharmacist	3 (1.6%)
Other	1 (0.6%)
Total	182

The 'other' healthcare professional identified themselves as a dentist.

The majority of the respondents were doctors. Nearly 20% of respondents were non-medical prescribers; this group was made up of nurses and pharmacists. Therefore non-medical prescribers were overrepresented in this study. Due to the small number of non-medical prescribers it was not possible to compare between professions the responses to the questions in this questionnaire study.

5.2.3 Job title or grade of respondents

Respondents completed a free text box asking them to describe their job title and/or grade. 169 responses were received to this question. The remaining respondents chose not to answer this question. The responses are summarised below in Table 12.

Table 12: Grade/job title of respondents at Birmingham Children's Hospital

Grade/Job Title	Frequency
Trainee doctor (FY, CT or ST)	58
Consultant	81
Other doctor	1
Advanced nurse practitioner	10
Trainee advanced nurse practitioner	3
Other nurse	13
Pharmacist	3
Total	169

(FY = foundation years, CT = core training, ST = specialist training)

5.2.4 Number of years of prescribing experience in paediatrics

Respondents completed a free text box where they reported the number of years of paediatric prescribing experience they had. 179 responses were received to this question (there was one respondent who had zero years' prescribing experience – this respondent was a trainee non-medical prescriber).

The mean length of paediatric prescribing experience in all staff groups was 10 years with a range of 30 years. When non-medical prescribers are grouped together (i.e. nurses and pharmacists) their mean experience was 2.5 years. The mean years of prescribing experience is described in Table 13 below.

Table 13: Mean years of paediatric prescribing experience of respondents

Prescriber group	Mean years of experience	Range of experience
Doctor	11.8	29.8
Nurse	2.4	8.0
Pharmacist	3.0	0.0
Other (dentist)	25.0	0.0

The range of experience is not in whole years as some respondents reported part years or months of experience.

There was a significant difference in average years of experience between the professional groups. The independent samples Kruskal Wallis test (value = 48.844) was significant with a p value of 0.000. If the nurses and pharmacists are grouped into one 'non-medical' prescriber group and compared to the medical (i.e. Doctors) prescribers there is a significant difference in paediatric prescribing experience between the two groups. (The Mann-Whitney U test, U = 577 and p value 0.000) The mean ranks indicated that medical prescribers had the most paediatric prescribing experience. This is expected when you consider the number of consultant participants and the number of years non-medical prescribers have been legally able to prescribe.

5.2.5 Clinical locations respondents prescribe in

Respondents were asked which of the following areas they prescribed in: inpatients, outpatients, emergency department, in the community or other. Multiple responses could be selected. 179 responses were received to this question. These findings are summarised in table 14.

Table 14: Areas of Birmingham Children's Hospital that respondents prescribed in

Area of the hospital	Frequency (% responses to this question)
Inpatients	147 (82)
Outpatients	118 (66)
Emergency department	92 (51)
In the community	28 (16)
Other	13 (7)

This data shows that prescribers at Birmingham Children's Hospital work in more than one area of the hospital. A small number work in the community where their access to prescribing information resources may be different to those based within the hospital. The areas that respondents considered as 'other' were: haemophilia walk in clinic; send prescriptions into the community; Paediatric Intensive Care Unit (PICU) (3); on retrieval; theatre (4); PICU & Emergency Department; healthcare at home and 'limited to perioperative anaesthesia medicines so all procedure areas'.

5.2.6 Most frequent area of prescribing for respondents

Respondents were asked which clinical location they most frequently prescribed: inpatients, outpatients, emergency department, in the community or other. 179 responses were received to this question. The responses are summarised in Table 15.

Table 15: Most frequent area of prescribing for respondents at Birmingham Children's Hospital

Area of the hospital	**Frequency (% responses to this question)**
Inpatients	102 (57)
Outpatients	49 (27)
Emergency department	18 (10)
In the community	7 (4)
Other	3 (2)
Total	179

More than half of the respondents most frequently prescribed for inpatients at Birmingham Children's Hospital. A large proportion also most frequently prescribed for outpatients at Birmingham Children's Hospital. Smaller proportions prescribed in the emergency department, in the community or elsewhere. It was not possible to test for differences between the profession of respondents and the most frequent clinical location of prescribing due to the large difference in numbers of respondents from each profession.

There was a significant association between years of paediatric prescribing experience and the most frequent areas of prescribing. The independent samples Kruskal Wallis test (value = 11.769) was significant with a p value of 0.019. The average number of years of paediatric prescribing experience for participants who reported to work in inpatients most frequently was 8.7 years (i.e. less experienced), whereas the average number of years of paediatric prescribing experience for those who reported to work in outpatients most frequently was 13.2 years (more experienced).

5.2.7 Regularity that respondents prescribed for children

Respondents were asked how often they prescribe for children. The question provided a number of set options; the responses to these are summarised in Table 16. 179 responses were received for this question.

Table 16: How often do respondents prescribe for children?

Regularity of prescribing for children	Frequency (% responses to this question)
Multiple times per day/shift	128 (72)
Once daily	8 (4)
Several times a week	23 (13)
Weekly	9 (5)
Monthly	4 (2)
Less than monthly	7 (4)
Total	179

Most respondents prescribed for a child multiple times per day/shift. The next most common regularity of prescribing for a child was several times a week. Those who prescribed monthly or less often were mainly doctors, along with one pharmacist. Five of these doctors described their speciality as surgical and four reported it to be psychiatry. The majority of doctors in this group described their job role as 'consultant'. The range of years of paediatric prescribing experience was from 4 years to 27 years and the prescribers specialised in a range of clinical areas. The other groups were made up of both medical and non-medical prescribers. Due to the large difference in numbers of medical and non-medical prescribers it was not possible to statistically compare their regularity of prescribing for children.

5.2.8 Specialty of respondents

Respondents were asked to describe in response to an open question 'when thinking about your prescribing in paediatrics, what is your specialist clinical area? (For example: PICU, oncology etc.)' 170 responses were received to this question. The responses are summarised in Table 17 below.

Table 17: Summary of responses for specialist area in relation to paediatric prescribing

Specialist area	Frequency
PICU	19
Surgery (all areas)	16
Emergency department	15
Haematology/Oncology	14

General Paediatrics	13
Respiratory medicine	10
Psychiatry (inc CAMHS)	9
Diabetes and endocrinology	8
Anaesthesia, analgesia, sedation, inotropes	7
Nephrology	6
Cardiology	6
Haemophilia, Haemoglobinopathy, anticoagulation and related bleeding disorders	4
Gastroenterology	4
Rheumatology	3
Neurology	3
Pain management	3
Hepatology	2
Dermatology	2
Orthopaedics	2
Inherited metabolic disorders	2
Hospital@Night	1
Burns	1
Dentistry	1
Ophthalmology	1
Microbiology	1
Neonates	1
Parenteral nutrition	1
Tissue viability	1
Total	170

Three responses covered two distinct areas: 'General medical/ED', 'Liver disease, metabolic diseases, transplantation' and 'ED/PICU'. These are not included in the above table. These responses demonstrate that a wide variety of specialties (28) were represented in this study and the questionnaire was delivered successfully to prescribers across Birmingham Children's Hospital.

5.2.9 Regularity of information resource use when prescribing by prescribers

Respondents were asked to select their frequency of resource use when prescribing for paediatric patients from a fixed option question. The responses are summarised in Table 18 below. 171 responses were received.

Table 18: Regularity of reported referral to reference sources when prescribing in paediatrics

Regularity of reference source use when prescribing in paediatrics	**Frequency (% responses to this question)**
Every time I prescribe	45 (26)
Several times a day	60 (35)
Daily	14 (8)
Several times a week	28 (16)
Weekly	15 (9)
Monthly	9 (5)
Less often (than monthly)	0 (0)
Total	171

The majority of respondents were likely to use an information source at least daily when prescribing for paediatric patients. Due to the small numbers in the different professional groups it was not possible to test for statistical differences between the medical and non-medical prescribers and their frequency of resource use. However, there was a statistically significant association between frequency of resource use and years of experience in paediatric prescribing (Kruskal Wallis p = 0.004). When comparing the means of each group of respondents and their frequency of reported referrals to resources; those who referred to a resource weekly were the most experienced paediatric prescribers (15.6 years) and those who referred to a resource daily were the least experienced paediatric prescribers (6.9 years). Respondents who referred to resources when prescribing in paediatrics every time they prescribed, several times a day/week or monthly had a mean experience of paediatric prescribing of 10-12 years.

5.2.10 Frequency of particular resource use by respondents

Respondents were asked to consider how often they used each resource when they prescribed for paediatric patients. 170 responses were received to this question.

5.2.10.1 British National Formulary for Children

The BNFc is a nationally produced formulary that is updated monthly online and updated yearly in the paper format. Summary of responses of reported use of the paper version is summarised in Table 19 below.

Table 19: Frequency of reported BNFc paper format use when prescribing for paediatric patients

Regularity of use of BNFc (paper format)	Frequency (% responses to this question)
Every time I prescribe	32 (19)
Several times a day	55 (32)
Daily	13 (8)
Several times a week	34 (20)
Weekly	21 (13)
Monthly	14 (8)
Less often	0 (0)
N/A I don't use this resource	1 (1)
Total	170

The BNFc in the paper format was used by the majority of respondents at least weekly. Use of the BNFc several times a day was the most commonly reported practice, followed by use several times a week and use every time I prescribe. There was one respondent, a senior consultant with 28 years of paediatric experience, who did not use this resource, but did report to use the BNFc smartphone app several times a week. There was a statistically significant association between reported use of the BNFc paper format and years of paediatric prescribing experience (Kruskal Wallis, $p = 0.027$). The mean years of paediatric prescribing experience was lowest for respondents who reported to use the BNFc paper format every time they prescribed (mean = 7 years). The mean paediatric prescribing experience increased as regularity of use of the BNFc paper format decreased from several times a day to weekly (mean ranges of years of paediatric prescribing experience from 9 years to 15 years). The least frequent users of the BNFc paper format had a mean paediatric prescribing experience of 10 years.

Respondents were then asked about their use of the online format of the BNFc. The responses are summarised in Table 20 below.

Table 20: Frequency of reported BNFc online format use when prescribing for paediatric patients

Regularity of use of BNFc (online format)	Frequency (% responses to this question)
Every time I prescribe	0 (0)
Several times a day	5 (4)
Daily	3 (2)
Several times a week	11 (6)
Weekly	9 (5)
Monthly	7 (4)
Less often	42 (25)
N/A I don't use this resource	94 (55)
Total	170

The BNFc online format was not used by the majority of respondents. However, one quarter of respondents reported using it occasionally (less than monthly) and 17% used it at least weekly. The group of respondents who reported to use the online format at least weekly were likely to also be frequent prescribers (i.e. prescribed multiple times per shift). There was no statistical association between years of paediatric prescribing experience and regularity of use of the BNFc online format (Kruskal Wallis p = 0.206). There were both medical and non-medical prescribers who used the BNFc online format.

Respondents were then asked about their use of the smartphone app format of the BNFc. The responses are summarised in Table 21 below.

Table 21: Frequency of reported BNFc smartphone app format use when prescribing for paediatric patients

Regularity of use of BNFc (smartphone app)	Frequency (% responses to this question)
Every time I prescribe	6 (4)
Several times a day	9 (5)
Daily	2 (1)
Several times a week	12 (7)
Weekly	5 (3)
Monthly	5 (3)
Less often	17 (10)
N/A I don't use this resource	114 (67)
Total	170

The BNFc smartphone app was not used by the majority of respondents. However, 20% of respondents used it at least weekly and a further 13% used it monthly or less often. The respondents who used is at least weekly were frequent prescribers (21/25 prescribed multiple times per shift). There was a significant association in years of paediatric prescribing experience and regularity of BNFc smartphone app use (Kruskal Wallis, p = 0.04). The mean years of paediatric experience for respondents who used the BNFc smartphone app every time they prescribed and several times a day were 6 years and 3 years. For all other categories the mean years of paediatric prescribing experience was higher (between 9 and 13 years) demonstrating an inverse relationship between regularity of BNFc smartphone app use and years of paediatric prescribing experience.

5.2.10.2 Guy's, St Thomas' & Lewisham Hospitals paediatric formulary

The Guy's, St Thomas' & Lewisham Hospital paediatric formulary is a locally developed and produced paediatric formulary. It is updated annually. The majority of respondents did not use this resource, see Table 22 below.

Table 22: Frequency of reported Guy's St Thomas' & Lewisham Hospitals paediatric formulary use when prescribing for paediatric patients

Regularity of use of Guy's St Thomas' & Lewisham Hospital paediatric formulary	**Frequency (% responses to this question)**
Every time I prescribe	0 (0)
Several times a day	0 (0)
Daily	1 (1)
Several times a week	0 (0)
Weekly	1 (1)
Monthly	4 (2)
Less often	5 (3)
N/A I don't use this resource	159 (94)
Total	170

The numbers in each group of Guy's etc Formulary use were too small to test for a statistically significant association between profession and regularity of Guy's etc Formulary use. Both medical and non-medical prescribers reported to have used this resource, but the majority of respondents did not use it. The range of prescribing experience in paediatrics for reported users of this resource was less than one year to 20 years.

5.2.10.3 Pharmacy team member

Pharmacy team members include pharmacists and pharmacy technicians. The frequency of use of these resources is described in Table 23 below.

Table 23: Frequency of reported use of pharmacy team members as a resource when prescribing for paediatric patients

Regularity of use of pharmacy team members	**Frequency (% responses to this question)**
Every time I prescribe	0 (0)
Several times a day	7 (4)
Daily	11 (6)
Several times a week	18 (10)
Weekly	25 (15)
Monthly	31 (18)
Less often	55 (32)
N/A I don't use this resource	23 (14)
Total	170

The majority of respondents used a member of the pharmacy team as a resource at least monthly. However, 14% of respondents never used the pharmacy team as a resource when making prescribing decisions for children. The majority of those who never used the pharmacy team as a resource when prescribing were doctors who prescribed at least daily and described themselves as consultants (21 doctors (15 consultants, 6 other grades); in addition 1 dentist, 1 nurse). Twelve of the respondents who did not use pharmacy as a resource worked in either surgery or the emergency department, where at the time of the study they would be unlikely to see a pharmacist to ask for advice. There was no significant association between years of prescribing experience and regularity of use of a pharmacy team member as a resource (Kruskal Wallis $p = 0.754$).

5.2.10.4 Microbiology department

The microbiology department may advice on the use of antimicrobials including which antimicrobial the infection is sensitive to and relevant local guidelines. The use of the microbiology department as an information source is described in Table 24.

Table 24: Frequency of reported use of microbiology guidance when prescribing for paediatric patients

Regularity of use of microbiology	Frequency (% responses to this question)
Every time I prescribe	0 (0)
Several times a day	1 (1)
Daily	5 (3)
Several times a week	16 (9)
Weekly	10 (6)
Monthly	31 (18)
Less often	65 (38)
N/A I don't use this resource	42 (25)
Total	170

A quarter of respondents stated that they never used the microbiology department as a resource when prescribing for children. This group of respondents had a range of paediatric prescribing experience and worked in a variety of areas of the hospital. The majority of respondents stated they do make use of this resource. The most reported option was 'less often' than monthly, suggesting there is not a frequent need to use this source of information. There was no significant association between years of paediatric prescribing experience and the regularity of use of a microbiology team member as a resource (Kruskal Wallis p = 0.266).

5.2.10.5 Other colleagues

Other colleagues referred to a reference to any other colleague at Birmingham Children's Hospital who was not a member of the pharmacy or microbiology team. The responses to this question are described in Table 25.

Table 25: Frequency of reported use of other colleagues as a resource when prescribing for paediatric patients

Regularity of use of other colleagues	Frequency (% responses to this question)
Every time I prescribe	4 (2)
Several times a day	1 (1)
Daily	10 (6)
Several times a week	24 (14)
Weekly	22 (13)
Monthly	28 (16)
Less often	50 (30)

N/A I don't use this resource	31 (18)
Total	170

(NB trainee advanced nurse practitioners would be required to always prescribe in conjunction with a colleague who is a qualified prescriber)

The majority of respondents reported to refer to other colleagues when prescribing for paediatric patients. The professions of colleagues referred to are described in Table 26. Of the 18% of respondents who did not report to refer to other colleagues; 29/31 were doctors. There was a statistically significant association between years of paediatric prescribing experience and regularity of reported use of other colleagues as a resource (Kruskal Wallis p = 0.00). Respondents who reported to use other colleagues between several times a day and several times a week as a resource when prescribing were the least experienced (means between 2 and 4 years), but prescribed frequently. They were doctors or nurses or pharmacists. Respondents who reported to refer to other colleagues as a resource less often or didn't refer to other colleagues as a resource had a mean experience of 13 years. The more experienced the respondent was the less likely they were to have reported to use other colleagues as a resource.

Table 26: Profession of colleagues reported to be referred to for prescribing support by respondents at Birmingham Children's Hospital

Healthcare profession	**Frequency**
Pharmacy/pharmacist	78
Doctor	66
Microbiology/Microbiologist	12
Nurse	8
Non-medical prescriber	3
Dentist	1
Pharmacology	1
Profession not specified	17
Total	186

The majority of respondents reported to refer to colleagues such as doctors and pharmacists as a resource when making a prescribing decision. Respondents also reported to refer to microbiologists, nurses, non-medical prescribers, dentists and pharmacologists. These responses are aligned with respondents' previous responses that stated they report to refer to pharmacy team members more than microbiology team members.

5.2.10.6 Birmingham Children's Hospital Results Systems

The results may include blood results, other test results and imaging. The regularity of reported use of this system is described in Table 27.

Table 27: Frequency of reported use of BCH results system as a resource when prescribing for paediatric patients

Regularity of use of BCH results systems	Frequency (% responses to this question)
Every time I prescribe	10 (6)
Several times a day	36 (21)
Daily	25 (15)
Several times a week	20 (12)
Weekly	19 (11)
Monthly	18 (11)
Less often	24 (14)
N/A I don't use this resource	18 (11)
Total	170

Respondents' reported use of the BCH results systems when prescribing for paediatric patients was varied. There was no significant association between years of paediatric prescribing experience and regularity of use of BCH results system as a resource (Kruskal Wallis p = 0.178). There was a small proportion (11%) who reported to not use the BCH results systems as a resource when prescribing for children. This group contained a variety of professions (doctor, dentist, nurse) and years of experience of prescribing in paediatrics. Prescribers in this group reported a variety of clinical specialties.

5.2.10.7 Patient notes

Patient notes include a variety of resources; for example: medication and medical histories, letters from outpatient clinics and information on previous admissions. Table 28 describes how often respondents reported to use patient notes as a resource when prescribing for paediatric patients.

Table 28: Frequency of reported use of patient notes as a resource when prescribing for paediatric patients

Regularity of use of patient notes	Frequency (% responses to this question)
Every time I prescribe	37 (22)
Several times a day	30 (18)

Daily	17 (10)
Several times a week	29 (17)
Weekly	14 (9)
Monthly	12 (7)
Less often	20 (12)
N/A I don't use this resource	11 (6)
Total	170

The majority of respondents reported to have used patient notes several times a week or more frequently. There was a significant association between years of experience of prescribing in paediatrics and reported regularity of use of patient notes as a resource (Kruskal Wallis p = 0.006). Generally respondents who reported to have referred to patient notes more frequently were less experienced than respondent who reported to have referred to patient notes less frequently. The mean number of years of paediatric prescribing experience for respondents who reported to have used patient notes every time they prescribed and daily was between 7 years and 9 years, whereas for respondents who reported to have used patient notes between several times a week and monthly the mean years of prescribing experience was between 13 and 15 years. There was a small proportion of 6% who reported to have never used patient notes when making prescribing decisions for children. This group contained respondents representing a range of years of experience in paediatric prescribing and a range of professions. The respondents who reported not to use patients notes were not located in a particular area of the hospital or clinical specialty.

5.2.10.8 Google

Table 29 below describes their reported use of Google when prescribing for paediatric patients.

Table 29: Frequency of reported use of Google when prescribing for paediatric patients

Regularity of use of Google	**Frequency (% responses to this question)**
Every time I prescribe	0 (0)
Several times a day	2 (1)
Daily	2 (1)
Several times a week	7 (4)
Weekly	5 (3)
Monthly	8 (5)
Less often	32 (19)
N/A I don't use this resource	114 (67)
Total	170

The majority of respondents did not report to have used Google as a resource when making prescribing decisions for children. Respondents who reported to use Google as a resource frequently (several times a week or more) were frequent prescribers, doctors and work in the inpatient setting. There was no significant association between years of paediatric prescribing experience and regularity of Google use (Kruskal Wallis p = 0.414).

5.2.10.9 National Institute for Health and Care Excellence (NICE) guidelines

The National Institute for Health and Clinical Excellence produces a range of guidelines in the UK that may be used by paediatric prescribers. Table 30 below described how often respondents reported to have used NICE guidelines when prescribing.

Table 30: Frequency of reported use of NICE guidelines when prescribing for paediatric patients

Regularity of use of NICE guidelines	**Frequency (% responses to this question)**
Every time I prescribe	2 (1)
Several times a day	1 (1)
Daily	5 (3)
Several times a week	6 (4)
Weekly	14 (8)
Monthly	30 (18)
Less often	61 (36)
N/A I don't use this resource	51 (30)
Total	170

The majority of respondents reported using NICE guidelines when prescribing; but most often they reported to have used them monthly or less often. There were 30% of respondents who reported that they did not use NICE guidelines when prescribing for children. This group of respondents had a range of professions and years of paediatric prescribing experience within it. Those that reported to use the guideline frequently (several times a week or more) were frequent prescribers and were not from one singular specialty or hospital setting. The NICE guidelines respondents reported to use are described in Table 31. There was no statistical association between years of experience in paediatric prescribing and regularity of use of NICE guidelines (Kruskal Wallis p = 0.159).

Table 31: NICE guidelines reported to have been used by respondents at Birmingham Children's Hospital

Name of NICE guideline (guideline reference number)	**Frequency**
Urinary tract infection in children (CG54)	11
Attention deficit hyperactivity disorder (CG72)	7
Depression (CG28)	7
Constipation (CG99)	7
Feverish illness in children (CG160)	5
Meningitis (CG102)	4
Asthma (QS25)	3
Epilepsy (CG137)	3
Psychosis & Schizophrenia (CG155)	3
Obsessive compulsive disorder (CG31)	2
Diabetes (CG15 and CG66)	2
Growth hormone (TA188)	2
Upper respiratory tract infection (CG69)	2
Tuberculosis (CG117)	2
Sedation (CG112)	2
Familial hypercholesterolaemia (CG71)	2
Sepsis/febrile neutropenia (CG151?)	2
Omalizumab (TA278)	2
Continuous subcutaneous insulin infusion (TA151)	1
Inflammatory bowel disease (yet to be published)	1
Dental (CG19?)	1
Idiopathic thrombocytopenia purpura (TA221 or TA293)	1
Borderline personality disorder (CG78)	1
Head injury (CG176)	1
Neonatal sepsis (CG149?)	1
Gastroenteritis (CG84)	1
Trauma (TA74 or yet to be published)	1

Immunosuppression (TA99?)	1
Chronic pain (?)	1
Autistic spectrum disorder (CG128)	1
Headache/migraine (CG150)	1
Enuresis (CG111)	1
Anxiety (CG159?)	1
Non-specific reference	13
Total	96

The guideline reference numbers marked with a question indicate that it was not clear to the researcher if this was the specific guideline being referred to by the respondent. The name of the NICE guideline described by the respondent did not clearly match the guidelines listed on the NICE website. The researcher looked at the NICE website to establish the closest match to the responses given.

