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Digitally enabled flash glucose monitoring for inpatients with COVID-19: Feasibility and pilot implementation in a teaching NHS Hospital in the UK

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Abstract

Background: COVID-19 placed significant challenges on healthcare systems. People with diabetes are at high risk of severe COVID-19 with poor outcomes. We describe the first reported use of inpatient digital flash glucose monitoring devices in a UK NHS hospital to support management of people with diabetes hospitalized for COVID-19.

Methods: Inpatients at University Hospitals Coventry & Warwickshire (UHCW) NHS Trust with COVID-19 and diabetes were considered for digitally enabled flash glucose monitoring during their hospitalization. Glucose monitoring data were analysed, and potential associations were explored between relevant parameters, including time in hypoglycaemia, hyperglycaemia, and in range, glycated haemoglobin (HbA1c), average glucose, body mass index (BMI), and length of stay.

Results: During this pilot, digital flash glucose monitoring devices were offered to 25 inpatients, of whom 20 (type 2/type 1: 19/1; mean age: 70.6 years; mean HbA1c: 68.2 mmol/mol; mean BMI: 28.2 kg/m^2) accepted and used these (80% uptake). In total, over 2788 h of flash glucose monitoring were recorded for these inpatients with COVID-19 and diabetes. Length of stay was not associated with any of the studied variables (all p-values >0.05). Percentage of time in hyperglycaemia exhibited significant associations with both percentage of time in hypoglycaemia and percentage of time in range, as well as with HbA1c (all p-values <0.05). The average glucose was significantly associated with percentage of time in hypoglycaemia, percentage of time in range, and HbA1c (all p-values <0.05).

Discussion: We report the first pilot inpatient use of digital flash glucose monitors in an NHS hospital to support care of inpatients with diabetes and COVID-19. Overall, there are strong arguments for the inpatient use of these devices in the COVID-19 setting, and the findings of this pilot demonstrate feasibility of this digitally enabled approach and support wider use for inpatients with diabetes and COVID-19.

Keywords

COVID-19, diabetes, inpatient care, digital health, flash glucose monitoring

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Introduction

The pandemic caused by SARS-CoV-2 has presented significant challenges to healthcare service delivery globally and for the UK National Health Service (NHS), with a substantial number of patients hospitalized due to COVID-19.[1] Diabetes (both type 1 and type 2) has been shown to increase the risk of severe COVID-19, resulting in

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increased risk of hospitalisation and COVID-19 related adverse outcomes in this patient population[2–5]. As such, patients admitted to hospital with COVID-19 and a co-existent diagnosis of diabetes require careful glucose monitoring to ensure appropriate glycaemic control during this period of acute illness. The use of traditional "finger-prick" based monitoring of blood glucose levels for inpatients is time consuming for healthcare staff, whilst it requires close proximity between the SARS-CoV-2 infected (and potentially infectious) patient and the healthcare practitioner. The latter increases the risk of SARS-CoV-2 transmission from the patient to the healthcare staff.[6]

Acute illness, such as COVID-19, has the potential to impair glycaemic control in people with diabetes, whilst stress related hyperglycaemia is usually noted in patients admitted to hospital (*e.g.* in patients with sepsis, acute myocardial infarction and the critically ill)[7–9]. Glycaemic control in such patients can be further disrupted by the need to pause, or change certain glycaemic lowering medications during the hospitalisation for COVID-19.[8,10,11] Finally, corticosteroids may be administered as a treatment modality for hospitalised patients with COVID-19 which may aggravate hyperglycaemia[12–16]. Taken together these elements stress the need for close glucose monitoring of hospitalised patients with COVID-19 and diabetes. However, using traditional approaches for inpatient glucose monitoring would require resources/time from hospital staff that are already under pressure and, as aforementioned, may increase the exposure of healthcare staff to the risk of SARS-CoV-2 infection.