The NICE guidelines reported to have been used were varied (33 different guidelines reported), potentially a reflection of the varied patient population within the hospital.

5.2.10.10 Local guidelines

Local guidelines refer to guidelines developed by Birmingham Children's Hospital or other hospitals. The regularity of reported use of BCH guidelines when prescribing is described in Table 32.

Table 32: Frequency of reported use of local guidelines as a resource when prescribing for paediatric patients

Regularity of use of local guidelines	**Frequency (% responses to this question)**
Every time I prescribe	7 (4)
Several times a day	9 (5)
Daily	12 (7)
Several times a week	25 (15)
Weekly	42 (25)
Monthly	32 (19)
Less often	29 (18)
N/A I don't use this resource	14 (8)
Total	170

The majority of respondents reported to have used local guidelines when prescribing for children. The specific BCH guidelines used are described in Table 33. There was a statistically significant association between years of experience of prescribing in paediatrics and use of local guidelines (Kruskal Wallis p = 0.00). Less experienced prescribers were more frequent reported users of local guidelines when prescribing. However a small proportion, 8%, reported that they did not use local guidelines. This group had significant paediatric prescribing experience (mean = 16 years).

Table 33: Local guidelines reported to have been used by respondents

Name of guideline	**Frequency**
Antibiotic	43
Emergency department guidelines	11
Haematology/Oncology	10
Respiratory	6
Cystic fibrosis	6
Analgesia	6
PICU	6
Vitamin D	4
Sedation policy	4
Diabetic Ketoacidosis guideline	3
Liver transplant/unit	3
Pharmacy information	3
Nephrotic syndrome	3
Sickle cell management/crisis	3
Nephrology protocol	2
Rapid tranquillisation	2
Sepsis pathway	2
Anticoagulation	2
Cardiac surgery protocol	2
Kawasaki disease	2
Microbiology	1
Attention Deficit Hyperactivity Disorder	1
Newly diagnosed type 1 diabetes	1
Ischaemic limb	1
Haemophilia unit guidelines	1
Burns	1

Midazolam pathway	1
Fluid and electrolyte guidelines	1
Zoledronate/pamidronate	1
Hypoglycaemia	1
Congenital Adrenal Hyperplasia patients requiring surgery	1
Gastroenterology protocols	1
Infusion charts	1
Antiemetic	1
Central Venous Line site policy	1
TB	1
Endocrine test protocols	1
Parenteral nutrition prescribing guidelines	1
Renal transplant protocol	1
Anaesthesia good practice guide	1
BCH app	1
Bronchiolitis	1
Malaria	1
Asthma	1
West midlands psychopharmacology forum	1
No specific guideline response (e.g. 'unit')	20
Total	168

A wide variety of local guidelines (45) were reported to have been used by prescribers at Birmingham Children's Hospital when prescribing for children. The most frequently reported guideline was the antibiotic guideline.

5.2.10.11 Other national guidelines

There are many organisations in the UK such a Royal Colleges and health charities who also write prescribing guidelines that be used as a resource by the respondents. The reported use of this type of guideline is described in Table 34 below.

Table 34: Frequency of reported use of other national guidelines when prescribing for paediatric patients

Regularity of use of other national guidelines	**Frequency (% responses to this question)**

Every time I prescribe	0 (0)
Several times a day	2 (1)
Daily	3 (2)
Several times a week	8 (5)
Weekly	6 (4)
Monthly	28 (16)
Less often	61 (36)
N/A I don't use this resource	62 (36)
Total	170

The other national guidelines reported to have been used when prescribing are described in Table 35. The majority of respondents reported to have used other national guidelines when prescribing for children. However, 36% of respondents used them less often then monthly when prescribing and a further 36% not at all. There was no statistical association between number of years of paediatric prescribing experience and use of other national guidelines (Kruskal Wallis p = 0.511). One third of the respondents who reported to use other national guidelines frequently (at least several times a week) described their speciality as haematology.

Table 35: Other national guidelines reported to have been used by respondents at Birmingham Children's Hospital

Name of organisation	**Frequency**
British Thoracic Society	10
British Committee for Standards in Haematology	4
Maudsley Guidelines	3
British Inherited Metabolic Diseases Group	3
British Society for Paediatric Endocrinology and Diabetes	2
Children's Cancer and Leukaemia Group	2
SIGN (Scottish Intercollegiate Guidelines Network) guidelines	2
European Society for Paediatric Gastroenterology, Hepatology and Nutrition	2
British Association of Dermatologists	1
United Kingdom Haemophilia Doctors	1

Organisation	
British Society of Paediatric Dentistry	1
Department of Health toolkit (dentistry)	1
College of Emergency Medicine	1
Royal College of Obstetricians and Gynaecologists	1
Retrieval guidelines	1
British Society for Paediatric and Adolescent Rheumatology	1
American College of Rheumatology	1
Cystic Fibrosis Trust	1
UK ALL protocols	1
Royal College of Paediatrics and Child Health	1
Resuscitation Council	1
European Society for Clinical Nutrition and Metabolism	1
British HIV Association	1
Paediatric Intensive Care Society	1
American Society for Parenteral and Enteral Nutrition	1
Association of Paediatric Anaesthetists of Great Britain	1
European Vasculitis Study Group	1
Association of Anaesthetists of Great Britain and Ireland	1
British Association for Paediatric Nephrology	1
APA guidelines (?)	1
ASD (?)	1
No organisation specified	10
Total	61

The researcher had to identify the likely solution of some of the acronyms listed. A question mark has been used to indicate where there was more than one possible option for the acronym provided by the respondent.

The most frequently reported guidelines used were those produced by the British Thoracic Society. There were also a wide variety of other professional organisation guidelines used with 31 different organisations reported.

5.2.10.12 Frank Shann

Frank Shann is a paediatric drug dose booklet available in a variety of formats. The format most frequently reported to have been used by respondents was the paper format, which was reported to have been used by 11% of respondents. The online format was reported to have been used by 1% and the smartphone application format was reported to have been used by 6% of respondents. Users of Frank Shann were likely to describe their speciality as PICU, emergency department or anaesthetics.

5.2.10.13 Other resources

Respondents were also asked to list any other resources that they used when prescribing for paediatric patients.

Other resources included: Maudsley guidelines; 'BAP' guidelines; United Kingdom Haemophilia Doctors Organisation; 'chemotherapy protocols': 'UK ALL protocols', 'CCLG National chemotherapy protocols'; 'Epocrates' phone app; Adult BNF; 'Oncology formulary'; Lexicomp; 'pediatric & neonatal dosage handbook' (app); Micromedex (online); Renal Handbook; 'e medicines compendium'; 'dose calc app'; 'BCH App created by Barry Lambert'; international guidelines; Journals – clinical research papers.

Maudsley guidelines were reported by four respondents and chemotherapy related guidelines were reported by four respondents. All other suggestions were reported by a single respondent.

5.2.11 The most useful resources according to respondents when prescribing for paediatric patients

Respondents were asked to list the references that were most useful to them and to provide a reason for this in an open question. 167 responses were received for the first part of the question (summarised in Table 36) and 124 reasons were recorded in the second part of this question. The reasons have been analysed qualitatively. The ranking was determined by how many participants listed the resource as the resource reported to be most useful to them.

Table 36: The most useful resources according to respondents when prescribing for paediatric patients

Rank	Resource	Frequency
1	BNF/BNFc (all responses)	130

	BNFc	68
	BNFc paper	8
	BNFc app	7
	BNF	32
	BNF app	5
	BNF paper	8
	BNFc online	2
	Dental BNF	1
2	Pharmacy or pharmacist (all responses)	10
	Renal pharmacist	2
	PICU pharmacist	2
3	Local guidelines or handbook (all responses)	9
	Liver unit guidelines	1
	CF guidelines – BCH	1
	Sedation policy	1
	Transplant protocol	1
	Oncology formulary	1
4	Colleague	4
5	Patient or case notes	3
6	Frank Shann	2
6	Microbiology	2
8	Medicines for children	1
8	Patient results	1
8	UK ALL protocols	1
8	ESPGHAN guidelines 2005	1
8	PICS	1
8	American academy of child and adolescent psychiatry	1
8	Lexicomp pediatric and neonatal dosage app	1

Total		167

It was not possible to confirm if all respondents meant the BNF or the BNFc in their responses. Therefore all references to the BNF/BNFc have been collated as well as reported as described by the respondents.

The resource considered most useful when prescribing by respondents was the BNF/BNFc. This was reported to be the most useful resource by 78% of respondents to this question.

Reasons resources are deemed to be the most useful by respondents

This section summarises the open ended descriptions provided by respondents as to why they have selected the resources summarised in the above table as the most useful to them. Some respondents provided reasons for more than one resource. Therefore for some resources there may be more comments regarding why it is useful than the number of respondents who reported that resource as the most useful.

The most useful reference source to respondents was the BNF/BNFc (131 of 167 responses). The reasons why have been grouped into five main themes. These are: ease of use and reliability; coverage of relevant information; familiarity; assessing drug options and references to specific information.

The most frequently reported reasons for use of the BNF/BNFc were ease of use and reliability. 25 out of 55 reasons why the BNF/BNFc was the most useful resource fell into this category. Information within the BNF/BNFc was described as “reliable” and “accurate”. The BNF/BNFc were also considered easy to use and easily accessible in the work environment. Respondents commented that the BNF/BNFc was the most available source of information on a ward and it was easy to take the BNF/BNFc to the bedside on the ward. Respondents also commented that the BNF/BNFc was regularly updated and information was presented clearly. The content of the BNF/BNFc was described as evidence based and authoritative. One respondent stated that the “BNFc should be the first reference source for prescribers in the UK”. Finally the BNF/BNFc was reported to cover the information needs of respondents and present this information with guidance.

The second most frequently reported reason for use of the BNF/BNFc was the coverage of relevant information. This represented 9 out of 55 responses. The BNFc, according to respondents, was useful because it was “designed especially for children” and it provided “information on drugs that I am likely to use in my area of practice”. The BNFc was also likely to “cover every drug I would ever prescribe” and was “applicable to the majority of patients” for “standard paediatric drugs”.

Three respondents cited that familiarity was part of the reason why the BNF/BNFc was the most useful resource. One respondent described the BNF/BNFc as a resource they are “comfortable with” and one described it as “the only one I know”. Two respondents referred to the BNF/BNFc as being useful for helping “decide which drug to prescribe” and looking at “various options”.

There were a further 16 comments that referred to specific functions of the BNF/BNFc that made it the most useful. This included available information regarding: licensing of drugs; interactions; adjustments for organ impairment; legal prescribing; checking doses; costs; side effects; and available formulations. There were five comments that referred to the smartphone app. These comments focussed on its accessibility: particularly when in the community and you can’t find a computer or a paper copy. Two comments mentioned that the speed of using the smartphone app was quicker than the use of the paper format of the BNF/BNFc and one comment praised the search function available within the smartphone app.

The main reason why the pharmacy department and/or pharmacists were reported to be the most useful resource was the specialist knowledge they had. Seven of 13 comments referred to the specialist knowledge as the reason the pharmacy team were the most useful resource. The pharmacy team were described as “reliable” and “accessible”. One respondent referred to the pharmacist as their “first port of call”. Pharmacists were also valued for their “understanding of the patient” and their ability to adapt to the clinical scenario.

The reasons why local guidelines were useful covered four main themes. These were: specific to local practice; information on non-standard treatments; evidence based and accessibility. The most frequently reported reason that local guidelines were useful was that local guidelines are specific to the local practice and method of working. This reason covered 8 out of 19 comments regarding local guidelines. Local guidelines were useful because they were specific to the task, specialty or BCH day to day working. The second most common theme, containing 5 comments related to the accessibility of local guidelines. Local guidelines were reported to be in “an easy to access format” and clearly presented. One respondent reported that the guidelines were “produced by the team” which meant they all worked within them. It is important to note local guidelines were also described in a contradictory manner by one respondent as “cumbersome, hard to find, and less useful”.

5.2.12 Types of information that aids respondents’ prescribing decisions for paediatric patients

Using information suggestions from the prior focus groups respondents were asked to select which types of information they needed to refer to when prescribing for children from seven fixed

options and an 'other' option. 165 responses were received for this question. The responses are summarised in Table 37.

Table 37: Types of information that aids respondent's prescribing decisions for paediatric patients

Type of information	Frequency (% responses to this question)
Drug doses	158 (96)
Contraindications	135 (82)
Interactions	118 (72)
Patient test results	109 (66)
Formulation information	95 (58)
Drug choice	89 (54)
Compatibilities	77 (45)
Other	12 (7)
Total	793

NB respondents could select more than one option for this question.

Other information individual respondents referred to included: previous prescriptions; license issues; indication; clotting factor % correction levels; preparation/administration instructions; pharmacology; side effects. Some respondents also listed specific dosing issues as 'other'. These were: renal doses and frequency. There was no statistical difference between profession/years of experience in paediatrics and the type of information sought when prescribing for paediatric patients.

Respondents were then asked to select from the available options which type of information they were most likely to need when prescribing in paediatrics. The responses are described in Table 38 where drug doses were reported as the most common type of query.

Table 38: Type of information most frequently referred to when prescribing for paediatric patients

Type of information	Frequency (% responses to this question)
Drug doses	136 (82)
Patient test results	8 (5)
Contraindications	6 (4)
Drug choice	5 (3)
Formulation information	5 (3)
Interactions	1 (1)

Compatibilities	1 (1)
Other	3 (2)
Total	165

165 responses were received to this question.

5.2.13 Types of paediatric prescribing information lacking in current resources

The literature review and the findings from the focus groups study established that there is a lack of paediatric prescribing information available to prescribers. This question sought to identify more specifically what this deficit was. 161 responses were received and these are described in Table 39.

Table 39: What paediatric prescribing information do respondents feel is lacking from current resources?

Type of information	**Frequency (% responses to this question)**
Lack of advice other than 'caution'	66 (41)
Links to individual patient factors	43 (27)
Availability of paediatric formulations	44 (27)
There is no lack of information.	42 (25)
Lack of access to information	26 (16)
Paediatric doses	21 (13)
Other	26 (16)

One quarter respondents did not feel there was a lack of available prescribing information for paediatric patients. For respondents who felt there was a lack of paediatric prescribing information, the most common areas where they believed the lack occurred were: lack of advice other than 'caution' (i.e. in the paediatric dosing section of the prescribing resource the only comment is 'caution' and no further advice is provided).

Individual respondents also identified other areas that lacked paediatric prescribing information. These are listed below:

- An easier and less time consuming way of checking interactions (particularly for oncology drugs)
- Information regarding difficult infusions
- How to give some medications
- Speciality specific or rare treatment information (e.g. pubertal induction)

- Off license (but recognised) indication doses (e.g. Clonidine for tics)
- Costs to the trust and the community
- Clotting factor % calculations are not published in one specific publication
- Alternative drugs following a drug reaction
- Compatibility of infusions
- Information regarding colour of medicines
- Suggested duration of treatment
- Pharmacology and pharmacokinetics in paediatric and neonatal patients
- Availability of medicines in a paediatric formulation
- A formulary for PICU with all information in one place
- Clearly stated frequency of side effects

Those respondents who replied that there was a lack of dosing information were asked if this was in any particular area or whether this was a general problem. A total of 28 responses were received to this question. These are described in Table 40. The options for this question were derived from the focus group study that took place prior to this questionnaire where dosing in paediatric specialties was highlighted as an area lacking information. Respondents could select multiple answers to this question

Table 40: Specific types of paediatric dosing information that respondents reported to have been unavailable at the time of the study

Type of information	**Number of responses**
Paediatric doses in general	16
Doses for premature babies	13
Renal doses	12
Hepatic doses	10
CVVH/dialysis information	6
ECMO doses	5
Filtration dosing information	5
Other	3
Total	70

(CVVH – Continuous veno-venous haemofiltration, ECMO – extracorporeal membrane oxygenation)

Responses to other included: ‘none in my area’; drug handling in special patient groups and doses and formulation information on the few drugs available in my specialty.

There was a range of areas where there respondents reported a lack of paediatric prescribing information.

5.2.14 Does lack of paediatric prescribing information have an effect on patient care

Respondents were offered three fixed options. 158 responses were received. The responses are summarised in Table 41 below.

Table 41: Does a lack of paediatric prescribing information have an effect on patient care?

Answer selected	Frequency (% responses to this question)
Yes	79 (50)
No	36 (23)
Don't know	43 (27)
Total	158

Half the respondents considered that a lack of paediatric prescribing information can have an effect on patient care. However approximately one quarter did not consider there was an effect on patient care and a further quarter of respondents were not sure. The respondents who weren't sure had fewer years of paediatric prescribing experience than those who responded yes or no (mean years of experience 6 years compared to mean years of experience 12 years for yes/no respondents). Respondents were also asked to explain their response to this question and describe why they did or did not think patient care could be affected.

Reasons why a current lack of paediatric prescribing information may have affected patient care

The reasons provided by respondents as to why a lack of paediatric prescribing information could affect patient care can be summarised under five themes. These were: patient safety is compromised, delays for patients, factors affecting the prescriber, drug choice for patients and 'other'.

Patient safety was reported to be at risk when there was a lack of paediatric prescribing information. 25 out of 58 comments referred to an aspect of patient safety that could be affected by a lack of paediatric prescribing information. One aspect was that the prescriber could be "over or undertreating" if the relevant information was not available. One respondent suggested this may mean that the "clinicians sometimes have to guess the right dose due to lack of information". A second aspect was that a lack of information could lead to the wrong drug being chosen. Both

these aspects were confounded by the lack of evidence and data available in paediatrics according to respondents. One respondent highlighted that it was difficult to determine the dose of a medicine that was not licensed in children due to the lack of available information. Respondents also commented that a lack of information regarding side effects and/or interactions could put patients at risk. One example given was “I don’t know the risk of topical cleaning agents and medicines in neonates and exposed skin conditions like burns”. One respondent commented that the patient safety issue could be highlighted if prescribers were newly qualified or not used to working in paediatrics. Another respondent noted that “we are dependent on pharmacists” to check things are being done correctly and this was not fail proof as pharmacists are not available at weekends.

The second most frequently reported reason was that delays to patient care could occur when information was being sought by prescribers. This theme accounted for 14 out of 58 comments that explained why a lack of paediatric prescribing information can affect patient care. Respondents also commented that delays can occur when general practitioners do not have access to the relevant prescribing information meaning the patient may have to return to the hospital in order to get a medicine prescribed. In addition, delays can occur when information is being sought and when information is being evaluated by the prescriber. Respondents also reported that delays can occur when combinations of medicines are needed or when computers are not working effectively to find information. Two respondents commented that when prescribers are searching for medication information time is taken away from direct patient contact.

The third most common reason recorded by respondents was factors that affected the prescriber and their ability to make prescribing decisions. This theme was found in ten respondents’ comments. All of these comments suggested that without the right information prescribers may not feel confident or comfortable prescribing. One respondent stated it was “harder to take decisions” and a second respondent commented that prescribers “often have to make educated guesses”. This view was summed up by one respondent who stated “I am anxious about prescribing something on which the official line is to say there is no information available”. It was also recognised that clear prescribing information can improve doctors “autonomy and efficiency in prescribing”.

The fourth theme was that a lack of paediatric prescribing information can limit drug choice. This was reported in comments from six respondents. One respondent suggested that a patient may not get the best available drug as it has not been tested enough in the paediatric population. This problem was noted to affect access to new medicines by one respondent. Two respondents noted

that there can be paediatric prescribing information unavailable for drugs that would be expected to be of benefit in paediatric patients.

There were several further reasons that were reported by single respondents. The first reason was that prescribing information was not aimed at reducing costs and as resources were limited this could indirectly affect the availability of resources available to care for patients. Another respondent commented that parents can become very worried about a lack of research evidence that demonstrates a particular drug is safe. This could impact the consent to provide treatment. Finally, a respondent commented that when you don't know what formulations are available children can be given preparations that are not ideal. The example given was that MUPS omeprazole can block nasogastric tubes and takes longer for families to administer compared to omeprazole syrup.

Comments from respondents who were not sure if a lack of paediatric prescribing information affected patient care

The comments from this opinion group were too contrasting to be grouped into themes. Examples of comments from respondents who were not sure if a lack of paediatric prescribing information can affect patient care are presented below.

- "It is difficult to know whether small dosing errors or formulation errors have any effect on patient outcomes."
- "The excellent PICU pharmacy team are available to support prescribers which I believe may reduce negative effects on patient care that may arise from lack of information or to help prescribers understand the information available."
- "Within my area of prescribing I feel that I have enough information and resources about the drugs that I am prescribing. I am sure if I didn't have this information however that it would impact on patient care."
- "It could be a case that lack of information regarding paediatric formulations could mean patients receive doses in unsuitable forms in an effort to achieve prescribed dose; for example a patient may receive crushed tablet, to achieve specific dose, when liquid form was available."
- "A number of our prescribing practices are already only performed because of consensus opinion and presumed best practice – a lack of clarity of prescribing information is not likely to affect this. Too much prescribing information can similarly affect patient care, as is seen with the sudden withdrawal of codeine from the BCH formulary."
- "A lot of prescribing decisions are based on 'education (*sic*) guess' rather than clear evidence. We often don't know whether a deterioration in patient condition is due to

illness or adverse drug effect, particularly in patient with complex pharmacotherapy. Pharmacology data are limited in children, the critically ill and where medicines interact."

- "It can make finding an answer slower, but usually an answer of sorts can be found eventually."
- "A lot of the doses we use, especially in cardiology, are empirical, which can potentially have implications of safety and efficacy. "
- "In my area of practice I don't think it does – emergency and urgently needed prescriptions are easily referenced. However in busier departments the availability of prescribing information may have an effect."

Reasons why a current lack of paediatric prescribing information may not have affected patient care

There were twenty one respondents who provided reasons why patient care was not affected by a lack of paediatric prescribing information. These comments were grouped into four themes: information is available; pharmacy staff provide support; clinical experience and consensus on treatment.

The most commonly reported reason that patients were not affected was that currently available information was suitable. This was stated in 12 of the twenty reported comments in this group of respondents. Respondents reported that the necessary information was available; however three respondents noted that it may take time to obtain the required information. "I think there is enough information you just sometimes have to search for it". The second most common reason was that there were pharmacy staff to provide support for paediatric prescribers. This reason was reported by 5 of the respondents in this opinion group. One example is: "BCH has fantastic pharmacy support which means there is always somewhere to go if you have a question."

The themes of clinical experience and consensus on treatment were supported by two respondents each. Clinical experience was noted to partly mitigate for the limitations of studies in paediatric patients. One respondent commented that "My knowledge and experience over the last 5.5 years have ensured patient care is not affected." With regard to consensus on treatment one respondent reported that "The drugs we use are often specialised and uses off license, but with consensus for doses etc. so I don't think patient care is compromised". This was supported by a second respondent who commented that although products may be unlicensed they can still be used in children.

5.2.15 Is there a difference in difficulty between prescribing for children and prescribing for adults?

This open ended question was answered by 125 respondents. The responses have been summarised into five distinct categories: children are more difficult to prescribe for (n=81); adults are more difficult to prescribe for (n=3); there is no difference in difficulty (n=5) and an unsure/don't know category (n=7), response unclear (n=19).

Comments that supported that there was a difference in difficulty between prescribing for children and prescribing for adults

The responses were organised into six themes. There were eleven respondents that simply answered "yes" children are more difficult to prescribe for than adults.

The most frequently reported reason for why children are more difficult to prescribe for than adults was that children required varying doses. This was reported by 42 of 81 respondents with this opinion. This group of respondents noted that variety of calculations needed to be carried out in order to prescribe for paediatric patients. Dosing calculations were based on a variety of parameters including: age, weight, body surface area, varying units of measure (e.g. micrograms, milligrams, units) and changing organ function. These parameters then change as a child grows. This variety was considered to be the main reason prescribing for children is more difficult than prescribing for adults. A second reason was that "adult dosing is much more standardised" and therefore "easier to remember". Another factor was that blood results vary with age in paediatric patients, rather than having one standard acceptable range as found in adult patients. One respondent commented that the range of doses prescribed "makes it more difficult to have an intuitive feel when the dose is wrong". An additional complexity was that formulations "are designed for use in adults" and then additional calculations can be required in the manipulation of a paediatric dose from an adult formulation.

The next most common reason for children being more difficult to prescribe for than adults according to the study respondents was there was a lack of evidence for paediatric prescribing compared to adult prescribing. This theme was supported by comments from 11 respondents. Respondents noted that there was less written evidence available in paediatrics and one respondent commented that trials in children could be "less rigorous".

The third most frequently reported reason in this study was that children are inherently more complex than adults to prescriber for. This theme was supported by comments from seven respondents. Children were reported to be more complex because of varying sizes/ages. One respondent, who was an adult trainee, stated that he/she didn't understand why it needed "to be

so complicated" in paediatrics (i.e. using weight, age and body surface area to calculate doses) when body surface area was consistently used to calculate drugs in adult haematology patients.

Comments that supported the opinion that adults are more difficult to prescribe for than children

Three respondents commented that adults were more difficult to prescriber for than children. The reasons for this were that adults had more polypharmacy and comorbidities to consider when prescribing. One respondent stated that the comorbidities of adults gave them a greater chance of adverse drug interactions and that "elderly patients are particularly difficult as their tolerance to medication is affected by their ageing physiology".

Comments stated there was not a difference in difficulty between prescribing for children and prescribing for adults

Five respondents commented that there was not a difference in difficulty for prescribing for children or prescribing for adults. Their comments were as follows:

- "No, except simple maths."
- "No, different difficulties in both age groups. One not more difficult than the other."
- "Not once you are used to both patient groups."
- "Not really when following the guidelines, dose requirements etc."
- "No, I don't think so."

Comments that did not support either direction or were unable to answer the question

There were seven respondents who commented that they were unable to answer this question as they had either never prescribed for adults or not prescribed for adults for a long period of time. There were nine further comments that explained some of the reasons why prescribing in paediatric may be different to prescribing in adults, but did not state that this meant it was more difficult. There were no consistent reasons reported in this group of respondents so it was not possible to draw rational themes from the comments. The comments were:

- Paediatric prescribing is less straight forward, but does highlight the fact that in adult practice we should be considering our patients weight, build and body composition with our prescribing decisions.
- Probably not, I often wonder about dosing in adults not being related to their body weight
- The resources available to inform prescribing for children with haemophilia or a related bleeding disorder are robust if consulted and implemented as advised and in consultation.

- The dosing is too general. For example some doses are given as age 6-12 years 250mg. not very useful as some 6 year olds are less than 20kg and some 12 year olds are over 50kg.
- Bringing together the varying age groups within the specialist care need can be challenging alongside the individual status of the patient.
- Although there is not always sufficient evidence for prescribing decisions in certain adult populations this situation is worse in the paediatric population due to lack of clinical trial data and various paediatric age groups, children with rare conditions, lack of recruitment to clinical trials, small patient numbers etc.
- On the whole many adult medicines are set doses which can be 'learned' – however in children this is different and reference to a text to ensure the correct dose per weight/body surface area is given.

5.3 Discussion

The prescribing habits of some prescribers at Birmingham Children's Hospital have now been identified. The majority of prescribers were doctors who prescribed frequently (several times per shift) across more than one hospital setting (see tables 37 to 43). There was no dominant clinical specialty, reflecting the environment of Birmingham Children's Hospital that provided secondary care for the local population alongside tertiary care for a range of specialties. Non-medical prescriber had less experience of prescribing in paediatrics, but also prescribed frequently in a range of specialties. There was a wide range of paediatric prescribing experience (range 30 years) and paediatric prescribing frequency (several times a shift to less than monthly) across the respondents which was linked to their differences in reported use of several paediatric prescribing information resources.

The large number of consultants in this study and their high level of prescribing experience will have affected the reported prescribing information requirements. It was hypothesised that years of prescribing experience would not be associated with reported frequency of resource use. However, some of the reported resource use indicated that those with more prescribing experience used prescribing resources less frequently (see section 5.2.10). However, experience of prescribing in paediatrics did not eliminate the reported requirement of access to paediatric prescribing information. Over half of respondents reported to use a resource every day, with over a quarter reporting to use a resource every time they prescribed. In this study respondents reported to use a variety of paediatric prescribing sources irrespective of their years of paediatric prescribing experience. This suggests that future developments in electronic systems to support paediatric prescribing should include access to paediatric prescribing information and this access

need not be adjusted to prescriber experience. Removing the requirement to have varying levels of access to prescribing information or guidance may make the development of paediatric prescribing systems more straightforward.

The paper version of the BNFc was reported to be used most frequently and to be the most useful by respondents (see Table 62). The BNFc is a standard UK reference source for paediatric prescribing [110] and it is promoted by the GMC as a recommended resource for prescribing within its guideline on 'Good practice in prescribing'. [91] Hence it may be expected that doctors would choose to use it as their 'go to' resource for prescribing. The frequent reported use of the paper version of the BNFc (the format reported to be used most frequently at BCH) may be aided by the fact it is distributed free to all hospitals annually in England and as such it should be readily available to hospital based prescribers.

78% of respondents at BCH reported that the BNF/BNFc was the most useful reference source when prescribing for paediatric patients. The two main reasons reported were the reliability/authenticity of the information and the ease of use/availability of the BNFc. This is consistent with the reported priorities of clinicians when using a medicines information resource. [75] These were: "reliability of information" and "ease and speed of information retrieval". [75] Respondents also reported that the BNFc was useful because it included all relevant prescribing information in one place and it was comprehensive. Again, consistent with a prior publication that stated the BNFc has got the breadth and depth of its coverage correct. [75] The type of information looked up when making prescribing decisions was primarily information required after the respondent has decided which drug to give. This may partially explain why information on drug choice was not looked up so often by prescribers at BCH in prescribing resources; although guidance on prescribing was reported to be one feature of the BNFc that made it useful to prescribers at BCH. The most frequent type of information required was dosing information, consistent with prior focus group findings by Mehta. [75] Dosing information is contained in the BNFc alongside information on contraindications and interactions. These three types of information were reported to be required from prescribing resources by the respondents in this study; hence the BNFc could be a potential one stop paediatric prescribing reference source for prescribers.

The BNFc online was not in widespread use at BCH and was reported no to be used by the majority of respondents, unlike the paper format of the BNFc. The BNFc online does not require a subscription. One reason the BNFc online may have been less frequently used than the paper BNFc was that it was less accessible at BCH. The online BNFc required the user to have access to the internet via a computer or tablet and access to computers was reported to be difficult in the

focus groups held prior to this study. These devices may not have been available in the location where the resource needed to be used, for example, few computers may have been located by the patient bedside. However, despite this there was a very small group of users who used the online format on a daily basis. The BNFc app is available at no charge to healthcare professionals who have a NHS Athens password both in iPhone and Android formats. The BNFc app has a higher number of regular users than the BNFc online format at BCH. The BNFc app does not require internet access to function and can be accessed on a portable device, which may partly explain why it has more regular users at BCH than the BNFc online format, i.e. it is suitable for use in any location.

Respondents reported that one aspect of the BNFc that made it useful to them was its authority. This authority was implied by the GMC when it recommended that its members use the BNF to support 'good prescribing practice'. [91] During a recent 2013 review of information resources by the National Institute for Health and Social Care Excellence (NICE) the BNF and the BNFc were not granted approval. [111] The reasons for this were linked to the lack of defined process for assessing strengths and weaknesses of evidence; lack of relevant stakeholder involvement and finally the reader cannot ascertain when each section was last updated. [111] Respondents reported that the BNFc was useful because it was evidence based and up to date, but NICE did not agree that the BNFc had a transparent robust process for assessing evidence or clearly displaying when each section of the BNFc was last updated. This NICE report was available at the time of the study, but no respondent referred to it in any comments they made. This suggests that the NICE accreditation of a prescribing resource does not have an impact on the authority of the BNFc to respondents of this study.

Respondents were also asked to list other resources they used that had not been referred to specifically in the questionnaire. These mainly fell into the category of other national guidelines, such as Maudsley. However, there were several different smart phone apps mentioned in this question, perhaps linked to the earlier trend of the BNFc smartphone app being reported to have been used more frequently than the online version of the BNFc. The development of smartphone apps to support paediatric prescribing may allow direct access to relevant information in an accessible location due to the portability of smartphones and tablets. However, errors in local development of prescribing support tools have been reported previously therefore any development of 'in house' apps should proceed with great care to ensure that appropriate quality control can be applied to avoid errors being built into the app. [67]

Some resources reported to be used in this study may only be useful to certain specialties due to their content. Future electronic prescribing systems would need to consider if access to these

should be limited to specific clinical specialties. For example, the Guy's and St Thomas', King's College and University Lewisham Hospitals Paediatric Formulary is intended to be a reference source for prescribing in paediatrics that also includes additional information on off license or off label uses of medication. Therefore developers should consider if this resource should be restricted to clinical areas where unlicensed prescribing has the potential to be more prolific; this may include the paediatric intensive care unit. A further example is Frank Shann, a collection of paediatric critical care guidelines; its content may only be useful to those respondents who worked in PICU.

Respondents to this study reported that it can take longer to become familiar with paediatric doses than it does to become familiar with adult doses. This may partially explain why respondents with fewer years of paediatric prescribing experience used the BNFc (an information source with dosing information) more frequently than experienced prescribers. However, as evidenced by the reported use of many other sources of paediatric prescribing information, the BNFc does not contain all the information required for all paediatric prescribing decisions.

Half of respondents believed that a lack of paediatric prescribing information could have an effect on patient care. Factors that affected the accuracy of paediatric prescribing were the most frequently reported reason a lack of paediatric prescribing information could affect patient care. Respondents reported that a lack of paediatric dosing information could lead to a risk of under or over treating and that this could come from prescribers reporting they were required to 'guess' the right dose or extrapolate a dose from adult data. Another way that patient care was reported to be affected was that lack of prescribing information could have led to delays in administration of medication and other aspects of patient care. Respondents reported delays could occur when the prescriber needed to consult several resources, which in turn led to delays in decision making regarding medication for that patient. Recognising that this type of delay to patient care can happen is important. Ideally all paediatric prescribing information would be contained in a single, easy to use and comprehensive formulary, i.e. an improved BNFc. However, it is apparent that the current formulary does not meet the needs of prescribers in this study.

Approximately a quarter of respondents did not think patient care was affected by current levels of paediatric prescribing medication. This group of respondents recognised that there were a wide range of resources available to paediatric prescribers and this was complimented by the support offered from the pharmacy team at BCH. Pharmacy support in prescribing has also been recognised by the EQUIP study as an important way of reducing prescribing errors made by foundation doctors. [62] However, this group of respondents also reported that it can take time to find paediatric prescribing information. Despite differences in opinions respondents recognised

that limitations in paediatric prescribing information stem from the lack of trials in this population. This is an international issue, reflected in the decreasing quantity of paediatric prescribing information in the Physician's Desk Reference and the legislation put in place to encourage more research to include paediatric populations. [73, 112]

Respondents reported that there was a lack of paediatric prescribing information across a range of information types. The most common response option selected by respondents was 'lack of advice other than caution'. This statement was also discussed in the focus groups and the overall view from participants was that a simple statement of 'caution' was unlikely to be helpful to prescribers as it provided no direction as to the best course of action. Another information type that was reported to be lacking was links to individual patient factors, for example prescribing guidance on what adjustments should be made when a patient has poor renal function. This is consistent with an American review paper that described current resources as not adequate for individual patient dosing. [71] Increased use of electronic prescribing and electronic patient records may allow for the development of software that uses individual patient results in combination with decision support to provide individualised prescribing advice. However, it is difficult to see how a comprehensive paediatric clinical decision system could be accomplished when prescribers report that some there are some areas of paediatrics that do not have the necessary research taking place to provide the data required.

The results of this study should impact the way in which electronic prescribing and clinical decision support systems are configured in paediatrics. The respondents in this study demonstrate via their reported frequent use of information sources that access to paediatric prescribing information is required. Information regarding dosing, interactions and contraindications was reported to be the most frequently required information and as such should be prioritised when developing electronic prescribing and clinical decision support in paediatrics. Respondents also reported the frequent use of patient notes as a source of information indicating the need for high quality and readily accessible patient notes. In order for patient notes to be accessible to more than one user at a time an electronic patient record system is required. The majority of respondents believed that prescribing for children was inherently more difficult than prescribing for adults. The most frequent reason for this was that adult dosing is generally more standardised and does not necessitate the individual dosage calculations required in paediatric patients. It was these variations in doses that respondents felt made prescribing for paediatric patients more difficult, hence the requirement to frequently access dosing information. The difficulty in these dose calculations has been recognised as a source of prescribing errors in paediatric patients and is trying to be solved through the provision of computerised clinical decision support at the point of prescribing. However, there have been

difficulties in adapting current commercial clinical decision support systems for use in the paediatric environment. [113]

The use of local information sources such as patient notes, patient results and local guidelines by respondents indicates that the development of future paediatric prescribing system should allow for customisation to local practice. The guidelines reported to have been used most frequently by prescribers at BCH were local guidelines rather than NICE or other national guidelines. Local guidelines may incorporate the advice found in national guidelines and apply this information to local protocols and practices. The practical application of national guidelines could be an important area of future information systems in paediatric prescribing. The large number of local guidelines reported to be used in this study indicates the need for the hospital to develop its own guidelines that bring together relevant information to guide prescribers in the use of medication. This process would need to be translated to an electronic system proposed to be used for paediatric prescribing to remove the need for prescribers to consult several resources before being able to make a prescribing decision. The requirement to review several sources of information was one reason respondents reported that could cause delays to patient care. Hence electronic systems developed should try and reduce the burden on prescribers and provide easy access to the required information.

5.4 Limitations

The pilot of this study confirmed that the questions were worded appropriately. This was demonstrated by the answers to the open ended questions clearly answering the question as intended by the researcher. The clarity of the questions and the choice of language used were also influenced by the early focus groups in this research programme. The early focus groups enabled the researcher to gain an understanding of the language use of the participants as well as a general understanding of current practice in the research area. These factors ensured that the research instrument was suitable for use.

This study had a moderate response rate of 46%. This exceeded the researcher expectations as studies involving questionnaires completed by medical doctors typically have a low response rate. [102] Reasons why invited participants did not respond are indicated by the responses to two early questions where several participants refused to provide consent or did not currently prescribe at BCH. There may well be further invited participants who did not want to participate or did not prescribe at BCH, but did not go as far as to click through the questionnaire link to indicate this. Other reasons identified by previous published research include: doctors have a lack of time to spend filling in research questionnaires and they consider patient related tasks more

important. [102] These reasons may also be reasonable to apply to the non-respondents in this study.

The response rate for non-medical prescribers was higher than the response rate for medical prescribers, indicating that they were overrepresented in this study. Non-medical prescribers were significantly less experienced at prescribing in paediatrics than medical prescribers. This may have had an impact on the reported frequency of use of some resources; some resources had less experienced prescribers report to use them more frequently. Therefore when using this data to inform the design of clinical decision support systems it is important to consider resources may have been reported to be used more frequently in this study than on average in practice.

The demographic questions indicated that the medical respondents to this study had considerable experience of prescribing in paediatrics. The study was conducted at a specialist paediatric hospital where there were a larger proportion of consultant and senior specialist trainees than expected at an average paediatric service provision in a general hospital. This was required at the study site due to the high concentration of specialist services present alongside general paediatric services. Some resources in this study had more experienced prescribers report to use them less frequently. Prescribers with considerable experience may have undergone routinisation of their tasks; meaning they have written the same type of prescription many times and do not believe they require the use of a resource when working within their usual area of practice. Therefore is it is important to consider that the frequency of resource use may have been underestimated due to the overrepresentation of senior medical prescribers in this study.

This study was conducted at a single site. Therefore the results may not be generalizable to all paediatric hospital prescribers. The majority of paediatric services are provided by paediatric wards in general hospitals rather than specialist paediatric hospitals. Specialist paediatric hospitals provide a wider range of specialist paediatric services than paediatric provision in a general hospital. Additional data from paediatric prescribers working in other hospitals should be collected to determine if this has skewed the data of this study.

This study was conducted at a single specialist paediatric hospital, which may or may not be representative of paediatric prescribers as a whole. However, it fits the purpose of informing service development in electronic prescribing at BCH. It would not be expected that the results of this study would be reproduced exactly in other paediatric NHS Trusts in England because of local variation in access to resources and differing local prescribing practices in each place. There may also be differences in the people who prescribe between different hospitals. Lastly, access to resources can change over time as new editions of books are published or made available online and new mobile phone applications are developed.

Finally, there was no method of tracking if a respondent had filled out the questionnaire more than once. However, given the challenges in obtaining a reasonable response rate in healthcare professionals, it is unlikely that many will be willing to give up their time to complete the questionnaire multiple times.

5.5 Conclusion

- Prescribers at BCH reported to prescribe frequently across a range of hospital settings. They had a wide range of paediatric prescribing experience and reported an array of clinical specialties.
- Prescribers at BCH reported to have used a wide range of resources when prescribing for children.
- Prescribers at BCH recognised the BNFc as the most useful and most frequently used resource when prescribing in paediatrics. It was valued for its authority, ease of use and ease of access.
- Prescribers at BCH reported there was a lack of paediatric prescribing information across a range of areas and hypothesised that this was a result of the lack of research in paediatric populations.
- Prescribers at BCH felt that a lack of paediatric prescribing information could affect patient care, predominantly through difficulty in determining correct doses for paediatric patients and delays in care when information as being sought.
- This study will inform electronic prescribing developers about the resource needs of paediatric prescribers when making prescribing decisions and the type of prescribing information that an electronic prescribing system would ideally provide.

5.6 Recommendations for practice

- A single source of paediatric prescribing information would be a valuable and potentially patient care improving resource. For example, an enhanced version of the BNFc with additional information covering off label and unlicensed uses of medication.
- A clinical decision support system for paediatrics needs to have the ability to provide recommendations and advice that is patient specific. For example, a dose recommendation should consider the patients age, weight, kidney function etc.
- Prescribers use the knowledge of a range of other healthcare professionals. Therefore there should be multidisciplinary working in place to enable effective use of the expertise available.

6. Use of information sources by members of the Neonatal and Paediatric Pharmacist Group (NPPG) when providing paediatric pharmacy services

The aim of this study was to examine the use of, and satisfaction with, information resources used by pharmacists in paediatrics. This study was completed by pharmacist members of the NPPG. The results of the previous study reported in chapter 3 identified that access to patient's medication information was an important component of electronic medicines management and the prior focus groups identified that pharmacists were used as a source of information by paediatric prescribers. Therefore, as an important part of the medication process in hospitals, the resource use of pharmacists when providing paediatric pharmacy services was investigated further.

The method of this study was an online self-completed questionnaire; the details of the method are described fully in chapter 2, page 47. The objectives of this study were to:

- Identify the current paediatric pharmacy services provision reported by NPPG pharmacist members in terms of frequency of service provision, paediatric pharmacy experience and clinical specialty,
- Identify the prescribing information resources pharmacist members of the NPPG report to use most frequently,
- Identify which prescribing information resource was the most useful to pharmacist members of the NPPG and why,
- Identify areas of paediatric prescribing information where pharmacist members of the NPPG report a lack of available prescribing information,
- Identify the potential impact on patients of the current availability of paediatric prescribing information reported by pharmacist members of the NPPG.

6.1 Context of this study

Little is known about how often pharmacists consult a resource whilst providing a paediatric pharmacy service or how useful these resources are to pharmacists. This study of information resource use by pharmacists working in paediatrics was conducted in collaboration with the NPPG.

The NPPG is an organisation for paediatric and neonatal pharmacists that is based in the UK. It aims to improve the care of neonates, infants and children by assisting the development of pharmacists and of quality pharmacy services. Since there are no other organisations in the UK that have direct access to a similar number of paediatric pharmacists, the NPPG members were chosen as the target population for this study. The NPPG membership is made up mainly of pharmacists from the UK who work or have an interest in paediatrics, neonates or children and women's health.

6.2 Results

6.2.1 Response rate

The questionnaire was successfully sent to 280 potential participants. 133 initial responses were received, of whom 96 were able to complete the membership validation question, resulting in a response rate of 34.3%. Provision of NPPG membership number was designed to validate the respondent as a member and avoid any repeat completions of the questionnaire. There was difficulty encountered with this question as it was reported to the researchers that some respondents did not know their membership number and almost a third of respondents did not continue beyond this question.

6.2.2 Provision of paediatric pharmacy services

All 96 respondents to this question confirmed that they provided paediatric pharmacy services.

6.2.3 Job title of respondents

Respondents completed a free text box asking them to describe their job title and/or grade. 90 responses were received to this question and are summarised in Table 42 below.

Table 42: Grade/job title of pharmacist respondents

Grade	Frequency
Band 7	11
Band 8a	30
Band 8b	12

Band 8c	4
Job title	**Frequency**
General paediatric/women and children	38
Pharmacist (no specialty declared)	13
Specialist paediatric - oncology/haematology	4
Specialist paediatric – neonates	3
Specialist paediatric- Medicines information/formulary	2
Specialist paediatric – intensive care	2
Consultant pharmacist	2
Specialist - Education and training	1
Specialist paediatric – rheumatology	1
Specialist paediatric – cystic fibrosis	1
Specialist paediatric – cardiothoracic	1
Dispensary lead	1
Locum pharmacist – paediatrics	1
Resident pharmacist	1
Multiple specialties	1 x MI & clinical trials 3 x MI & paediatrics 1 x PICU & paediatric nephrology 1 x Chief pharmacist & oncology/haematology
Total (number of responses)	90

The most frequent grade of pharmacist reported was NHS band 8a (pharmacists upon qualification are band 6, usually moving to band 7 after 2/3 years, then band 8a after a similar period of time), indicating respondents to this study were senior pharmacists. Most pharmacists reported to be general paediatric pharmacists or pharmacists covering women and children, rather than a paediatric clinical specialty. There was a group of pharmacists who did not declare any specialty in their description of their job title or grade (n=7). There were no respondents who identified themselves as a community pharmacist.

6.2.4 Number of years of experience of providing paediatric pharmacy services

Respondents completed an open question asking them to state in years how much experience they had in providing pharmacy services in paediatrics. There were 94 responses received to this question, two responses were not in the format requested and were not included in the analysis. The mean years of paediatric experience was: 9.7 years. The range of paediatric experience was: 32 years (1 year to 33 years).

6.2.5 Clinical areas where respondents provided paediatric pharmacy services

Respondents were asked which of the following areas of the hospital they provided paediatric pharmacy services in: inpatients, outpatients, emergency department, in the community or other. Respondents could select more than one option. There were 94 responses received to this question and these are summarised in Table 43 below.

Table 43: Areas where respondents provided paediatric pharmacy services

Area	**Frequency**
Inpatients	94
Outpatients	73
Emergency department	25
In the community	23
Other	5
Total	94

All respondents reported to work in the inpatient area with the majority of these respondents also working in the outpatient area. Approximately one third of respondents reported to work in three areas (both inpatients and outpatients plus either the emergency department or in the community). There were 10 respondents who reported to work in all four areas presented to them. The areas that the respondents considered as 'other' included: advice to community paediatric staff and hospice; homecare; community children's nursing team pharmacist; ambulatory; neonatal and paediatric ITU/HDU.

6.2.6 The most frequently reported area of work for respondents when providing pharmacy services for paediatric patient

Respondents were asked which area they most frequently provided paediatric pharmacy services. There were 93 responses received to this question, which are summarised in Table 44 below.

Table 44: The area in which respondents provided pharmacy services for paediatric patients most frequently

Area	Frequency (% of responses to this question)
Inpatients	86 (92)
Outpatients	5 (5)
Emergency department	0 (0)
In the community	1 (1)
Other	1 (1)
Total	93

Only one respondent reported to work in the community. The respondent who responded 'other' reported to work in paediatric intensive care most frequently.

6.2.7 When on duty, how often did respondents provide pharmacy services for paediatric patients?

Respondents were asked how often they provided pharmacy services for children. There were 91 responses received to this question, these are summarised in Table 45 below.

Table 45: When on duty, how often do you provide pharmacy services for a paediatric patient?

Regularity of providing pharmacy services for children	Frequency (% of responses to this question)
Multiple times per day/shift	82 (90)
Once daily	4 (4)
Several times a week	3 (3)
Weekly	2(2)
Monthly	0 (0)
Less than monthly	0 (0)
Total	91

Most respondents provided pharmacy services for children multiple times per day/shift. All respondents provided pharmacy services for children at least weekly.

6.2.8 Clinical specialty of respondents

Respondents were asked to input in an open question "When thinking about your pharmacy services in paediatrics, what is your specialist area? (For example: PICU, oncology etc.)". There were 87 responses received to this question, these are summarised in Table 46 below.

Table 46: Specialties of respondents regarding paediatric pharmacy services

Specialty	**Frequency**
General paediatrics	24
NICU	11
General and neonates/NICU	10
Oncology/Haematology	7
Neonates	6
PICU	5
Cystic fibrosis	3
Rheumatology	2
Medicines information	1
Liver	1
N/A rotational	2
Total	87

The most frequent response was general paediatrics. The two next most frequent responses were NICU and 'general and neonates/NICU'. Many of the responses of general and neonates were accompanied by a comment stating these were the areas of service provided by their district general hospital. One response did not refer to a specialty. There were 14 responses that referred to more than one specialty.

6.2.9 How often did respondents consult a reference or resource when providing pharmacy services for paediatric patients?

Respondents were asked how often they consulted a reference or resource when providing pharmacy services for paediatric patients. The options were closed and the 88 responses are described in Table 47 below.

Table 47: How often did respondents consult a reference or resource when providing pharmacy services for paediatric patients?

Incidence of reference source use	**Frequency (% of responses to this question)**
Every time I provide paediatric pharmacy	5 (6)

services	
Several times a day	66 (75)
Daily	9 (10)
Several times a week	8 (9)
Weekly	0 (0)
Monthly	0 (0)
Less than monthly	0 (0)
Total	88

Most respondents referred to a reference frequently (at least daily) and all respondents referred to a reference source at least several times a week. There were no respondents who reported using a reference source less than several times a week. The data was tested for an association between reported frequency of pharmacy services to paediatric patients and reported frequency of reference source use. The independent samples Kruskal Wallis test was not significant. This indicates that reported frequent use of reference sources was not associated with frequent reported provision of pharmacy services to paediatric patients.

6.2.10 Reported frequency of particular reference source use by respondents

This question asked respondents to consider how often they used a series of reference sources when providing pharmacy services to paediatric patients. Each question was closed, with eight options presented. There were 88 responses were received to this question and the responses are summarised in each section below.

6.2.10.1 British National Formulary for Children

The BNFc is a UK nationally produced formulary. Responses are summarised in Table 48 below.

Table 48: Frequency of reported BNFc paper format use when providing paediatric pharmacy services

Regularity of use of BNFc (paper format)	**Frequency (% of responses to this question)**
Every time I provide pharmacy services	6 (7)
Several times a day	46 (52)
Daily	14 (16)
Several times a week	11 (13)
Weekly	6 (7)
Monthly	2 (2)

Less often	1 (1)
N/A I don't use this resource	2 (2)
Total	88

There were five respondents who did not use this resource frequently (at least weekly). Three of these five reported that their specialist area of work was the neonatal intensive care unit.

Frequency of BNFc online format use is summarised in Table 49 below.

Table 49: Frequency of reported BNFc online format use when providing paediatric pharmacy services

Regularity of use of BNFc (online format)	**Frequency (% of responses to this question)**
Every time I provide pharmacy services	1 (1)
Several times a day	13 (15)
Daily	11 (12)
Several times a week	15 (17)
Weekly	11 (12)
Monthly	11 (12)
Less often	12 (14)
N/A I don't use this resource	14 (16)
Total	88

The BNFc online format was used by the majority of respondents less frequently than the BNFc paper format. Nearly half of respondents (13/28) who reported to use it at least daily worked in paediatric or neonatal intensive care. The defining characteristic of respondents who did not use this resource was their experience in paediatrics – mean 14 years. This is double the number of years of paediatric experience compared to the respondent that reported to use the BNFc online format at least daily (mean - 7 years experience).

The frequency of BNFc smartphone app use is summarised in Table 50 below.

Table 50: Frequency of reported BNFc smartphone app format use when providing paediatric pharmacy services

Regularity of use of BNFc (smartphone app)	**Frequency (% of responses to this question)**
Every time I provide pharmacy services	0 (0)
Several times a day	13 (15)

Daily	3 (3)
Several times a week	6 (7)
Weekly	2 (2)
Monthly	4 (5)
Less often	3 (3)
N/A I don't use this resource	57 (65)
Total	88

The BNFc smartphone app was the format of the BNFc reported to be used least frequently by respondents. Similarly to the online format of the BNFc the respondents who reported to use the BNFc smartphone app at least daily had less paediatric experience compared to those who did not use the BNFc smartphone app (7.25 years vs 10.3 years).

The BNFc paper format was the format reported to have been used most often by respondents; 75% of respondents reported to have used it daily or more frequently. There were 98% of respondents who reported to have used the BNFc in the paper format, 84% reported to have used the online version of the BNFc and 35% reported to have used the BNFc smartphone app.

6.10.2 Guy's, St Thomas' & Lewisham Hospitals paediatric formulary

The responses regarding Guy's, St Thomas' & Lewisham Hospitals paediatric formulary use are summarised in Table 51 below.

Table 51: Frequency of reported use of Guy's, St Thomas' & Lewisham Hospital paediatric formulary when providing paediatric pharmacy services

Regularity of use of Guy's, St Thomas' & Lewisham Hospitals paediatric formulary	**Frequency (% of responses to this question)**
Every time I provide pharmacy services	2 (2)
Several times a day	14 (16)
Daily	6 (7)
Several times a week	14 (16)
Weekly	14 (16)
Monthly	18 (20)
Less often	16 (18)
N/A I don't use this resource	4 (5)
Total	88

25% of respondents used this reference source at least daily. A small group of respondents (5%) did not use this resource. This group provided pharmacy services to paediatric patients frequently and reported to use an information source to support their provision of paediatric pharmacy services several times a day.

6.2.10.3 Pharmacy team member

Table 52 summarises the responses to this question.

Table 52: Frequency of reported use of pharmacy team members as a resource when providing paediatric pharmacy services

Regularity of use of pharmacy team members	Frequency (% of responses to this question)
Every time I provide pharmacy services	0 (0)
Several times a day	8 (9)
Daily	7 (8)
Several times a week	31 (35)
Weekly	9 (10)
Monthly	11 (13)
Less often	18 (20)
N/A I don't use this resource	4 (5)
Total	88

The majority of respondents referred to another member of the pharmacy team at least weekly. However there was a small group of respondents (5%) who did not. This group of respondents did not have any defining characteristics.

6.2.10.4 Microbiology department

Table 53 summarises the responses to this question.

Table 53: Frequency of reported use of microbiology guidance when providing paediatric pharmacy services

Regularity of use of microbiology	Frequency (% of responses to this question)
Every time I provide pharmacy services	0 (0)
Several times a day	0 (0)
Daily	2 (2)
Several times a week	13 (15)
Weekly	22 (25)

Monthly	17 (19)
Less often	31 (35)
N/A I don't use this resource	3 (3)
Total	88

Over one third of respondents (35%) used microbiology as a resource less often than monthly and 3% of respondents did not use microbiology as a resource.

6.2.10.5 Other colleague

'Other colleagues' was intended to include a reference to any other colleague the respondent works with who was not a member of pharmacy or microbiology. The question was "Please state how often you use each of the following resources" and the option was named "other colleague". The randomisation of the options may have meant this was not clear. Table 54 summarises the responses to this question.

Table 54: Frequency of reported use of other colleagues as a resource when providing paediatric pharmacy services

Regularity of use of other colleagues	**Frequency (% of responses to this question)**
Every time I provide pharmacy services	0 (0)
Several times a day	5 (6)
Daily	11 (13)
Several times a week	14 (16)
Weekly	21 (24)
Monthly	15 (17)
Less often	20 (23)
N/A I don't use this resource	2 (2)
Total	88

The majority of respondents refer to other colleagues at least weekly when providing paediatric pharmacy services. Respondents then identified which colleagues they referred to in the next question. Respondents could list as many colleagues as they wanted to in their answer. Respondents most frequently referred to pharmacy or medical colleagues. They also referred to members of the multidisciplinary healthcare team such as nurses, dieticians, physiotherapists and pharmacy technicians. Respondents also contacted colleagues who worked outside of their hospital/Trust when providing paediatric pharmacy services. Respondents did not report to refer

to healthcare professionals working in primary care such as community pharmacists or general practitioners.

6.2.10.6 Hospital results system

Table 55 summarises the responses to this question.

Table 55: Frequency of reported use of hospital results systems when providing paediatric pharmacy services

Regularity of use of hospital results systems	Frequency (% of responses to this question)
Every time I provide pharmacy services	6 (7)
Several times a day	40 (45)
Daily	23 (26)
Several times a week	13 (15)
Weekly	1 (1)
Monthly	0 (0)
Less often	1 (1)
N/A I don't use this resource	4 (5)
Total	88

A small group of respondents (5%) did not report to use the results system as a resource when providing paediatric pharmacy services. This may have been the result of a type which labelled this option as 'BCH results systems' rather than 'results systems'.

6.2.10.7 Patient notes

Table 56 summarises the responses to this question.

Table 56: Frequency of reported use of patient notes as a resources when providing paediatric pharmacy services

Regularity of use of patient notes	Frequency (% of responses to this question)
Every time I provide pharmacy services	16 (18)
Several times a day	48 (55)
Daily	16 (18)
Several times a week	6 (7)
Weekly	0 (0)
Monthly	0 (0)
Less often	0 (0)
N/A I don't use this resource	2 (2)

Total	88

The majority of respondents referred to patient notes when providing paediatric pharmacy services at least several times a day. There were 2% of respondents who reported not to use patient notes (one of these respondents reported to work in the community most frequently, an area where patient notes would be unlikely to be available).

6.2.10.8 Frank Shann

Frank Shann is a specialist paediatric intensive care drug dose resource available in a variety of formats. The most used format was the paper format that was reported to have been used by 20% of respondents. The online format was reported to have been used by 11% of respondents and the smartphone app was reported to have been used by 10% of respondents. The majority of respondents who reported to use the Frank Shann resources reported paediatric or neonatal intensive care as their specialty.

6.2.10.9 Google

Table 57 summarises the responses to this question.

Table 57: Frequency of reported use of Google when providing paediatric pharmacy services

Regularity of use of Google	**Frequency (%)**
Every time I provide pharmacy services	0 (0)
Several times a day	7 (8)
Daily	3 (3)
Several times a week	21 (24)
Weekly	20 (23)
Monthly	9 (10)
Less often	21 (24)
N/A I don't use this resource	7 (8)
Total	88

Over half of the respondents used Google at least weekly as a resource when providing paediatric pharmacy services. Approximately 34% used Google monthly or less often.

6.2.10.10 NICE guidelines

The National Institute for Health and Care Excellence produces a range of clinical guidelines in the UK that may be used by respondents when providing paediatric pharmacy services. Table 58 summarises the responses to this question.

Table 58: Frequency of reported use of NICE guidelines when providing paediatric pharmacy services

Regularity of use of NICE guidelines	Frequency (% of responses to this question)
Every time I provide pharmacy services	0 (0)
Several times a day	0 (0)
Daily	1 (1)
Several times a week	11 (13)
Weekly	12 (14)
Monthly	37 (42)
Less often	25 (28)
N/A I don't use this resource	2 (2)
Total	88

The majority of respondents reported using NICE guidelines, however most respondents used them monthly or less often. Respondents were then asked to specify which NICE guidelines they used. Respondents were free to list as many guidelines as they wanted to in their answer. Table 59 summarises the responses to this question.

Table 59: Approximated NICE guidelines used by respondents when providing paediatric pharmacy services

Name of NICE guidelines (guideline reference number)	Frequency
Epilepsy (CG137)	10
Urinary tract infection (CG54)	7
Neonatal sepsis (CG149)	4
Feverish illness in children (CG160)	4
Asthma (QS25)	4
Meningitis (CG102)	3
Sepsis/febrile neutropenia (CG151)	3
Growth hormone (TA188)	2
Constipation (CG99)	2

Cystic fibrosis, nebulised antibiotics (TA276?)	2
Crohn's disease (CG152)	2
Tocilizumab in juvenile arthritis (TA238)	2
Infliximab (TA187)	2
Diarrhoea and vomiting in children (CG84)	1
Attention deficit hyperactivity disorder (CG72)	1
Sedation (CG112)	1
Intravenous fluids (yet to be published)	1
Hepatitis C (TA300?)	1
Renal transplant (TA99)	1
Diabetes (CG15/CG66?)	1
Anaemia (CG114?)	1
Specific guideline not mentioned	26
Total	81

The data in Table 28 was compiled by matching the responses with the list of resources on the NICE website and establishing the closest match. A question mark after the guideline in the above table indicates that it was not possible to make a definite identification of the guideline from the information provided by the respondent.

There was a wide variety of guidelines referred to with 22 different guidelines being identified in total.

6.2.10.11 Local guidelines

Table 60 summarises the responses to this question.

Table 60: Frequency of reported use of local guidelines as a resource when providing paediatric pharmacy services

Regularity of use of local guidelines	**Frequency (% of responses to this question)**
Every time I provide pharmacy services	3 (3)
Several times a day	15 (17)
Daily	25 (28)
Several times a week	26 (33)
Weekly	13 (15)
Monthly	0 (0)
Less often	0 (0)

N/A I don't use this resource	3 (3)
Total	88

The majority of respondents used local guidelines at least several times a week to support their provision of paediatric pharmacy services. Respondents were then asked to specify which local guidelines they used. Respondents were free to list as many local guidelines as they wanted to in response to this question.

A wide variety of local guidelines (32) were referred to by respondents as resources used when providing paediatric pharmacy services. The most frequently referred to guideline was the antibiotic guideline. There were 34 responses that did not refer to a specific guideline, but instead referred to a hospital or department guideline in general.

6.2.10.12 Other national guidelines

There are many organisations in the UK such as Royal Colleges that develop guidelines for clinical conditions that may be used as a resource by the respondents when providing paediatric pharmacy services. Table 61 summarises the responses to this question.

Table 61: Frequency of reported use of other national guidelines as a resource when providing paediatric pharmacy services

Regularity of use of other national guidelines	Frequency (% of responses to this question)
Every time I provide pharmacy services	0 (0)
Several times a day	2 (2)
Daily	3 (3)
Several times a week	12 (14)
Weekly	18 (20)
Monthly	27 (31)
Less often	18 (20)
N/A I don't use this resource	8 (9)
Total	88

The majority of respondents reported to use other national guidelines. They were reported to have been used by most respondents between weekly and monthly. 9% of respondents did not use other national guidelines. Respondents were then asked to specify which other national guidelines they used in a free text response. Respondents could list as many other national guidelines in their answer as they wanted. The most frequently reported other national guidelines

used were from SIGN and the British Thoracic Society. There were also a wide range of other organisations referred to with 29 different organisations reported. This demonstrates that information required for provision of paediatric pharmacy services comes from a wide range of sources.

6.2.10.13 Other resources

Respondents were also asked to record any further resources that they reported to use. Respondents identified 42 further sources of information that they used when providing paediatric pharmacy services. The most frequently reported additional resource was the Neonatal Formulary (NNF) followed by the Electronic Medicines Compendium (EMC). This provides further evidence that a large number of sources of information are required to provide paediatric pharmacy services

6.2.11 The most useful information resource when providing paediatric pharmacy services

Participants were asked to list up to three reference sources that were most useful to them and to provide a reason for this. 88 responses were received to this question with 79 respondents providing reasons for their choice. Table 62 summarises the responses to this question.

Table 62: The most useful resources as reported by respondents when providing paediatric pharmacy services

Rank	Name of resource	Frequency
1	BNFc	60
2	Guy's and St Thomas' paediatric formulary	7
3	Neonatal formulary	6
4	Trust/Local guidelines	4
5	Local formulary	2
5	Local neonatal formulary	2
5	Paediatric and Neonatal dosage handbook (Taketomo)	2
8	Martindale	1
8	Original protocol (trial)	1
8	Paediatric formulary	1
8	Local NICU IV guidelines	1
Total		88

The BNFc was described as being the most useful resource to respondents for the following reasons:

- It was accessible.
- It was up to date.
- It was easy to use.
- It covered the drugs and information needed in paediatrics.
- It was evidence based.
- It was the national standard for paediatric doses, therefore it was authoritative.
- It contained information on licensing and products available.
- It had useful background information.
- It was a familiar resource; therefore respondents were confident in using it.
- App/paper version – these are useful to show information to others and when computers are not available.

6.2.12 What types of information do respondents look up to support their decisions in paediatrics

Respondents were asked to select which types of information they 'looked up' to support their decisions in paediatrics from a fixed list of options and an 'other' option where additions could be typed. Respondents were able to select more than one response. There were 88 responses received to this question. Table 63 summarised the responses to this question.

Table 63: Types of information reported to be have been looked up to support decisions in paediatrics

Type of information	Frequency
Doses	87
Interactions	80
Formulation information	79
Contraindications	78
Patient test results	73
Drug choice	72
Compatibilities	71
Other	20
Total	560

Respondents reported to have accessed all of the information types listed when providing paediatric pharmacy services. They also reported an additional twenty types of information that may be 'looked up' to support decisions in paediatrics. The other types of information used by respondents demonstrate the breadth of information required when providing paediatric pharmacy services.

Table 64 below describes the type of information most frequently required by respondents when providing paediatric pharmacy services.

Table 64: Type of information reported to have been 'looked up' most often

Type of information	Frequency (% of responses to this question)
Doses	76 (86)
Patient test results	6 (7)
Formulation information	2 (2)
Drug choice	1 (1)
Contraindications	1 (1)
Interactions	1 (1)
Compatibilities	0 (0)
Other	1 (1)
Total	88

The 'other' response was "remains a combination of all".

The most frequently looked up type of information by respondents when providing paediatric pharmacy services was doses.

6.2.13 What information did respondents report current resources lacked to support their paediatric decisions?

Respondents were asked to select which types of information were lacking in current resources to support their paediatric decisions from a fixed list of options. Respondents could select as many options as they felt appropriate or "there is no lack of information". 87 responses were received to this question. Table 65 below summarises the responses to this question.

Table 65: What information did respondents report current resources lacked to support paediatric decisions?

Type of information	Frequency
Availability of paediatric formulations	56
Lack of advice other than 'caution'	44

Paediatric doses	28
Links to individual patient factors	24
Lack of access to information	13
There is no lack of information	5
Other	25
Total	195

Respondents were most frequently reported that there was a lack of information on availability of paediatric formulations. Five respondents reported that there was no lack of information.

Other areas respondents reported a lack of information in can be summarised as the following:

- Dosing guidance for obese children
- Dosing guidance for children with renal impairment
- Administration information, particularly concerning the effect of dissolving medication in fruit juice or other food/drink to mask the taste
- Further information on off-label or unlicensed use of medication in children, doses that have been given safely
- Pharmacokinetics in paediatric patients
- Impact of medication on baby/child when mother is breastfeeding.

Those who gave a positive response to the option "lack of paediatric dosing information" were directed to an additional question which asked respondents to identify the specific areas of paediatric practice which they considered to be lacking dosing information. Respondents could select as many responses as they felt appropriate. Table 66 below summarises the responses to this question.

Table 66: Types of paediatric dosing information reported that are lacking in current resources

Type of dosing information	**Frequency**
Doses for premature babies	27
Renal doses	24
Hepatic doses	23
Paediatric doses in general	21
CVVH/dialysis information	16
ECMO doses	5

Filtration dosing information	5
Other	8
Total	129

The type of dosing information most respondents felt was lacking paediatric specific information was doses for premature babies. The responses to other areas that respondents reported to have a lack of paediatric dosing information included: dosing in obese children; doses for unlicensed drugs; which filters are appropriate with which drug; incidence of side effects in paediatrics; dosing in plasmapheresis/plasma exchange.

6.2.14 Does a lack of paediatric prescribing information have an effect on patient care?

There were 85 responses received to this question. Table 67 summarises the responses received.

Table 67: Does a lack of paediatric prescribing information have an effect on patient care

Answer selected	**Frequency (% of responses to this question)**
Yes	53 (62)
No	12 (14)
Don't know	20 (24)
Total	85

Although a majority of respondents considered that a lack of prescribing information in paediatrics could affect patient care, just under one quarter of respondents were not sure and about fifteen percent considered that there was no effect on patient care. Respondents were also asked to explain the reasons for their response, 69 responses were received to this part of the question.

Reasons why a lack of prescribing information may affect patient care

- There can be a difficulty obtaining paediatric information quickly, which can lead to a delay in treatment.
    - Sometimes several reliable resources have to be checked, having one good resource would hasten this.
- Decisions are not always informed by evidence.
- Educated/extrapolated 'guesses' on doses have to be made from minimal data.
    - It relies heavily on clinical interpretation/experience.

- No data/information even when the drug has an indication for use in children makes selecting a dose very difficult.

Reasons why current paediatric prescribing information does not affect patient care

- The establishment of Medicines for Children and the BNFc has improved things substantially.
- We have many different resources available.
- You can contact colleagues in tertiary centres for information.
- Responses (of the patient) need to be monitored and then dose/choice of medication can be adjusted as needed.

Reasons why respondents are not sure if currently available paediatric prescribing affects patient care

- Each time we have a lack of information, we have a n=1 study, so it is difficult to day if outcomes are changed.
- We are quite good at finding information.
- We use clinical judgement to make the decision.
- It can be difficult getting a specific answer to a specific question, which is frustrating.
- There is a lack of evidence base but I query whether this makes care substandard.
- There is limited safe drug choice in some conditions, but this makes paediatric prescribers more familiar with the medications they use and cautious in their prescribing habits.
- It is impossible to know if too much or too little of a drug is used when information is based on extrapolation of adult data.

6.2.16 Is there a difference in difficulty between prescribing for children and prescribing for adults?

Respondents were asked: “in your opinion is there a difference in difficulty between prescribing for children and prescribing for adults? Please explain your answer.” This open ended question was answered by 79 respondents. The responses have been summarised and grouped into three distinct categories: children are more difficult to prescribe for (n=53); there is no difference in difficulty between prescribing for adults and prescribing for children (n=1) and an unsure/don’t know category (n=25).

Comments that support the option children are more difficult to prescribe for than adults

Comments from respondents have been summarised into four distinct categories representing the most prominent themes found in their answers. These were:

- Factors relating to calculations of drug doses:
    - Doses need to be calculated on an individual basis for children.
    - Calculations have to be done considering different factors for different drugs; e.g. age, weight and body surface area.
    - Dose rounding needs to be considered more often for paediatric patients to enable the chosen dose to be measurable.
- Factors relating to the changes that happen as children grow:
    - Children have a constantly changing profile in terms of drug adsorption, distribution, metabolism and elimination.
    - The dose for a child can vary for different age groups on a dose/kg basis.
    - There are more risks in prescribing for children because there are more variables that affect the dosing.
- Factors that relate to the information available on prescribing in paediatrics:
    - There may not be a dose in the BNFc, therefore the difficulty lies in deciding what dose to use.
    - There is less data/information available to support paediatric prescribing. For example, there may be a dose for 12-18 years olds but not a dose for under 12 year olds.
- Additional knowledge required for prescribing in paediatrics:
    - The lack of paediatric friendly formulations makes prescribing more difficult in paediatrics. For example, the alcohol content of some formulations is very high.
    - Greater knowledge of pharmacology and pharmacokinetics is required when prescribing in paediatrics.
    - There is greater use of off-label/unlicensed prescribing, where there is less evidence to support decisions.
- Other comments outside of these four areas included:
    - There is an increased likelihood that errors won't be picked up because there are a variety of correct doses rather than a single correct dose often seen with adults.
    - In paediatrics pharmacists may have to make value based decisions and as they are educated as scientists it is not something they are used to doing.

Comments that do not support either option of adult or paediatric patients being more difficult to prescribe for:

The comments were grouped into four categories to reflect the most prominent themes in the respondents' answers. These were:

- Factors relating to data available for paediatric prescribing:

    - There is definitely less definitive or clear cut prescribing information/data.
- Factors relating to personal perceptions of paediatrics:
    - Not really, I think it is a confidence issue if you are not used to prescribing for children.
    - Possibly, but a lot of this is perception rather than reality.
- Factors relating to prescribing difficulties in adult and paediatric populations
    - Perhaps, but then again maybe adult medicine makes too many assumptions.
    - It is more difficult to make a risk/benefit decision to prescribe a medication at either extreme of life.
    - Each has their own problems. There is less polypharmacy in paediatrics and the smaller range of drugs helps to ensure familiarity with them.
    - Adults have more complex medicines, but less complex dosing. Children generally have fewer medicines but more complex dosing.
    - These issues aren't unique to paediatrics but are more common.

In addition to the two main opinions described above, a single comment was received where the respondent identified that prescribing for children was not more difficult than prescribing for adults. This respondent stated "Complex yes, difficult no. It is a question of practice and very frequent exposure."

6.3 Discussion

This study identifies the current practice of pharmacist members of the NPPG who provide pharmacy services to paediatric patients. The majority of respondents provided pharmacy services to paediatric patients several times a day and had considerable experience of providing pharmacy services in paediatrics (see Table 14 and Section 6.2.4 Number of years of experience of providing paediatric pharmacy services). Respondents in this study reported a wide range of clinical specialties as their specialist area when providing pharmacy services to paediatrics (see Table 15). The majority of respondents reported using an information source to support their provision of pharmacy services in paediatric several times a day (see Table 16).

The BNFc was the resource that respondents reported to use most frequently (see Table 17) and reported to be the most useful in their practice (see Table 31). Two of the most reported reasons for using the BNFc were that it was up to date and authoritative. The evidence underlying each of these reasons could be questioned. One could query the authority of BNFc as it did not pass the initial assessment to be a NICE approved resource. [111] The reliability of the BNF's information has previously been reported as a priority for clinicians, although this is also questioned in the

report by NICE. [75] One reason it did not pass the NICE accreditation was it did not sufficiently demonstrate a transparent and robust method for assessing the evidence base. [111] However, this could also demonstrate that respondents in this study do not consider NICE to be the authority on medicines information. This is supported by the data in this study that respondents use local guidelines more frequently than NICE guidelines. The second common reason the BNFc was reported to be useful is that it is up to date. The most frequently used format of the BNFc, the paper version, is updated annually, although electronic updates are provided monthly via email if the user has requested them. [114] This information highlights that a resource respondents consider to be up to date and authoritative may be neither.

Pharmacists are regulated by the General Pharmaceutical Council (GPhC). As a result of this the GPhC could be considered a source of authority for pharmacists. The GPhC states that the BNF is a resource that it "expects trainees to use regularly when they are in training and once they are registered". [115] This may partially explain why the respondents in this study consider the BNF to be authoritative. However, the GPhC recognises that the BNF is not the only source of information pharmacists are required to interpret in order to practice safely. This is recognised by inclusion of education about critical appraisal in the 'Standards for the Initial Education and Training of Pharamcists' and the recent inclusion of other sources of information, such as summary of product characteristics for drugs and medication charts, within the new registration assessment. [115] Recognition by the pharmacy regulator that more than the BNF is required in practice indicates that pharmacists are expected to be able to interpret and use information from multiple sources in practice. The Royal Pharmaceutical Society (the professional membership body for pharmacists in Great Britain) also provides guidance for pharmacists on how to use the BNF; providing further assurance on its 'authority' to pharmacists. [116]

This study has raised concerns about the information available to support the provision of pharmacy services in paediatrics. Respondents reported that there were many types of medicine information that are lacking paediatric specific data (see Tables 34 and 35). The lack of paediatric information has been recognised for several years. There is legislation from the European Medicines Agency in place to drive further paediatric data collection from pharmaceutical companies. [112] However, this study suggests that this information is not yet at levels suitable to provide sufficient support in paediatric pharmacy service provision. Respondents have reported that they agree that the current level of paediatric prescribing information may have an effect on patient care (see Section 4.2.14). They described scenarios where inadequate paediatric information may lead to inappropriate dosing and searching for paediatric information may lead to a delay in the receipt of care.

The accessibility of current paediatric prescribing information is also highlighted by this study. Respondents reported using Google to support their provision of paediatric pharmacy services as well as numerous other sources of information. The variety of resources reported may highlight that the information required for paediatric pharmacy services is not available in a single accessible resource. Over fifty different sources of paediatric information were reported to be used by respondents. Despite this, two thirds of respondents reported the same resource to be the most useful to them; the BNFc. The aim of the BNFc was to "provide all available information from all available sources on medicines used in children". [117] This study suggests it is not meeting this aim demonstrated by the large number of additional resources reported to be used when providing pharmacy services to paediatric patients.

Respondents in this study recognised that prescribing for children is more difficult than prescribing for adults. This is a recognised difficulty and has been highlighted again in recent literature. [16, 17] The difficulties of paediatric prescribing have been well described and are reinforced by the respondents in this study who state that there are many more factors to consider when prescribing for a child and this is the principal issue that makes prescribing for children more difficult than prescribing for an adult. The NICE Guideline on medicines optimisation recommends that clinical decision support should be considered to support prescribing. [88] It could be inferred that this is in response to the vast quantities of data across a range of sources that is now available and needs to be assessed when making a prescribing decision. The data from this study would support use of a clinical decision support system as respondents recognised that manual and individual evaluation of available information can lead to delays in patient care and errors in dosing recommendations.

The study had a response rate of 34.3%. There was a single respondent who did not provide consent to complete the survey and as such was not asked any further questions. Some information was received about non-respondents as they made contact with the researcher to explain why they could not complete the survey. The reasons included: working in industry rather than hospital pharmacy and working outside the UK. The NPPG is not solely open to hospital pharmacists so it is reasonable that a proportion of the potential respondents chose not to respond to the questionnaire as it was not applicable to them. The chances of non-pharmacist respondents completing the questionnaire have been minimised as it has been sent out via a professional group (The Neonatal and Paediatric Pharmacist Group).

The pilot of this study with pharmacists has helped ensure the validity of the questionnaire as a research instrument. The pilot and the prior focus groups confirmed that an appropriate choice of language had been used. This was demonstrated by the answers to open ended questions in the

pilot, which answered the question as the researcher had intended it to be answered. This confirmed that the researcher that an appropriate understanding of the subject area and language had been gained from the initial focus groups. There were no additional options suggested to closed questions; this suggested all reasonable options within the question had been presented.

6.3.1 Limitations of the study

The main limitation of this study was that there is poor access to the pharmacist population. There is not an easy method of contacting and inviting specialist groups of pharmacists to participate in research. The pharmacy regulator does not record the areas of practice of its registrants and does not usually provide contact details to enable a researcher to invite its registrants to participate in a research study. Therefore the researcher used a specialist paediatric pharmacist group (The NPPG) to disseminate the study to potential respondents. This group has a voluntary membership scheme and therefore not all pharmacists in paediatrics were available to invite to participate in this study. However, it was decided that delivering this study via the professional group the NPPG was significantly more efficient that individually contacting each hospital to determine who their paediatric pharmacists were.

This study may not represent the views accurately of the entire population of pharmacists who provide paediatric pharmacy services. There may be many more pharmacists who provide these services, but who were not a member of the NPPG and as such were not included in this study. The experience and frequency of provision of paediatric pharmacy services by NPPG members may not reflect the general paediatric pharmacist population in this country. For example, the most frequently reported grade of respondent was “band 8”; this is a senior pharmacist position in the NHS. There are likely to be more junior pharmacists who work in paediatrics on a permanent or rotational basis that have chosen not to join the NPPG. Therefore the high level of experience of the respondents in this study may have led to underestimation of the frequency of use of resources when providing paediatric pharmacy services.

The responses in this study may not reflect the reality of providing paediatric pharmacy services because respondents may not have accurately reported their current experiences. The membership of the NPPG may not reflect the average pharmacist who provides paediatric pharmacy service. It is possible that members of the NPPG may be more interested in the provision of clinical pharmacy services than those who are not members. Extension of this study to non-NPPG pharmacists who provide pharmacy services to paediatric patients would be valuable.

There was an error in one question of this study where 'BCH results systems' rather than 'hospital results systems' was displayed. The responses to this question seem to indicate the question remained understood as respondents reported using patient results. The understanding of this question would have been improved by the examples provided after it in brackets; these included blood results, imaging.

Respondents reported that they did not know their membership number for the NPPG so respondents could not be verified to be paediatric pharmacy service providers. There were also a number of respondents who left the questionnaire at this point, possibly because they thought that the membership number was a required field to continue. This loss of potential respondents could have been avoided with more thorough piloting in the pharmacist population.

It was anticipated that non-paediatric pharmacists would not have had access to the questionnaire as it was distributed by the NPPG directly to each respondent and the link to the questionnaire was not made available elsewhere. It was not possible to confirm if any participant chose to complete the questionnaire on more than one occasion. However, given that prior research has suggested that healthcare workers have little time to complete research questionnaires and will prioritise patient focussed tasks it seems unlikely that this will have occurred. [102]

6.4 Conclusion

- The majority of respondents provided paediatric pharmacy services daily and used an information resource to support the provision of paediatric pharmacy services several times a day.
- The most frequently used information resource within this study was the BNFc. It was the most useful resource due to its ease of use, its comprehensive coverage of paediatrics and its current information.
- Respondents reported that there was a lack of paediatric data across a range of information types, for example paediatric doses and availability of suitable formulations.
- Respondents believed that the lack of paediatric medicines information could have an effect on patient care. This would be most likely seen as delays in treatment whilst information was sort and the inability to determine doses accurately in paediatric patients.

6.5 Recommendations for practice

- This study identified the information needs of pharmacists when providing paediatric pharmacy services. It indicates the requirement for a single comprehensive paediatric resource. For example, an enhanced BNFc, as this resource was reported to be used most frequently.
- Delays in treatment can occur whilst paediatric medication information is found and evaluated, therefore the development of a single point of access for complex paediatric data is recommended.
- Respondents reported using a range of online resources, indicating that a reliable method of access to these sources is required to provide paediatric pharmacy services effectively.

7. Paediatric prescribing support in board meeting minutes of English paediatric NHS trusts

The aim of this study was to investigate the reported discussions of paediatric prescribing support at board level for hospitals with paediatric services. In order to confirm solely paediatric support was being referred to the four specialist paediatric trusts in England were selected as the study sites for this study. These were: Alder Hey Children's NHS Foundation Trust; Birmingham Children's Hospital NHS Foundation Trust; Great Ormond Street Hospital for Children NHS Foundation Trust and Sheffield Children's NHS Foundation Trust. The objectives of this study were:

- To investigate what tools/systems are reported to be used to improve paediatric prescribing practice at the study sites,
- To examine the effect these tools/systems are reported to have on paediatric prescribing practice and/or paediatric medication errors at the study sites?

The board meeting is the strategic level of decision making in each NHS Trust. Therefore it was decided that the incidence of references to paediatric prescribing support should be measured in the documents from these meetings to determine if this was an issue being considered seriously by the decision makers in each Trust. Board meeting minutes and their associated papers are public documents in England. This means that they should be freely available to members of the public. These documents are usually available on the Trust's website, but on occasions this may not be the case. When this happened a freedom of information request was sent to the hospital to request the documents. One freedom of information request was sent to each hospital to request any papers that were not available on the hospitals' websites. On every occasion there was a positive response to such requests.

The papers and minutes for each board meeting from January 2010 to December 2012 were qualitatively analysed using applied thematic analysis; the focus of the themes was supporting prescribing in paediatrics. A total of 85 sets of minutes were analysed (33 from Sheffield, 32 from Alder Hey, 24 from Great Ormond Street (GOSH) and 16 from Birmingham Children's Hospital (BCH)) The full details on the method can be found in chapter 2, page 48.

7.1 Results and discussion

The results and discussion are presented together for this qualitative study in the themes that were developed in the qualitative analysis process.

7.1.1 Support for prescribers

Training for all prescribers has been identified in each of the hospitals' minutes as a way of providing support for prescribing. It was the most frequently referred to intervention (n=25) and it was reported in nineteen meetings. Much of this came in the form of mandatory training which would have covered antibiotic prescribing and paediatric early warning scores. New staff often received one off training sessions on medicines management, paediatric prescribing and risk management.

> *"Training activities: antimicrobial prescribing is provided for medical induction and annual update." GOSH*

According to a prior study training on paediatric prescribing and information about common prescribing errors was often provided by a pharmacy-led presentation at induction. [60] However, there was no evidence to support this in the data collected from this study. There is no further information provided on the effect this mandatory training had on prescribing practice at any of the study sites:

> *"No evidence could be identified to support a causal link between … training and medication errors." Sheffield*

However previous research has identified prescriber education as a key factor in reducing prescribing errors, which was consistent with the provision of training described in the minutes of the hospitals in this study. [118, 119]

Prescribing support specific to a certain area of practice (e.g. use of antimicrobials) was reported in the papers from all hospitals in the study. There were a total of thirteen references to this type of prescribing support across seven meetings. This usually involved a specialist pharmacist and/or specific prescribing guidelines. The most common area of specific prescribing support reported in the minutes was for the use of antimicrobials.

> *"We implemented antimicrobial pharmacist ward rounds targeting specific antibiotics." BCH*

Three hospitals reported having antimicrobial pharmacists in place to help support good prescribing practice in this area. Policies designed to improve prescribing in the area of

antimicrobials included: targeted ward rounds for high use antibiotics and care bundles that directed the prescriber to rational and safe antimicrobial prescribing. BCH papers referred to further tools designed to improve antimicrobial prescribing. These included the use of reminder stickers to promote prescribing in accordance with guidelines; an easy to access intranet page on antibiotic prescribing; an eLearning module on antibiotic prescribing that forms part of the mandatory training and a campaign on prudent antibiotic prescribing as part of European Antibiotic Awareness Day. Further examples of specific prescribing support include: one to one training with a ward pharmacist in haematology/oncology and clinical practice guidelines for high risk drugs (e.g. insulin).

> *"The ward based pharmacists have continued their package to reduce prescribing errors (including initial close supervision of prescribing and regular feedback of errors." GOSH*

Credit card sized support tools were in use at two hospitals: Sheffield and GOSH. At Sheffield after an audit regarding accuracy of prescribing in dentistry, one of the actions implemented was the introduction of a credit card-sized weight adjustment card for calculating medication doses.

> *"credit card size handy weight adjustment card for calculation of prescription dose". Sheffield.*

These were designed to be practical and easy to keep on your person when prescribing. They may be attached to clinical staff ID badges, which presumably were in frequent use and as such were seen often, thereby providing regular reminders to improve prescribing. No subsequent report on the success of this tool was made within the minutes or papers at Sheffield. The credit card tool at GOSH was used as a memory prompt for the child early warning score intervention and the 'SBARD' communication tool.

> *"They are also given laminated credit card sized memory prompts to attach to their ID badge." GOSH*

SBARD stands for 'situation, background, assessment, recommendation, decision'. This communication tool is also referred to as 'SBAR' and it is recommended on the NHS Institute for Innovation and Improvement website as a tool to improve the communication of critical information, particularly information requiring the attention of a doctor. [120] There was no further information reported within the minutes and documents on the effectiveness of either of these tools.

Feedback to clinicians about their prescribing habits was reported in the GOSH minutes and associated papers. It was referred to in seven meetings. However, this process may be easier in

hospitals that already have electronic prescribing in place due to system features such as prescribing reports. Collating individual prescribing feedback in hospital with paper based prescriptions would involve significantly more staff time. Feedback to clinicians at GOSH could be provided with

> *"Analysis of JAC (electronic prescribing system name) data." GOSH*

Pharmacists at GOSH were also providing daily feedback to the whole prescribing team on other errors or trends and could include

> *"one to one feedback on any significant errors." GOSH*

According to the EQUIP study on prescribing errors, pharmacists make many interventions including identifying prescribing errors that contribute to improvements in prescribing. [62] Minutes from GOSH and Sheffield both referred to pharmacy support in relation to prescribing. This covered areas such as prescription checks and providing a safety net for prescribers.

At GOSH the prescribers were encouraged to put actions in place before prescribing mistakes were made and this was supported by dashboards that communicated information related to drugs commonly featured in prescribing errors such as paracetamol and morphine. Similar actions were not reported within the other minutes and papers from the other hospitals.

The minutes of one Trust (GOSH) referred to medicine or infusion calculators on five occasions. Medicine calculators are used to assist prescribers in calculating the correct medication dose for a patient. GOSH has developed an infusion calculator designed to reduce prescribing errors on one of the cardio-respiratory wards – CICU.

> *"CICU have continued their package of innovations aimed at reducing prescribing errors. In addition, an electronic infusion calculator too is used, and further improvements to the tool are being tested." GOSH.*

There were no references to this infusion calculator tool that indicated the effect it had (if any) on prescribing errors. Medicine calculators have been demonstrated to show improvement in prescribing. For example, in one study, students using a PICU calculator were able to write more accurate emergency drug infusions than consultants using the BNFc. [121] A further study demonstrated that an online calculator for parenteral nutrition reduced calculation errors and other dosing errors such as issues with inappropriate osmolality. [45] It would be useful to other paediatric centres if GOSH had data that it could publish on the effect of the infusion calculator on infusion prescribing errors.

7.1.2 Electronic patient records and medical records

Medical records are not often thought of as a prescribing support tool, but the quality of medical records could certainly have an impact on the quality of prescribing. Information recorded in medical records can be used to inform prescribing decisions. The importance of medical records is demonstrated by the frequent referral to this subject in the minutes of each of the hospitals' board meetings (n=18). There were references to poor record keeping in the minutes and papers studied (n=5 at GOSH and n=3 at Sheffield). GOSH minutes reported that there was a

> *"Failure to follow basic standards of record keeping and failure to document key events in the patient journey". GOSH*

There were also reports of problems with inconsistent filing which led to it being difficult to find key parts of the patient record such as discharge summaries. The minutes from GOSH reported the poor quality of medical records in further detail.

> *"It was reported that 33% of records contained an illegible medical entry; and 35% of records contained loose filing." GOSH*

Illegible or missing information has the potential to affect a prescribing decision.

All hospitals acknowledged that moving to an electronic patient record would be required in the future and they were at various stages in their progression towards this. Electronic patient records have the potential to improve access to patient information as they could remove the need to wait for paper records to be found and delivered to the department/ward. The minutes from BCH referred to the trial of a system called "me@BCH" which would be used for frequent attenders of the emergency department.

> *"This will be an electronically stored document that can be accessed in the emergency department and will hold all current treatment management plans, plus medication so children and young people can be cared for appropriately without parents/carers having to repeat their history on each occasion." BCH*

The BCH minutes reported that this could ensure that patients would receive appropriate medical care whilst the full record was brought to the department and it would reduce the need for parents/carers to repeat their child's medical history so frequently.

The hospitals in this study were considerably behind the standard set by the electronic National Patient Summary used in Sweden. [122] This electronic system contains current care contacts, personal details, chronic diseases, medical alert information and current medical examination results in a format accessible to all care providers. In the UK a similar system, the summary care

record is being introduced. This could provide comparable information to the system used in Sweden. The summary care record system is designed to be accessible to healthcare services to enable them to quickly identify patient's current health issues, medication, allergies and other key information. [123]

7.1.3 Healthcare professional involvement in projects

The importance of clinician and other healthcare professional involvement in patient related projects was referred to in the minutes of all hospitals in this study (n=6). Clinician involvement was deemed important from the start of the procurement process to the completion of implementation of the new systems.

> *"It is imperative that more linkage with clinicians and nurses is included". Alder Hey*

It was also reported by one hospital that regular communication was required to engage staff and to ensure that expectations were managed during the development of new systems and tools. The practice of engaging staff in the development process is consistent with recommendations of the current literature that advises clinicians and nurses involvement is recommended in the development of decision support. [107, 109] Involving healthcare professionals in the development of interventions was also recommended as a conclusion of the study on electronic medicines management (chapter 3) where further involvement of pharmacy staff in the development of the electronic medicines management system was described as one method of improving the development, application and implementation of the system.

7.1.4 Electronic prescribing

Electronic prescribing is not standard practice in UK hospitals. Instead prescribing is usually carried out on charts specifically designed for recording prescriptions and medication administration. Only one paediatric hospital (GOSH) in this study used electronic prescribing according to the board meeting minutes and associated papers. However, two further hospitals (BCH and Alder Hey) have had the initial business cases approved by the hospital as the first step in working towards electronic prescribing. The reports from BCH and GOSH suggest that electronic prescribing was one way that the hospitals have identified to improve prescribing practice.

> *"Most organisations see (electronic prescribing) as the way they will drive more prudent prescribing". GOSH*

> *"In relation to medication incidents… we are looking at ePrescribing". BCH*

Driving the implementation of electronic prescribing was identified as a priority in 2013 by the UK Department of Health and PricewaterhouseCoopers (national auditors), [124] so it is promising to report the majority of the hospitals in this study are already working towards this objective. A previous study regarding the use of electronic prescribing at GOSH has demonstrated that it can lead to a reduction in prescribing errors even when inbuilt clinical decision support is not provided. [25, 33] A further benefit of the system was reported in the minutes from GOSH; the electronic prescribing system holds

"A wealth of data." GOSH

The data from the electronic prescribing system could be used to provide more detailed information on prescribing errors and be used in prescribing improvement strategies. An anecdotally reported issue with the electronic prescribing system at GOSH was that the electronic prescribing system had made in harder to promote good prescribing practice in some areas. One example given was in relation to antimicrobial stewardship. In this example, the minutes reported that the system was unable to record some important information for antimicrobial prescriptions. This is an example of an innovative technology not being able to mimic good practice that can easily be managed on a traditional paper drug chart.

"The system does not enable clinicians to easily record reason for prescribing." GOSH

7.1.5 Junior doctors

The papers from all four hospitals referred to the workload or need for prescribing support for junior doctors (n=10). The minutes from BCH reported that all new doctors were given training in "medication for children" and assessed on their ability to prescribe for paediatric patients. There was no information included on the effect this has had on prescribing errors, but the fact that it is in place suggests both tools are needed to ensure a certain standard of prescribing practice in maintained across the hospital. A previous study across several different study sites has identified that lack of prescribing education can cause problems with junior doctor prescribing so there is evidence for having these tools in place at BCH. [62]

The minutes from GOSH reported that a different approach had been taken by some wards to ensure the safety of junior doctor prescribing. On oncology/haematology wards pharmacists provided

"One to one supervision of prescribing by all new doctors during their first week". GOSH

These initiatives are in line with current literature that has reported a lack of confidence in prescription writing and poor drug chart completion upon qualification as a doctor in the UK.

[125] Workload pressures on junior doctors were recognised in the papers from Alder Hey, BCH and Sheffield. At BCH sharing of workload with other healthcare professionals (e.g. advanced nurse practitioners) had helped reduce the reliance on junior doctors in the paediatric intensive care unit. The emphasis in the minutes of each hospital was on education of junior/new doctors and assessment of their prescribing ability. This seems appropriate as a previous study reported that junior doctors complete a large proportion of prescribing in hospitals. [62]

The minutes identified the use of prescribing tests to test the paediatric prescribing competency of new doctors at both BCH and GOSH (n=4). The prescribing test aimed to identify prescribers who need further support/education regarding paediatric prescribing and as such reduce the likelihood that they will commit a prescribing error. The Royal College of Paediatrics and Child Health has also developed a Paediatric Prescribing Tool designed to inform senior doctors of staff who may need extra paediatric prescribing support. [126] The introduction of a paediatric prescribing test at a further hospital, St Mary's Hospital, London, also allowed staff to identify prescribers in need of extra support at an induction session and provide support to them at the start of their employment. [127] This body of evidence suggests that junior paediatric prescribers should be tested on their paediatric prescribing competence to enable less competent prescribers to be identified for further training. Further training should then reduce the likelihood of a prescribing error being committed.

7.1.6 Dedicated prescribing area

The minutes from one hospital (GOSH) referred on several occasions to dedicated prescribing areas (n=9). These were areas reserved for prescribing that were in a quieter location where interruptions and distractions would be minimised. Minutes from GOSH had stated that interruptions could be a contributory factor to prescribing errors, hence the introduction of dedicated prescribing areas. There was no report on the success of this intervention in improving paediatric prescribing in the minutes. However, there is a report in the literature that the introduction of a dedicated prescribing area as part of a zero tolerance prescribing policy had reduced prescribing errors on the PICU at GOSH. [66]

Using a dedicated prescribing area to improve prescribing has evidence to support its use. However, this tool has not been introduced by the other paediatric hospitals in this study. This suggests that there is a lack of collaboration or learning across the different study sites. It is concerning that a hospital would choose to pursue an intervention without such evidence, for example credit card sized support tools, when there are interventions with an evidence base that they could implement instead.

7.1.7 Paediatric trigger tool

The paediatric trigger tool is one method of measuring harm caused by providers of paediatric healthcare. It can be used to identify areas where harm is occurring, for example due to prescribing errors. [128] The paediatric trigger tool is a monthly case note review intervention designed to identify adverse events and areas of care where harm is occurring. [128] The use of this tool was only reported in the minutes from GOSH (n=7). The minutes from GOSH did not report any actions arising from the use of the paediatric trigger tool that related to prescribing support. The Institute of Innovation and Improvement recommended that this tool was employed on a monthly basis to review a random set of case notes. The information should then be used to inform areas of priority for actions to take place. [128] If information from this tool found harm caused by prescribing errors, it could be used to inform future prescribing support to avoid a similar incident happening again.

7.2 Limitations

There are many other hospitals that provide paediatric services which may also be using tools to improve paediatric prescribing and reduce prescribing errors. The tools used in these hospitals could be different from the ones described above. However, in order to be certain the data in the board meeting minutes related to paediatric practice only the standalone paediatric hospital trusts were included in this study. Initial evaluations of larger hospitals with paediatric wards led to the conclusion that it was not possible to confirm if prescribing improvement initiatives were be used in the paediatric areas of the hospital or not.

Using original documents as the data set also provides some limitations. These include that the data that was available to the researcher was limited. Some sections of the board meeting are carried out in private and no public record is provided of this. Therefore there may have been further discussions relating to paediatric prescribing that were not available. It also cannot be confirmed if the data set is entirely complete due to the lack of control over the data collection. However, as the minutes are a public record of the board it is unlikely that they will be inaccurate. [94]

The validity of this study has been improved through the use of documentary sources. Use of data directly from the hospital studied is one method of ensuring validity. This is real world data that has been recorded for a purpose other than research, which maximises the external validity of this data set. Finally, the analysis has been carried out using as transparent procedure as described in the method chapter.

The second objective was not fully met as the data set did not provide full information describing the effectiveness of the interventions employed by each study site. In order to meet this objective further research and investigation into the success of each intervention at improving paediatric prescribing is required.

7.3 Conclusion

- Initiatives reported to support improvement of paediatric prescribing included: electronic prescribing (4 hospitals); electronic patient records (4 hospitals); feedback/specialty specific support to prescribers from pharmacists (4 hospitals); junior doctor education and tests (4 hospitals); credit card size reminder tools (2 hospital); medicine calculators (1 hospital); dedicated prescribing areas (1 hospital); the paediatric trigger tool (1 hospital).
- The lack of follow up data in the hospital minutes about the tools trialled to improve prescribing practice made it difficult to assess their effectiveness. The lack of follow up and completion of the audit cycle for these tools was a concern.
- Different hospitals, and often different wards in the same hospital, trialled several different techniques to improve prescribing practice simultaneously. As a result, it was difficult to determine which intervention is responsible if a change in prescribing practice or prescribing error rate occurs.
- Paediatric hospitals should be encouraged to share their experiences of these tools so best practice can be developed and efforts are not wasted on tools proven to be unsuccessful.
- There was no clear collaborative approach to improve and/or support paediatric prescribing practice within the study sites.

7.4 Recommendations for practice

- Complete evaluation or audit cycles of methods trialled to improve paediatric prescribing practice should be reported back to the hospital board to ensure money is spent effectively on methods that have an evidence base.
- A quality assurance tool should be developed for hospitals to use for the evaluation of their own tools. This would enable a quality statement to be applied to each method trialled and enable successful methods to be prioritised.

8. Interviews with leaders in electronic prescribing

The aim of this final study was to identify experiences and advice from the leaders in electronic prescribing and decision support that will provide evidence and support to hospitals yet to implement such systems. The objectives of this study were to:

- Identify the current reported benefits of electronic prescribing and decision support
- Identify the current reported barriers that prevent hospitals introducing electronic prescribing systems
- Identify reported issues related to electronic prescribing systems
- Identify the potential reported developments or improvements that may occur to electronic prescribing systems within the next five years
- Identify the advice leaders in electronic prescribing would provide to hospitals where electronic prescribing has yet to be initiated.

The researched described in chapter 7 identified that electronic prescribing was one method paediatric hospitals are using to improve paediatric prescribing practice. Another method identified was specific prescribing support, for example antimicrobial advice. Leaders in electronic prescribing were asked to provide examples of clinical decision support designed to improve prescribing to determine if this feature was also identified by the leaders in electronic prescribing. Finally questions regarding the level of integration with some of the information sources reported to be used by pharmacists and prescribers in chapters 4 and 5 were also asked.

Leaders in electronic prescribing were defined as senior staff at hospitals or companies with significant expertise or relevance to the research area. Participants from leading electronic prescribing companies and experienced hospital were interviewed alongside the independent paediatric hospital trusts. They were invited to give their views alongside the experiences that may be specific to their organisation. This ensured expertise in electronic prescribing and clinical decision support was fully explored and a paediatric perspective was included. A full description of the method can be found on page 50.

8.1 Results and discussion

The themes were largely led by the interview questions. The main themes were: benefits of electronic prescribing and decision support; features and functions of electronic prescribing and decision support; barriers to electronic prescribing and decision support; current issues with electronic prescribing and decision support; the future of electronic prescribing and decision support; and advice for those implementing electronic prescribing and decision support. Relevant interesting or abstract comments are included to ensure the full range of views and topics are presented from the data set.

Each leader in electronic prescribing has been anonymised. The code for each leader is:

- IV1 = hospital with electronic prescribing
- IV2 = hospital with electronic prescribing
- IV3 = hospital with electronic prescribing
- IV4 = electronic prescribing system representative
- IV5 = electronic prescribing system representative
- IV6 = paediatric hospital
- IV7 = paediatric hospital

8.1.1 Benefits of electronic prescribing and decision support

Six participants in this study could name many benefits that electronic prescribing and decision support could bring to the hospital environment. There were eight benefits that were most frequently referred to (n = number of references to this code/theme).

The first benefit was that electronic prescribing ensures that prescriptions are clear, legible and complete (n=10). Completeness covered ideas such as ensuring the correct units are included, removing inappropriate abbreviations, and full patient details.

> *"It's legible; it's always filled in correctly". IV4.*

> *"Everything is legible when it's typed compared to when it's handwritten." IV6.*

The data from this study is consistent with the conclusions of previously published literature that states the quality of prescription writing in terms of legibility and completeness has been described as a benefit of electronic prescribing. [21, 23] In studies where a reduction in prescribing errors was not seen, illegible and incomplete prescriptions were eradicated when electronic prescribing was introduced. [22] A more recent review of the benefits of electronic prescribing in paediatrics confirmed that errors related to illegible prescriptions are removed. [3]

The second benefit was that electronic prescribing systems are continuously improving and developing, which allows the system to drive improvements within the hospital (n=8). One hospital based interviewee referred to the fact that the system had much more functionality than they were currently able to use and that the company who owned the system were responsive to requests for changes and functions. A company interviewee reported that the electronic prescribing system is flexible and can be adapted to suit the individual hospital and the responses of the users within that hospital.

"You can do so much with the system that you are really improving it all the time". IV4.

The third benefit was prescribing decision support is available to prescribers (n=7). The level of decision support in the electronic prescribing systems known to each interviewee was varied. One electronic prescribing system at the time of the study only provided decision support for morphine and methotrexate. In comparison another electronic prescribing system provided decision support for 25 of the most common paediatric drugs. In this system the decision support could provide suggestions based on the weight or age of the patient.

"The doctors are guided to the right choice of frequency and dose". IV4.

The fourth reported benefit of electronic prescribing was that it improves the speed of access to information (n=6). Saving prescribers' time has been identified as a feature that can influence the success of a clinical decision support system. [107] However, this benefit is not often reported in the literature; therefore this study provides limited additional evidence to support this claim. Electronic prescribing was reported to allow the prescriber to access information easily as well as the pharmacy to receive information regarding drug orders quicker. One interviewee also reported that it allows medication to be written up for a patient quicker as the prescriber does not need to come to the ward to do so.

"Overall it saves time for the doctors next time the patient's in". IV4.

The fifth benefit was that order sets and pathways can be built to inform prescribers using electronic prescribing (n=6). This can range from predefined doses being offered at the point of drug selection in the electronic prescribing system to doses based on age/weight of the patient. The use of order sets or clinical pathways can be used to guide prescribers to the right drug choice and dosing regimen.

"When you pick a product we offer you the doses of the product that hopefully you normally use to prescribe". IV3.

The sixth reported benefit of electronic prescribing was that it improves safety (n=5), consistent with the conclusions of earlier publications that confirmed electronic prescribing can reduce medication errors. [129] The improvement in safety can be from providing prescribers with information to inform their prescribing choices and providing nurses with clear administration information. One interviewee reported that their electronic prescribing system does a lot of cross checking to ensure the prescriber is making the correct choices.

> *"Pharmacy staff spend a lot of time and resource ensuring that the information entered into the system maximises patient safety". IV1.*

The seventh reported benefit was that electronic prescribing can be used to improve prescribing quality and/or practice (n=5). This is consistent with conclusions of published literature. [130] Changes could be introduced by modifying order sets or instructions to the prescriber or editing the available formulary.

> *"We can implement change rapidly by changing over the order sets and instantly that practice is changed". IV1.*

The final reported benefit was that having an electronic prescribing system means there is easy access to data to use for audits and to provide data to demonstrate the meeting of certain targets (n=5). The participants had built reports were for antibiotics audits, billing of commissioning bodies, stock management using the data available.

> *"You can pull lots of reports out of the system so it's helped with CQUINS and QIPP projects". IV2.*
>
> *(CQUIN – commissioning for quality and improvement payment framework, QIPP – quality, innovation, productivity and prevention).*

Novel benefits identified in this study were: easy access to audit data and the ability to continuously improve and develop your electronic prescribing and decision support system.

8.1.2 Barriers to electronic prescribing and decision support

Participants in this study from both hospitals and companies described a range of barriers that prevent hospitals implementing electronic prescribing and decision support. Four main barriers were described. These were: available resources (including finance), management, government policies, and system choice.

The most frequently reported barrier to implementing electronic prescribing was available resources (n=12). One interviewee reported that their clinical systems team were not able to

support the introduction of electronic prescribing until recently. Another interviewee reported that you needed to be able to mobilise various professions to enable electronic prescribing to be implemented.

> *"It's not only the electronic prescribing programme that you have to have; you have to make sure you've got all the equipment". IV2.*

> *"We don't have the resources. We don't have the man-power. We don't have the expertise to support it". IV7.*

Financial resources were referred to six times. Electronic prescribing systems were reported to be expensive. The two paediatric hospitals without electronic prescribing reported that money was a barrier to implementation.

> *"I think we'd do it if we had the money." IV7.*

> *"They're enterprise wide, across the whole hospital and have a price tag to match". IV4.*

The hospitals with electronic prescribing systems also identified that financial reasons would be a barrier for hospitals yet to implement these systems. Lack of resources in terms of finance (for implementation, training and maintenance) and technology (for example, existing IT hardware and systems are not sufficient to support electronic prescribing) was identified some time ago as a barrier. [23] These issues were reported at the time of this study also.

The next barrier reported to prevent implementation of electronic prescribing was system choice (n=8). One interviewee from a hospital where electronic prescribing was already in use reported that selecting the right system is important and the use of different vendors supplying different systems could lead to problems with interfacing. Another interviewee from a hospital already using electronic prescribing noted that were was no paediatric system available at the time and this was supported by an interviewee from a paediatric hospital also.

> *"I think we were lucky we selected a good system at the time." IV3.*

> *"If you look at the electronic prescribing systems that are currently available; they're not very good frankly". IV7.*

The lack of a "dedicated paediatric system" was identified as a system selection related barrier. A different participant stated they were "lucky" to have selected a good system at the start. These comments identify that it was difficult to select a system for electronic prescribing, particularly perhaps in paediatrics where there was not a specialist system available. Sufficient development of systems has been identified as a reason for the small scale of electronic prescribing

implementation in secondary care. [80] More recent conclusions from the literature confirms that the immaturity of the electronic prescribing system supplier market and availability of information on the options available is still a reason that choosing an electronic prescribing system may be difficult. [131]

Another reported barrier to implementation of electronic prescribing was management within the hospital (n=5). One interviewee from a hospital using electronic prescribing reported that leadership was important. This interviewee noted that other hospitals failed to implement the same electronic prescribing system as them and one reason for their failure was leadership.

> *"We are struggling to implement our new system due to lack of commitment from some of the senior Trust management team." IV1.*

> *"From a supplier perspective experience shows that biggest obstacle to a successful implementation is clinical and executive level engagement". IV4.*

The importance of management/organisational backing has previously been identified as important in implementing electronic healthcare systems. [80, 132] Management support in each hospital was identified by three participants in this study as a barrier to electronic prescribing. The importance of this barrier was highlighted by one participant when several hospitals had successfully implemented a particular electronic prescribing system, whereby another hospital could not.

> *"We've got the same system as a couple of other hospitals did and another one of them made it work in terms of electronic prescribing and one of them didn't. That probably came down to again leadership in the hospital." IV3.*

The final barrier reported by interviewees was government policies (n=4). Two interviewees reported that this was an issue. The strategies of the government and national health policies were thought to be counterproductive. One example given was the current requirement for hospital to implement electronic prescribing for chemotherapy. This interviewee thought this policy encouraged hospitals to acquire a system to fill in a tick box, but was unlikely to be compatible with the hospital's existing clinical systems.

> *"I do however blame government and central NHS management, they throw far too many changes and initiatives that are usually short lived, distracting and counterproductive in the long term." IV1.*

> *"I think sometimes the national picture was confusing and that might have delayed trusts".* IV3

Recent literature provides evidence that barriers to electronic prescribing are being slowly dismantled. Advice on functional specifications provided by Connecting for Health and the development of a tool kit to support implementation of electronic prescribing are two examples of assistance available to hospitals yet to implement electronic prescribing. [131] However, these interviews identify that there are still barriers in place that prevent implementation of electronic prescribing. This is consistent with existing evidence that large numbers of hospitals are interested in implementing electronic prescribing, but only a small number have begun implementation. [133]

8.1.3 Current issues with electronic prescribing and decision support

Participants identified a wide range of issues that maybe encountered during implementation and/or maintenance of electronic prescribing and decision support systems. The main issues identified by participants were: project team staffing; system/technology related; training; slow roll out of the system; and deskilling the prescriber.

The first issue identified was having sufficient project team staffing available (n=13). More than one participant commented that working on electronic prescribing was done in addition to their "*day job*" (IV1) and this made it difficult to commit sufficient time to the project.

> *"The roll out team was very small. I think this made it hard for them to commit a lot of time to the project as they were doing this in addition to their day jobs rather than being seconded to it." IV6.*

This also related to the labour intensive nature of rolling out and maintaining electronic prescribing systems and their decision support features. One interviewee reported that there was always more content to create and that maintenance of this content can be an issue. Another interviewee commented that there was just their team to input the data required for decision support, so there was a lot to do. Finally, an interviewee noted that maintaining up to date access for users of the system was another feature that added to the labour involved in using electronic prescribing systems.

> *"The system is actually very labour intensive to maintain so while we've got the freedom to customise it, it's actually very time consuming to do and needs some very specific skill sets to do it as well. So sometimes just adding drugs to the catalogue or putting in pathways can just take, you know, quite a lot of time to change." IV1.*

It is recognised that setting up a good way to support the implementation of an electronic prescribing system can be complex. [80]

The second issue identified were those related to the technology required by electronic prescribing systems and the electronic prescribing systems themselves (n=12). These issues were likely to be local to the system familiar to each interviewee. One issue that was not system specific was the availability of mobile technology to be used on the wards. System specific issues that may be of relevance to other organisations were: ensuring log on/off times are efficient and do not waste clinicians' time; considering how the system will work in highly specialist areas (for example: is the system capable of complex dose frequency regimes or is the system suitable for areas such as anaesthetics where an exact dose may not be known?); the record of doses administered needs to be clearly viewable to nursing and other staff.

> *"We've got a lot of software issues which we've got to address." IV1.*

> *"One problem with the system is the way it does frequencies." IV2.*

> *"The system is actually very labour intensive to maintain." IV3.*

Training was identified as the third issue: both the need to train a large number of staff during roll out and then maintain staff training after the system is live (n=6). Managing training for non-regular staff was highlighted as a particular area of focus. Training was reported to be time consuming and you needed to have permanent trainers to keep the training going after the system was live. One participant identified the large amount of information junior doctors were required to take in at induction and commented that it was difficult for them to take in all the information.

> *"When we do it on the doctors' induction they're learning so many other things that day that they don't remember". IV2.*

> *"You need strategies for locums and all the other people that come into the organisation." IV1.*

Managing training effectively is reported to be an important part of in implementing electronic prescribing successfully. [80, 107] The electronic prescribing toolkit was built to assist hospitals to successfully implement electronic prescribing and it recommends that a training needs analysis is conducted to cover all potential users of the new system being implemented. [131] By following this recommendation future electronic prescribing implementers may be able to avoid some of the training issues identified by the participants of this study.

The fourth issue related to electronic prescribing systems and decision support was having a slow roll out of the system (n=5). One interviewee commented that it took about 15 months to roll out. A second interviewee noted that having a small project team meant the system roll out was

slower than intended. Slow roll out of an electronic prescribing system was also identified in a previous study to be an issue as it can cause confusion when you have more than one system in place. [80]

> *"Our problems really stemmed mainly from the slow nature of the project in rolling the project out between wards." IV1.*

The final issue identified was that electronic prescribing and decision support could deskill the prescriber (n=4). Deskilling is where complex tasks are divided down into simpler smaller tasks and as a result of this the person may lose the comprehensive knowledge or integrated skills of that area of work. Interviewees recognised that prescribing staff could become reliant on the system and could face difficulties if they then moved to a hospital without this type of supportive system in place. One paediatric based interviewee was concerned that doctors would not ever have to work out the doses for medication and this could deskill them.

> *"Care needs to be taken to ensure we do not de-skill medical staff." IV1.*

8.1.4 The future of electronic prescribing and decision support

Participants identified a range of future developments that they anticipated that their system might gain or that might be developed on a wider scale to improve existing electronic prescribing and decision support systems. Future features and developments identified were:

- Administration guidance
    - *"Guidance on how to administer". IV4.*
- Allergy checking
    - *"Interactive allergy checking". IV3.*
- Better interaction checking
    - *"More intelligent interactive systems". IV1*
- Calculators
    - *"A few more calculators". IV4.*
- Clinical pathways
    - *"We plan to build order sets so prescribers can click and order various items in one place." IV7.*
- Data analysis of prescribing data
    - *"We really need to get more out of the information that we've got." IV2.*
- Real time drug administration
    - *"One of our goals with our project now is to move to real time drug administration." IV3.*

- Electronic discharge/discharge prescriptions
    - *"When we do our discharge letters at the end to feed information back to GP systems." IV3.*
- Better hardware options
    - *"What mobile device is best in what situation?" IV4.*
- Invisible decision support
    - *"A classic example is the decision support, in actual fact decision support is best when it's invisible. Really the majority of the time I don't want the system in front of me, I want to be talking and working with the patient. And again, working through that so that we're actually almost invisible to the user, to the clinician that, a bit like Google now, it's offering you the right information at the right time." IV4.*
- Intravenous drug prescribing
    - *"We will have the IV software." IV2.*
- Medicines reconciliation
    - *"We're just still working out if the functionality is adequate and you know basically safe enough at the moment to use." IV3.*
- Non-stock orders sent directly to pharmacy
    - *"The orders for non-stock drugs to come down to pharmacy directly." IV2.*
- Paediatric friendly system.
    - *"We will have to adapt the system to our needs but there is the capability to build mg/kg dosing, ml/kg dosing, age-banded dosing etc. for the paediatric setting." IV6.*

There is some overlap with this list of future developments and the features already available in electronic prescribing systems. This suggests that not all electronic prescribing systems have the same functionality available currently. The variety of features available from different suppliers of electronic prescribing systems may make identification of the best system for a particular hospital challenging.

8.1.5 Advice from electronic prescribing leaders regarding electronic prescribing and decision support

All interviewees were able to provide advice to organisations that were yet to implement electronic prescribing and decision support. This included the interviewees from organisations that had not got electronic prescribing in place at the time of the interview.

8.1.5.1 Advice regarding integration of electronic prescribing and decision support with other hospital IT systems

The theme of integration was brought up frequently by the participants (n=17). Specifically they were referring to integration of the electronic prescribing and decision support systems with other existing hospital systems or having one system that provided all necessary functions. Integration was recognised by four participants as important to the usability and success of the system. This was consistent with prior research that recognises that clinical decision support systems can be more successful if they are integrated with electronic health records and/or existing health systems. [107]

Specific advantages of integrated systems reported by participants were:

- The amount of training required is minimised as there is a common system for all functions across the hospital.
- It is easy to move between the different parts of the system (compared to using separate systems, with separate log ins).
- There are reduced transcription errors when the pharmacy system is integrated with the prescribing system.

"Full integration is the key to safety, efficiency and maximising benefits". IV1.

8.1.5.2 Advice regarding engaging staff about electronic prescribing and decision support

All but one participant recognised the importance of engaging staff when introducing electronic prescribing and/or decision support. Several prior published studies have also reported the importance of end user engagement in this type of project. [80, 107, 131, 133] Participants emphasised that the system implementation needs to engage staff from a variety of healthcare professions. One participant reported having formal user groups that allowed staff to feedback ideas to the electronic prescribing team. This is line with a recently published study that stated that "it is important to be seen to respond to end users' ideas". [131] Ideas of ways to engage staff from one hospital (in the system development stage) included: showing and demonstrating the system to staff; taking part in large meetings; carrying out departmental visits; using email and the trust's intranet to tell staff about the system.

> *"You have to sell to everyone involved: pharmacy, chief executive, medical and nursing staff. It's got to benefit them because otherwise they're going to drag their feet and not cooperate." IV1*

"We've got various formal user groups. We've got a medical, a clinical which is mainly nursing and allied health professionals, we've got an operational which is for again clerical and support staff." IV3.

"So the priorities of the, of the IT system should be decided by clinicians." IV3.

One hospital recognised that it was difficult to get the main users of this type of system – nurses and junior doctors – to engage in the development process because they are so busy. This participant recognised that it is often the senior staff who influence the system design although they will be using it less frequently. Again, this is consistent with a recent study that has reported the difficulty of getting clinical staff freed from their duties in order to contribute to this type of system development and implementation. [131]

Interviewees in this study also provided the following advice which reiterated the importance of having a plan in place to manage training and your resources as described earlier in this chapter.

- Train people at the right time so they can remember their training when the system goes live.

  "The most important thing is to train people just before they are going to use it otherwise they forget what they're doing." IV2.

- Ensure you have a core team set up from early in the project.

  "I think it's important to have a core team from the beginning. Some of us have been seconded quite recently and it takes time to get into the project and understand it all." IV6.

  Electronic prescribing is not just a "plug in the wall and away it goes" (IV1) project. It is an ongoing project that will require continual support.

8.1.6 Important singular or abstract comments

There were three interesting comments that arose during the interviews that were not common enough to be identified as themes, but were unusual and/or abstract so added depth to the dataset.

The first interesting comment by a company representative was that the manager of the electronic prescribing and/or decision support system may become the most clinically important person in the hospital.

> "*Your system manager has just become the most clinically influential person in your hospital. That all templates, predefined prescription etcetera are now under the control of the system manager. What the doctor gets to see to prescribe, what the doctor chooses first off the list; all of these things are now under that person's control. And that's actually the most clinically, I can't think of the right word for it, powerful role probably in the hospital…" IV4.*

This was interesting because it highlights that the manager of the system if not a clinician could still hold a powerful clinical role in the hospital. This could raise concerns with clinical staff because of the lack of clinical knowledge and understanding the system manager may have. This issue was not identified by any of the hospital based participants in the study. This could be attributed to the fact that all hospital participants referred to having the system as being clinically led.

The second interesting abstract comment, again made by the same company representative, was that clinical decision support systems don't really offer decision support.

> *"Runs really once you've made your choice and really you're into harm reduction or harm avoidance, which is really what decisions support, which isn't decision support, is". (IV4)*

It was then suggested that the systems are not offering decision support, but are in fact providing harm avoidance/reduction. This is an important point to make as if the decision has already been made before the doctor uses the system, how beneficial can the system be in terms of decision support? In the UK junior doctors are often tasked with prescription writing after the drug choice has been made in conjunction with other doctors during the ward round. In this type of scenario the participant's comments fit with current practice as by the time the prescription writing occurs the decisions have already been made.

8.2 Limitations

Interview five was provided as a written interview as the company was unable to provide an interview face to face or over the phone. The responses in this interview were very much shorter and briefer compared to any of the other interviews conducted. Therefore, it was not possible to determine the full views of this company representative. The strength of evidence for each theme may have been different if a full interview with a second company representative had been obtained.

The audio recorder failed during the course of interview six. This meant the transcript was completed from the researcher's notes and was not as accurate as the audio transcripts. The

transcript was approved as an accurate record of the interview by the participant, but it will not have the same precision as the other transcripts.

Interviews were conducted solely with senior staff working in electronic prescribing. Their views may not be representative of an experienced end user who may have different experiences and recommendations to share. Therefore it would be useful to conduct a similar series of interviews with users of electronic prescribing systems, particularly users working in paediatrics.

8.3 Conclusion

- Leaders in electronic prescribing report to recognise benefits of electronic prescribing consistent with existing literature in addition to novel benefits such as easy to access data for audits and the ability to continuously improve your system.
- Leaders in electronic prescribing report barriers to electronic prescribing consistent with the existing literature suggesting that there are was still not sufficient resources or support to implement this type of electronic clinical system.
- Leaders in electronic prescribing report that current issues in electronic prescribing are: it is resource intensive to implement and maintain the system effectively and each system can have its own specific technical issues.
- Leaders in electronic prescribing report a wide range of developments to electronic clinical systems that may exist in the future.
- Two pieces of advice supported by electronic prescribing leaders are: to integrate your clinical system as much as possible to ensure they are usable and effective and reiterated the need to engage your staff at all stages of the development and implementation processes.

8.4 Recommendations for practice

- Consultation with hospitals already using electronic prescribing is recommended for hospital that are yet to implement electronic prescribing.
- Engage with a wide range of potential end users of an electronic system during its development and implementation.
- Where possible implement a single integrated clinical systems rather than separate standalone clinical systems.

9. Discussion

The specific objectives of this research programme were:

- Identify and describe the experience of pharmacy staff of the implementation of an electronic medicines management system at Birmingham Children's Hospital;
- Identify the current practice of prescribers at Birmingham Children's Hospital concerning their resource use to support prescribing decisions for paediatric patients;
- Identify the current practice of pharmacist members of the Neonatal and Paediatric Pharmacist Group concerning their resource use to support the provision of pharmacy services for paediatric patients;
- Identify the current practice of independent English paediatric hospitals provision of paediatric prescribing support as recorded in the minutes of their board meetings;
- Identify the current views and experiences of leaders in electronic prescribing concerning current benefits/barrier/issues, and their advice for hospitals to ensure successful implementation.

An important part of the medication process in hospitals is the efficient supply and management of medicines. The responsibility for this part of the medicine supply process usually lies with the pharmacy team in each hospital. As part of wider strategies to drive efficiency of medication supply the introduction of electronic tools to support medicines management has gathered pace. An example of this is the medicines management module in the Ascribe pharmacy software. This module enables pharmacist to send requests for supplies of medication electronically to the dispensary and record patients medication histories electronically. The implications of using the Ascribe medicines management electronic system had not been studied previously and there is not any published literature of staff experiences of moving from paper based clinical processes to electronic clinical systems. The present study on implementing an electronic medicines management system has provided data regarding the staff perspective and experience during the implementation of the electronic medicines management system in a paediatric hospital. It suggested that pharmacy staff should be highly involved at all stages of the development and implementation process to ensure the system is practical to use. In this case study, the medicines management system implemented was an efficient way of managing the supply of inpatient medication, but did not work as efficiently for the supply of discharge medication. Pharmacists reported that the system was not set up in a style that easily integrated into their previous workflow and had concerns that the time using the system would take away time that could have

been spent with patients. Although the data from this case study may not be generalizable to all hospitals, due to the specific electronic system used and the specialist patient population at BCH, it has provided insight into the opinions of staff that used the system that may be valuable to other hospitals considering electronic clinical systems in the future.

There is a distinct lack of published research on the medicines information resources used by healthcare professionals working in paediatrics. Currently there is no UK wide data available on this type of resource use by prescribers when they are making prescribing decisions for children in hospitals. It is important to collect this information now as government plans for healthcare indicate that hospitals are required to have plans for effective and patient centred use of IT particularly in relation to medicines. [88] It will be difficult to meet the future information needs of healthcare professionals if the current information needs are unknown. The information from the literature regarding prescribing support describes alert fatigue and prescriber dissatisfaction with the current decision support available demonstrating the need for further research in this area. [52]The study at BCH has now improved the information available to those designing prescribing support tools for paediatric prescribers as they have identified the most frequently used source of paediatric prescribing information – the BNFc (refer to Table 36). Prescribers reported to use the BNFc several times every shift and reported it to be the most useful source of information as it was easy to use, accessible and reliable.

Paediatric pharmacists work alongside paediatricians in hospitals and provide a check that the prescriptions written are appropriate for each individual patient. This role involves the use of many resources to check the appropriateness of each prescribing decision made by the prescriber. Prior to the research described in this thesis the frequency and range of resource use to support the provision of paediatric pharmacy services was not known. There was no published information available on what resources pharmacists need to use when checking paediatric prescriptions. Similarly it was not known if the resources used had the necessary paediatric prescribing information available. This study has provided a description of current resource use by pharmacists providing paediatric pharmacy services and this could be used by electronic prescribing system designers to ensure their information needs are met. Pharmacists in this study also reported that the BNFc was the most frequently used source of information and the most useful (refer to Table 62).

The respondents from the NPPG and BCH reported similar practice with regards to their working habits in paediatrics. Respondents from the NPPG and BCH reported a similar mean number of years of working in paediatrics. However, the pharmacist respondents from the NPPG reported to work more frequently in the inpatient hospital environment compared to the prescriber

respondents from BCH. The majority of both groups of respondents reported to use an information resource to support their work in paediatrics at least several times a day. When comparing specific information resource use the pharmacist respondents were more likely to report to use each resource than the prescriber respondents and if they did use a resource they reported that they did so more frequently. Pharmacists may have used information sources more frequently than prescribers due to their role of providing the final check for safety and appropriateness of prescriptions. This role was reported in the minutes from board meetings of paediatric hospitals and is consistent with the published literature. [54, 63, 64] Although there have been no randomised studies demonstrating the effect of this type of intervention, a systematic review identified 18 studies examining the role pharmacists can have in paediatrics. [63] Despite the variety of methods, settings and definitions used within the studies, the systematic review concluded that pharmacists are important in identifying paediatric medication errors. [63] The other resources identified by participants that had similar reported patterns of use to pharmacists were: other colleagues, NICE guidelines, local guidelines and other national guidelines. It would be useful to explore further the reasons that led to NPPG respondents reporting to use more resources more frequently. The respondents from the NPPG and BCH studies agreed that the BNFc was the most useful resource when working in their current role in paediatrics. The reasons for this were consistent across both studies and included that it was easy to use, accessible and familiar.

Both respondents from the NPPG and from BCH reported that there was a lack of data to support prescribing decisions in paediatrics (see Tables 39 and 65). This demonstrates that despite their different roles and responsibilities relating to the use of medicines in paediatrics there is a need for further information to be available about prescribing in paediatrics. Both groups of respondents reported that the current lack of information in paediatrics could have an effect on patient care (see Tables 41 and 67). Respondents from both studies reported prescribing for paediatric patients is more difficult than prescribing for adult patients. This is consistent with the limited published literature. [16, 17] It also indicates that there is a need for the currently available information to be accessible and easy to use, rather than requiring the healthcare professional to investigate several information sources before being able to make a decision.

When identifying the current use of information resources by prescribers and pharmacists working in paediatrics the wide range of resources reported to be used indicated that there is not a single resource that meets the information needs of this group. Based on this assertion it could also be suggested that the clinical decision support in electronic prescribing systems used in paediatrics cannot be based on a single source of information if it is to be successful. This is particularly relevant in paediatrics where information on off label and unlicensed dosing is often

required to be able to offer paediatric patients treatment. Currently off label and unlicensed paediatric prescribing information is not available in a single easy to access resource or within the decision support of a commercial electronic prescribing system. Off label and unlicensed prescribing in paediatrics is critical and as such clinical decision support regarding this type of medication use needs to be available in any electronic prescribing system that is to be successfully used in paediatrics. From a commercial perspective it could be deemed risky to include information in a clinical system that does not have high quality evidence to support it. The challenge of finding a suitable commercial electronic prescribing system for use in paediatrics is so difficult that BCH have begun to develop a paediatric drug catalogue that could be used in such a system. [134] One could argue that it commercially irresponsible to not provide the same level of decision support to paediatric patients as one does to adult patients, particularly when there is data that describes the higher level of medication errors and challenges encountered when prescribing for children. [16, 17] The quality of medication error studies in UK paediatric populations is limited to case studies, therefore this evidence should be used with caution until cohort or randomised studies have been conducted. However, the cost of developing a commercial paediatric clinical decision support system for a specialist area such as paediatrics is unlikely to be borne by a commercial company given the limited size of the market for such a system. Therefore it is likely that 'home-grown' solutions such as that in development as BCH will be the only resolution to this issue.

At the time of the studies the BNFc was not accredited by NICE. [111] It is not clear from the studies what NICE accreditation meant to the participants, but as the BNFc was reported to be the most frequently used resource, it suggests that its lack of accreditation does not affect their reported use of this information resource. This questions the value of the NICE accreditation process if the paediatric resource reported to have been used most frequently did not have NICE accreditation. Information sources that NICE has accredited, for example the British Thoracic Society guidelines, were also reported to have been used by the participants but not as frequently as the unaccredited BNFc. This adds further support that the accreditation of paediatric prescribing resources by NICE does not infer that they are the most useful in practice. Although the BNFc was reported by respondents from BCH and the NPPG to be comprehensive, the wide range of individual patient factors combined with the use of off-label or unlicensed medicines in paediatrics, means there is likely to be clinical scenarios that it does not cover. This may partly explain the reported use of many additional resources by respondents from the NPPG and BCH.

The importance of individual patient factors (e.g. weight, current medical conditions or blood test results) in informing prescribing decisions was highlighted by the frequent use of patient results (e.g. blood results) and patient notes by both prescribers and pharmacists when prescribing for

paediatric patients or providing paediatric pharmacy services. The lack of guidance relating to individual patient factors such as renal function has been identified previously as a fault of resources which were deemed unsuitable for devising individual dosing recommendations. [71] The ability of a resource to support patient specific recommendations is particularly important in paediatrics where doses are often based on weight. Participants in the leaders in electronic prescribing interview study also reported that integration of electronic prescribing with other clinical systems was important so that individual factors that could affect prescribing choice were easily available to prescribers. This supports the need for prescribing support to be able to provide guidance on doses for individual patients rather than a single generic dose.

The documentary analysis of paediatric hospital board minutes aimed to identify prescribing support initiatives that were discussed at hospital board level in paediatric hospitals. The discussion of topics at the highest level of decision making in hospitals could indicate the importance of this issue. Several different initiatives related to paediatric prescribing support and improving the quality of paediatric prescribing were identified. Upon further evaluation of these initiatives only one published article, on the use of electronic prescribing, described in the board meeting minutes and papers could be identified. [33] This study identified that paediatric hospitals often trial initiatives to improve paediatric prescribing but do not publish the results of prescribing improvement initiatives. However, a new method of sharing good practice regarding safe prescribing in paediatrics has been launched since this study was completed. The 'Meds IQ' initiative of the Royal College of Paediatrics and Child Health encourages the reporting of interventions that have successfully improved medication safety in children. [92] The Meds IQ initiative is a platform that allows paediatric hospitals to share good practice via a single accessible website without having to invest the time required to run a study and produce an article that meets the stringent standards of a peer reviewed journal. The 'Meds IQ' initiative may encourage further studies that are lower on the hierarchy of evidence rather than the required randomised studies that are needed to demonstrate evidence based methods of improving paediatric medication safety. The initiatives most frequently reported in the paediatric hospital board minutes were: supporting prescribers to improve their prescribing practice, using electronic patient medical records and ensuring healthcare professionals are involved in the development of new initiatives.

There is evidence from the studies within this thesis that multidisciplinary working is important when working in paediatrics and designing new initiatives to improve paediatric prescribing practice. Prescribers at BCH valued the expertise in medication that the pharmacists could provide and were disappointed that the expertise was not easily available outside normal pharmacy operating hours. The support of clinical pharmacy services and pharmacist double checking (for

example, using a pharmacist to check a calculation conducted by another healthcare professional has been completed correctly) has been identified by the Co-operative of safety of medicines in children: scoping study to analyse interventions used to reduce errors in calculation of paediatric drug doses (COSMIC) report as two interventions that can be used to reduce paediatric medication calculation errors in hospitals. [135] The COSMIC report used a mixed methodology to reach this conclusion, although it did not include any cohort or randomised study methods, thus its conclusions should be used with caution as they cannot be used to provide a causal link between the interventions studied and the reduction of paediatric medication errors. In the board meeting minutes of paediatric hospitals clinical pharmacy services were reported to have been extended to provide frequent reports on medication errors and to include direct supervision of new prescribers. Pharmacists may also provide pharmacy support through the provision of introductory sessions and tests for prescribers. [135] Tests for new prescribers and induction sections were reported in the minutes and papers from paediatric hospital board minutes also. Another report, the EQUIP study on causes of prescribing errors also noted the reliance of doctors on pharmacists to correct and identify prescribing errors. [62] The EQUIP study was a multisite study (conducted at 20 hospitals) indicating that there is good evidence to support the use of pharmacists in reducing prescribing errors. [62] The usefulness of pharmacists in improving medication safety for children was further supported by the participants in the study at Birmingham Children's Hospital who report using pharmacists regularly to support their prescribing decisions.

Electronic prescribing and decision support has been used for more than ten years in several hospitals in England, although the widespread use of this technology is not yet in place. Whilst there have been several US based studies that provide guidance to those considering implementing electronic prescribing there is a paucity of similar data with a UK focus. There have been some conference papers delivered on this subject but there is a lack of peer reviewed published information. The electronic prescribing toolkit has been developed recently to reduce the burden of work of implementing electronic prescribing as well as improve the likelihood of a successful implementation programme. [131] The interviewees described many benefits of electronic prescribing such as clear prescriptions and clinical decision support. The interviewees also reported that potential barriers to the implementation of electronic prescribing were availability of resources (staff and financial) and functionality of the system chosen. The interviews with key stakeholders in electronic prescribing and electronic prescribing project members in paediatric hospitals have allowed the advice and expertise of these people, particularly regarding paediatrics, to be shared. The most frequently reported advice was that integration of all clinical systems was recommended as well as ensuring engagement and

involvement of end users throughout the development and implementation stages. As a result of this study there is now more practical implementation related UK focussed information available to hospitals who are considering implementing electronic prescribing.

The studies within this thesis have identified the following key points for successful implementation of a new initiative or clinical system designed to improve prescribing practice in paediatrics:

- The initiative should aim to improve efficiencies of hospital processes to enable healthcare professionals to have more direct patient contact time;
- Healthcare professionals should be involved at all stages of development and implementation of electronic clinical systems with the aim of improving its usability and acceptability in clinical practice;
- New electronic initiatives or systems should be integrated with existing electronic systems. This should reduce the time burden on healthcare professionals for tasks such as data entry and logging on to different systems.

The initial focus groups and interview study identified that using electronic systems could deskill the prescriber or result in the prescribers making decisions that are not independent. Prescribers are healthcare professionals and professionals are defined by their standards of education and training; their license to practice and their ability to work autonomously. [136] Electronic systems to support decision making could reduce the ability of the prescriber to work autonomously, particularly if the system is managed by an information technology specialist rather than a healthcare professional. The increase in control of the healthcare professional by the information technology team may reduce the professional's authority in their specialist area. [136] As healthcare becomes further corporatized there are less healthcare professionals involved in decision making about how the hospital is run and with increasing use of technology healthcare professionals may have less personal autonomy. [136, 137] The loss of professionalism of healthcare professionals associated with the introduction of technology and corporatisation of healthcare is a subject that also requires further research.

Pharmacists and prescribers may become deskilled as the corporatisation of healthcare increases through increased use of technology and bureaucratisation. [137] For example, clinical guidelines and standard operating procedures reduce the level of decision making required by the prescriber or pharmacist. Use of electronic clinical systems in the pharmacy and for prescribing could also deskill professionals by reducing these complex tasks into simpler repetitive jobs. When a process has been subdivided into smaller routine tasks the healthcare professional has less independent control over their work. Where this happens individuals can lose the integrated skills and

comprehensive knowledge required for their profession. [137] Traditional autonomy of professionals can be removed by bureaucracy through the use of rules and regulations; specialised roles and hierarchies. [136, 137] There is no published literature that describes the effect of electronic health systems on the deskilling and professional status of healthcare professionals.

9.1 Proposed future research areas and implications for policy

This area of research is lacking studies that have used methods to generate high quality data and evidence to support the interventions trialled. Therefore all future work should consider the likely strength of the study method to ensure high quality evidence can be provided. The first area of future work that should be considered is extension of the current studies on the resource use of paediatric prescribers and pharmacists to ensure a generalisable dataset is available. This will address some of the limitations identified in previous chapters regarding the study population and ensure the data is applicable across a wider range of paediatric hospital settings. Suggested extensions to the questionnaire studies would be to take a random sample from all prescribers and pharmacists that work in paediatric hospital settings in England. Identifying these participants could be challenging as there is no accessible register or record of people who work in these positions. However, in order to ensure the results are generalizable to the field of paediatrics this work is necessary, particularly as the current literature in this field of research is largely provided by methods involving single study sites. Another consideration is to include community pharmacists and general practitioners in the studies on the use of paediatric prescribing information. It would be worthwhile to explore if healthcare professionals in the community have the same or different experiences regarding the availability of paediatric prescribing information. Further data supporting the findings of the studies in this thesis could provide support for the development of a single comprehensive paediatric resource.

The second area of work that is required is an observational study to determine the behavioural process that occurs when decisions regarding paediatric medicines are made. It is important to understand when and how these decisions are made in order to develop clinical decision support that provides guidance prior to and/or at the point of decision making. Defining the optimum time at which decision support is provided is vital to the development of effective clinical decision support systems. If information continues to be provided in a reactive manner to decisions about medicines (for example, providing drug interaction information after an electronic prescription has been written and is about to be confirmed) it is difficult to predict an improvement in prescribing practice and ultimately clinical outcomes. A lack of improvement in clinical outcomes

is not value for money and the current financial climate demands that clinical and cost effective measures to improve prescribing practice are required.

The implications of this research for policy are:

- to ensure efficient receipt of required paediatric prescribing information when making paediatric prescribing decisions there is a clear need for a further single comprehensive paediatric prescribing resource (the BNFc needs to provide more comprehensive paediatric prescribing information);
- paediatric hospitals should be encouraged to publish and share information regarding successful and unsuccessful strategies implemented to improve prescribing practice to ensure that successful solutions can be extended to other hospitals;
- to ensure appropriate paediatric decision support is provided in electronic prescribing systems the development should include the information from the broad range of paediatric specific resources reported to be used in chapters 4 and 5 as well as support based on individual patient factors such as test results and existing medical conditions. The best method of presenting this information to impact decision making should be determined prior to implementation of a clinical decision support system.

9.2 Conclusions

- Pharmacy staff reported that use of electronic medicines management improves the efficiency of supply of medication to inpatients. For more comprehensive use of electronic medicines management, the systems need to be developed further to allow existing medication related processes to be translated efficiently.
- The current resource use of paediatricians and pharmacists specialising in paediatrics now has the first UK specific data and it will be of use to developers of paediatric electronic prescribing and clinical decision support systems.
- The BNFc was reported to be used most frequently and to be the most useful resource to paediatricians and pharmacists specialised in paediatrics.
- Respondents reported that patient care can be affected by the lack of comprehensive and accessible sources of paediatric prescribing information.
- Paediatric hospital board meeting minutes reported a range of initiatives trialled to support good paediatric prescribing practice. However, there was a lack of evidence for collaboration and sharing of this information between paediatric hospitals and this may delay the rate of improvement in the quality of paediatric prescribing.

- Leaders in electronic prescribing reported a wide range of benefits of electronic prescribing, but described a lack of resources available to hospitals to implement these systems. They advised that hospitals should aim to have integrated systems and should involve healthcare professional end users as much as possible in their design and implementation processes.

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11. Appendices

Appendix 1 – focus group topic guide

Paediatric prescribing support – any tool or information source electronic or otherwise that aids your decision making during the paediatric prescribing process.

1. What is your profession? What is your level of experience – F1/2, ST, consultant or years of independent/supplementary prescribing experience?
2. Usual prescribing habits.
    a. How often do you prescribe?
    b. What setting do you prescribe in? IP, OP? Speciality?
3. How often do you need to find extra information or guidance before prescribing?
    a. Daily/several times a week/weekly/several times a month/monthly/less often?
4. What type of information do you look up most frequently, i.e. doses, guidelines, formulations available?
    a. What tools do you use to access this information? BNFc, online resources, colleagues, local guidelines, etc.
5. What types of information do you struggle to access?
    a. Why? Information not available for children? BCH not signed up for most useful reference source?
    b. Are there any other difficulties currently in the prescribing process? Reading Rxs, availability of medicines?
6. What prescribing support would you want/expect to be included in an electronic prescribing tool?
    a. How would you want to view this? Links to information, alerts (click or no click to acknowledge?), information displayed with no active reaction required (e.g. no clicking to continue with prescribing)?
7. Do you have any concerns about how an ePrescribing system would be implemented?
    a. Disruption to your workflow? Training? Any effects on patient care during implementation/early use?

Appendix 2 – electronic medicines management questionnaire

Aston University

eMedMan Questionnaire

This questionnaire is designed to be completed by pharmacy staff at Birmingham Children's Hospital.

Q1 **Please confirm your job role - tick the most relevant option:**

Pharmacist ☐

Pharmacy technician ☐

Other (please write your job title in the box provided) ☐

[ ]

Q2 **How long have you worked in Pharmacy at BCH?** (Please specify months/years)

[ ]

Q3 **Are you aware of the current change from paper based to electronic medicines management?**

Yes ☐

No ☐ Please finish the questionnaire here.

Q4 **Do you work or have you worked on a ward with both paper based and electronic medicines management systems?**

Yes ☐

No ☐ Please finish the questionnaire here.

Q5 **Before the introduction of eMedMan please describe your attitude towards change**

	Very much don't like change	*Don't like change*	*Neutral about change*	*Like change*	*Very much like change*
Attitude towards change	☐	☐	☐	☐	☐

Q6 **Please describe how you prepared for the change to eMedMan?**

[ ]

Q7 **Please state how satisfied you were with the training provided for eMedMan**

	Very dissatisfied	*Dissatisfied*	*Neither satisfied nor dissatisfied*	*Satisfied*	*Very satisfied*
Level of satisfaction	☐	☐	☐	☐	☐

Q8 **Please describe how you feel the training could have been improved?**

Q9 **Please state how satisfied you were with the implementation process for eMedMan**

	Very dissatisfied	*Dissatisfied*	*Neither satisfied nor dissatisfied*	*Satisfied*	*Very satisfied*
Level of satisfaction	☐	☐	☐	☐	☐

Q10 **Please describe your experiences during the changeover process: what do you think went well or less well during the changeover process?**

Q11 **Please describe what you feel could have been done to improve the implementation of the eMedMan system**

Q12 **Please rank the following ADVANTAGES of the PAPER BASED medicines management system from the most important advantage to the least important advantage** (tick one box per line)

	Most Important			*Least Important*
Same system used across all wards	☐	☐	☐	☐
The system process are familiar to staff	☐	☐	☐	☐
Encourages pharmacists to spend more time on the wards and find out about other aspects of treatment	☐	☐	☐	☐
Encourages verbal communication between pharmacists and technicians	☐	☐	☐	☐

Q13 **Please rank the following DISADVANTAGES of the PAPER BASED medicines management system from most important disadvantage to least important disadvantage** (tick one box per line)

	Most Important				*Least Important*
Only medicines supplied by pharmacy will be recorded on Ascribe (not full medication history)	☐	☐	☐	☐	☐
Paper patient profile can go missing	☐	☐	☐	☐	☐
Paper patient profile has to be seen by a pharmacist before medication is supplied	☐	☐	☐	☐	☐
Handwritten information can be misread or misinterpreted	☐	☐	☐	☐	☐
Relies on pharmacist and technician to be able to find each other and exchange information	☐	☐	☐	☐	☐

Q14 **Please describe any further advantages or disadvantages of the PAPER BASED medicines management system that are not mentioned above**

Q15 **Please rank the following ADVANTAGES of eMedMan from the most important advantage to the least important advantage** (tick one box per line)

	Most important					*Least important*
Patient information is put straight onto Ascribe, so it is not re-transcribed during dispensing	☐	☐	☐	☐	☐	☐
Pharmacist and technician can communicate via notes on the system, so notes don't get lost and they don't have to find each other	☐	☐	☐	☐	☐	☐
All current medication is recorded and archived information is easy to find	☐	☐	☐	☐	☐	☐
If medication has already been clinically screened it can be dispensed immediately	☐	☐	☐	☐	☐	☐
Patients will generally receive their medication faster	☐	☐	☐	☐	☐	☐
Less interpretation of supply requests as details are typed rather than handwritten	☐	☐	☐	☐	☐	☐

Q16 **Please rank the following DISADVANTAGES of eMedMan from the most important disadvantage to the least important disadvantage** (tick one box per line)

	Most important					*Least important*
It is not easy to find a computer with Ascribe to work on when on the wards	☐	☐	☐	☐	☐	☐
It is not used on all wards so you have to be familiar with more than one system	☐	☐	☐	☐	☐	☐
The system processes are unfamiliar to staff	☐	☐	☐	☐	☐	☐
The incoming worklist can cause confusion as there may be items on there that are for the next day or to be dispensed at a later date rather than now	☐	☐	☐	☐	☐	☐
It takes more time to use than the old system initially	☐	☐	☐	☐	☐	☐
Electronic clinical screen may be valid for too long for some medication so there is a risk that patients may receive a resupply of medication when it is not appropriate	☐	☐	☐	☐	☐	☐

Q17 **Please describe any further advantages or disadvantages of eMedMan that are not mentioned above**

Q18 **Please list any improvements that could be made to the eMedMan system**

Q19 **Following the introduction of eMedMan please describe you current attitude to change**

	Very much don't like change	*Don't like change*	*Neutral about change*	*Like change*	*Very much like change*
Attitude to change	☐	☐	☐	☐	☐

Q20 **Please provide any final comments you have or experience you'd like to share about the paper based or eMedMan systems you feel are important or have not been covered in the questionnaire**

Thank you for completing this questionnaire

Appendix 3 – Birmingham Children's Hospital prescriber's questionnaire

Birmingham Children's Hospital Questionnaire for Prescribers

1. Please read the following information before completing this questionnaire.

Birmingham Children's Hospital is working towards using electronic prescribing. This questionnaire has been designed for current prescribers within BCH NHS Foundation Trust to establish current prescribing practice and expectations of electronic prescribing.

The results of this study will be used to assist with electronic prescribing development in paediatrics. They may also be published anonymously in journals as well as the investigator's PhD thesis.

This questionnaire is registered with Birmingham Children's Hospital clinical governance department and approved by Aston University's ethics committee.

The questionnaire takes approximately 20 minutes to complete, depending on the answers you select.

The investigators are: Dr Fiona Reynolds, Dr David Terry and Alice Burridge.

You may ask questions regarding this study at any time: contact Alice Burridge at burridam@aston.ac.uk

Your data will be anonymised and will not be used for any other purpose than this study.

Your participation is voluntary and there is no payment for participation.

***Please confirm you have read the above information and consent to participate in this study.**

Select one option only.

- ◯ I consent to participate in this study and have understood the above information.
- ◯ I do not wish to participate in this study.

2. Information about you...

***Does your current role involve prescribing (doctor, nurse prescriber, pharmacist prescriber etc.) at Birmingham Children's Hospital NHS Foundation Trust?**

- ◯ Yes
- ◯ No

3. Information about you...

Birmingham Children's Hospital Questionnaire for Prescribers

***Please confirm your profession.**

- ◯ Doctor
- ◯ Nurse
- ◯ Pharmacist
- ◯ Other (please specify)

What is the job title and/or grade of your current position?

4. Questions about prescribing in paediatrics...

***Please state how many years you have been prescribing in paediatrics.**

Please select the areas in which you prescribe for paediatric patients.

Select one or more options.

- ☐ Inpatients
- ☐ Outpatients
- ☐ In the emergency department
- ☐ In the community
- ☐ Other (please specify)

Please select the area in which you prescribe for paediatric patients most frequently.

Select one option only.

- ◯ Inpatients
- ◯ Outpatients
- ◯ In the emergency department
- ◯ In the community
- ◯ Other

Birmingham Children's Hospital Questionnaire for Prescribers

***When on duty how often do you prescribe for a paediatric patient?**

Select one option only.

- ◯ Multiple times every day/shift
- ◯ Once daily or once per shift
- ◯ Several times a week
- ◯ Weekly
- ◯ Monthly
- ◯ Less often than monthly

When thinking about your prescribing in paediatrics, what is your specialist clinical area?

(For example: PICU, oncology etc.) Please describe in the box below.

5. Your resource/reference use when prescribing for paediatric patients...

***When prescribing for paediatric patients, how often do you consult a reference or resource (e.g. BNFc) before finalising your decision?**

Select one option only.

- ◯ Every time I prescribe
- ◯ Several times a day
- ◯ Daily
- ◯ Several times a week
- ◯ Weekly
- ◯ Monthly
- ◯ Less often

Birmingham Children's Hospital Questionnaire for Prescribers

*** Please state how often you use each of the following resources.**

	Every time I prescribe	Several times a day	Daily	Several times a week	Weekly	Monthly	Less often	N/A I don't use this resource
BNFc (paper format)	◯	◯	◯	◯	◯	◯	◯	◯
BNFc (online format)	◯	◯	◯	◯	◯	◯	◯	◯
BNFc (smartphone app)	◯	◯	◯	◯	◯	◯	◯	◯
Guy's, St Thomas' & Lewisham Hospitals paediatric formulary	◯	◯	◯	◯	◯	◯	◯	◯
Pharmacy team member	◯	◯	◯	◯	◯	◯	◯	◯
Microbiology	◯	◯	◯	◯	◯	◯	◯	◯
Other colleague	◯	◯	◯	◯	◯	◯	◯	◯
BCH results system (e.g. blood results, microbiology)	◯	◯	◯	◯	◯	◯	◯	◯
Patient notes	◯	◯	◯	◯	◯	◯	◯	◯
Frank Shann (paper format)	◯	◯	◯	◯	◯	◯	◯	◯
Frank Shann (online format)	◯	◯	◯	◯	◯	◯	◯	◯
Frank Shann (smartphone app)	◯	◯	◯	◯	◯	◯	◯	◯
Google	◯	◯	◯	◯	◯	◯	◯	◯
NICE guidelines	◯	◯	◯	◯	◯	◯	◯	◯
Local guidelines	◯	◯	◯	◯	◯	◯	◯	◯
Other national guidelines	◯	◯	◯	◯	◯	◯	◯	◯

Other (please specify)

If applicable please clarify the following responses.

Which local guidelines do you use?

Which NICE guidelines do you use?

Which other national guidelines do you use?

Which profession of colleagues would you refer to for prescribing support?

6. Your resource/reference use when prescribing for paediatric patients...

Birmingham Children's Hospital Questionnaire for Prescribers

***Please state the three resources/references you find most useful in order of usefulness, where 1 is the most useful.**

1.
2.
3.

Why are these resources the most useful?

7. Making prescribing decision in paediatrics...

***What types of information do you look up to aid your prescribing decisions in paediatrics?**

Select one or more options.

- [ ] Compatibilities
- [ ] Patient test results (e.g. plasma levels)
- [ ] Doses
- [ ] Interactions
- [ ] Formulation information
- [ ] Drug choice
- [ ] Contraindications
- [ ] Other (please specify)

Birmingham Children's Hospital Questionnaire for Prescribers

Please select the type of information you look up most often.

Select one option only.

- ◯ Doses
- ◯ Drug choice
- ◯ Contraindications
- ◯ Interactions
- ◯ Compatibilities
- ◯ Formulation information
- ◯ Patient test results (e.g. plasma levels)
- ◯ Other (please specify)

8. Challenges in paediatric prescribing...

What information do current references/resources lack to help support your paediatric prescribing decisions?

Select one or more options.

- ☐ There is not a lack of information for paediatric prescribing
- ☐ Paediatric drug doses
- ☐ Availability of paediatric formulations
- ☐ Links to individual patient factors (e.g. your patient's age, weight)
- ☐ Lack of advice other than 'caution'
- ☐ Lack of access to paediatric resources
- ☐ Other (please specify)

9. Challenges in paediatric prescribing...

Birmingham Children's Hospital Questionnaire for Prescribers

What type of dosing information do you feel is lacking for paediatric prescribing?

Select one or more options.

- [ ] ECMO dosing information
- [ ] Paediatric doses in general
- [ ] CVVH or dialysis dosing information
- [ ] Hepatic doses
- [ ] Renal doses
- [ ] Filtration dosing information
- [ ] Doses for premature babies
- [ ] Other (please specify)

10. Challenges in paediatric prescribing...

*** Does lack of paediatric prescribing information have an effect on patient care?**

- ◯ Yes
- ◯ No
- ◯ Don't know

Please explain your answer.

In your opinion is there a difference in difficulty between prescribing for children and prescribing for adults?

Please explain your answer in the box below.

Appendix 4 – Neonatal and Paediatric Pharmacists Group questionnaire

1. Please read the following information before completing this questionnaire.

You have been invited to complete this questionnaire as you are a member of the NPPG. This questionnaire has been designed to explore resource and reference use by pharmacists working in paediatrics.

The results of this study will be used to describe resource use and prescribing support in paediatrics. They may also be published in journals as well as the investigator's PhD thesis.

This questionnaire is approved by Aston LHS ethics committee.

The questionnaire takes approximately 10 minutes to complete, depending on the answers you select.

The investigators are: Dr David Terry and Alice Burridge.

You may ask questions regarding this study at any time and obtain summary results by contacting Alice Burridge at burridam@aston.ac.uk

Your data will be anonymised and will not be used for any other purpose than this study.

Your participation is voluntary and there is no payment for participation

* Please confirm you have read the above information and consent to participate in this study.

Select one option only.

- ○ I consent to participate in this study and have understood the above information.
- ○ I do not wish to participate in this study.

2. Information about you...

* Please enter your NPPG member number

This will be used by the NPPG to ensure you are eligible to complete this questionnaire. At no stage will the researcher have access to your personal data held by the NPPG.

* Are you a pharmacist who provides or has provided pharmacy services for a paediatric patient?

- ○ Yes
- ○ No

3. Information about you...

What is the job title and/or grade for your current position?

* Please state how many years you have provided pharmacy services for paediatric patients.

Please select the areas in which you provide pharmacy services for paediatric patients.

- ☐ Inpatients
- ☐ Outpatients
- ☐ In the emergency department
- ☐ In the community
- ☐ Other (please specify)

Please select the area in which you provide pharmacy services for paediatric patients most frequently.

Select one option only.

- ○ Inpatients
- ○ Outpatients
- ○ In the emergency department
- ○ In the community
- ○ Other

4. Firstly questions about pharmacy services in paediatrics...

* When on duty, how often do you provide pharmacy services for a paediatric patient?

Select one option only.

- ○ Multiple times every day/shift
- ○ Once daily or once per shift
- ○ Several times a week
- ○ Weekly
- ○ Monthly
- ○ Less often

When thinking about your pharmacy services in paediatrics, what is your specialist area?

(For example: PICU, oncology etc.) Please describe in the box below.

5. Your resource use when providing pharmacy services for paediatric patients...

* When providing pharmacy services for paediatric patients, how often do you consult a reference or resource (e.g. BNFc) before finalising your decision?

- ○ Every time I provide pharmacy services
- ○ Several times a day
- ○ Daily
- ○ Several times a week
- ○ Weekly
- ○ Monthly
- ○ Less often

* Please state how often you use each of the following resources.

	Every time I provide pharmacy services	Several times a day	Daily	Several times a week	Weekly	Monthly	Less often	N/A I don't use this resource
BNFc (paper format)	○	○	○	○	○	○	○	○
BNFc (online format)	○	○	○	○	○	○	○	○
BNFc (smartphone app)	○	○	○	○	○	○	○	○
Guy's, St Thomas' & Lewisham Hospitals paediatric formulary	○	○	○	○	○	○	○	○
Pharmacy team member	○	○	○	○	○	○	○	○
Microbiology	○	○	○	○	○	○	○	○
Other colleague	○	○	○	○	○	○	○	○
BCH results system (e.g. blood results, microbiology)	○	○	○	○	○	○	○	○
Patient notes	○	○	○	○	○	○	○	○
Frank Shann (paper format)	○	○	○	○	○	○	○	○
Frank Shann (online format)	○	○	○	○	○	○	○	○
Frank Shann (smartphone app)	○	○	○	○	○	○	○	○
Google	○	○	○	○	○	○	○	○
NICE guidelines	○	○	○	○	○	○	○	○
Local guidelines	○	○	○	○	○	○	○	○
Other national guidelines	○	○	○	○	○	○	○	○

Other (please specify)

If applicable please clarify the following responses.

Which local guidelines do you use?

Which NICE guidelines do you use?

Which other national guidelines do you use?

Which profession of colleagues would you refer to for prescribing support?

6. Your resource use when providing pharmacy services for paediatric patients...

* Please state the three resources/references you find most useful in order of usefulness, where 1 is the most useful.

1.

2.

3.

Why are these resources the most useful?

7. Making decisions in paediatrics...

* What types of information do you look up to support your decisions in paediatrics?

- ☐ Drug choice
- ☐ Doses
- ☐ Interactions
- ☐ Contraindications
- ☐ Compatibilities
- ☐ Formulation information
- ☐ Patient test results (e.g. plasma levels)
- ☐ Other (please specify)

Please select the type of information you look up most often.

- ○ Drug choice
- ○ Doses
- ○ Interactions
- ○ Contraindications
- ○ Compatibilities
- ○ Formulation information
- ○ Patient test results (e.g. plasma levels)
- ○ Other (please specify)

8. Challenges in paediatrics...

What information do current references/resources lack to support your paediatric decisions?

- ☐ There is not a lack of information for paediatrics
- ☐ Paediatric doses
- ☐ Availability of paediatric formulations
- ☐ Links to individual patient factors (e.g. your patient's age, weight)
- ☐ Lack of advice other than 'caution'
- ☐ Lack of access to paediatric resources
- ☐ Other (please specify)

9. Challenges in paediatrics...

What type of dosing information do you feel is lacking for paediatrics?

- ☐ Paediatric doses in general
- ☐ Renal doses
- ☐ Hepatic doses
- ☐ CVVH or dialysis dosing information
- ☐ ECMO dosing information
- ☐ Filtration dosing information
- ☐ Doses for premature babies
- ☐ Other (please specify)

10. Challenges in paediatrics...

* Does lack of paediatric information have an effect on patient care?

- ○ Yes
- ○ No
- ○ Don't know

Please explain your answer.

In your opinion is there a difference in difficulty between prescribing for children and prescribing for adults?

Please explain your answer in the box below.

Appendix 5 – interview guide

Current status regarding ePrescribing:

- Please summarise your electronic prescribing history to date: when did it begin and what changes have you been through to come to the current product?
- Companies: what functions do your products currently provide? (e.g. dosing support)

Currently, what works well with ePrescribing and what doesn't work so well?

- Works well:
- Doesn't work well:
- Are end users expectations met?

What is the history of ePrescribing: what are the main wins and losses it has brought about thus far?

- Wins:
- Losses:

What are the biggest constraints/obstacles to getting and/or outcomes/achievements of using ePrescribing?

- Obstacles/constraints to getting ePrescribing:
- Outcomes/achievements when using ePrescribing:

Where will you be in five years with ePrescribing?

- Functions you would envision:
- Improvements you want to achieve:

What are the lessons you have learnt and/or your advice to others yet to implement electronic prescribing?

- Lessons learnt:
- Advice to others:
- Future guidance for the NHS:
- What importance should electronic prescribing have in NHS IT strategies?

Appendix 6 – List of publications and conference papers

Publications

SP 06: What information resources do paediatric pharmacists use when providing clinical pharmacy services for children? Archives of Disease in Childhood 2015, volume 100, e1.

SP 02: Rationalisation of paediatric drug dosing age ranges: reducing confusion. Archives of Disease in Childhood 2015, volume 100, e1.

P 36: Electronic prescribing: the development of a paediatric drug database. Archives of Disease in Childhood, volume 100, e1.

Paediatric prescribing practice and opinions of paediatric prescribers on ePrescribing. International Journal of Pharmacy Practice 2015, volume 23, p225-227.

Support for paediatric prescribers: what is discussed at hospital board level? European Journal of Hospital Pharmacy 2014, volume 21, p330-334.

Support tools for paediatric prescribers: a review. European Journal of Hospital Pharmacy 2014, volume 21, p113-117.

Conference papers

Resource use by pharmacists providing paediatric services. Presentation at Neonatal and Paediatric Pharmacist Group Annual Conference, Nottingham, November 2014.

Pharmacy staff experiences of implementing electronic medicines management at a UK paediatric hospital. Poster at International Pharmaceutical Federation (FIP) World Congress, Bangkok, September 2014.

What information resources do pharmacists use when providing clinical pharmacy services for children? Poster at FIP World Congress, Bangkok, September 2014.

What information resources do paediatric prescribers use when making prescribing decisions for children? Poster at FIP World Congress, Bangkok, September 2014.

Experiences of medical and non-medical prescribers and their views on electronic prescribing. Poster FIP World Congress, Dublin, September 2013.

Experiences and opinions of non-medical prescribers in a paediatric hospital concerning electronic prescribing. Poster at Neonatal and Paediatric Pharmacist Group Annual Conference, Liverpool, November 2012.