Digitally enabled flash glucose monitoring devices/sensors, such as the Abbott Freestyle Libre system, measure glucose from the interstitial space rather than from the blood[17–19]. Indeed, these devices allow real-time monitoring of glucose levels from a sensor applied to the skin of the patient (automatic glucose measurement every minute with readings stored in 15-min intervals; each sensor can be worn for up to 14 days).[18,19] Glucose levels can then be easily read by placing an electronic reader or appropriately configured smartphone device over the reader/sensor. This then presents an interstitial glucose at that point in time to be viewed, as well as a continuous pattern of blood sugar since the last time the sensor was read. The time taken to scan the sensors is minimal and can be performed by patients themselves more easily than finger-prick based blood glucose monitoring.

Digital flash glucose systems are recommended in the United Kingdom for certain subsets of patients with diabetes,[20] typically on an outpatient basis. We propose that the use of such glucose monitoring devices offers significant advantages in the context of the current pandemic by allowing closer monitoring of glucose levels with reduced contact time between these patients and the treating healthcare staff. Here, we present the first pilot use of inpatient digitally enabled flash glucose monitoring across a NHS hospital in the United Kingdom, for patients with diabetes that were hospitalized due to COVID-19.

Table 1. Exclusion criteria for inpatient use of flash glucose monitoring devices.

Exclusion criteria
Age under 18 years
Pregnancy
Current hospitalization in an intensive care unit setting
Current hospitalization on an individualised care of the dying pathway
Expected imminent hospital discharge within <24 h

Methods

This pilot was conducted as a service development initiative at the University Hospitals Coventry & Warwickshire NHS Trust (UHCW) following review by the Trust's Research & Development Department COVID-19 Ethics Committee. UHCW is a major tertiary referral centre in the West Midlands region of the United Kingdom with 1064 acute beds. A daily review of all inpatients with a diagnosis of COVID-19 was conducted using the UHCW electronic patient record system between the 21st April 2020 and the 13th May 2020. All inpatients with a confirmed diagnosis of COVID-19 (via polymerase chain reaction testing) and diabetes were considered for initiation of inpatient flash glucose monitoring. Exclusion criteria are listed in Table 1. All eligible inpatients were offered use of a digital flash glucose monitoring system (including both sensors and reader) for the duration of their hospitalisation. Patients who initially met exclusion criteria (i.e. patients initially hospitalised in an intensive care unit setting), but subsequently became eligible were also included. Both inpatients and treating staff were given written instructions regarding the appropriate, safe and effective use of these glucose monitoring devices. An example of the information sheet used is included in Appendix 1; this included details on how to use the scanners, with the readings to be treated similarly to finger-prick blood glucose readings, whilst additional information was given in response to potential/known limitations of the freestyle glucose system, particularly at low glucose readings.

The sensors were scanned by either nurses or the patients. During training with staff, it was encouraged that where patients were able, patients scan their own devices

to reduce exposure/time commitment of staff; however, it was acknowledged that in some patients this would not be possible. Nursing teams would always record the sensor reading and act on it accordingly, as described above at low glucose levels a finger prick test was required. A daily review of all patients using the digitally enabled flash glucose monitoring devices was performed, and devices and sensors were collected prior to discharge with download of data. The review of patients was by ward-based medical teams (doctors and ward nurses), alongside redeployed medical students who were trained to support the implementation of glucose monitoring devices and reported any problems back to the Trust's diabetes team. A descriptive analysis was performed. For this analysis hypoglycaemia was defined as a flash glucose recorded value below 4 mmol (72 mg/dL), whilst hyperglycaemia was defined as a flash glucose value above 11 mmol (198 mg/dL), with "time in range" calculated for the time/duration that the flash glucose values of the patient were recorded as being between these two values. An upper glucose value of 11 was chosen based on the local approach, noting that national guidelines in COVID-19 recommend glucose levels below 10, but accepting a glucose level below 12 (11).

Statistical analyses

Descriptive data reports were generated first, following which, the Shapiro-Wilk test determined that the data were not normally distributed ($p < 0.001$). Accordingly, associations between time in hypoglycaemia, time in hyperglycaemia, time in range, HbA1c, average blood glucose, body mass index (BMI), and length of hospital stay, were tested using the Spearman's Rho correlation coefficient, as appropriate. In addition, a multiple linear regression was performed in order to determine the extent to which length of hospital stay could be predicted. All analyses were conducted in R (R Core Team, 2018), and jamovi software extension (The jamovi project (2019). jamovi. (Version 1.1.7) [Computer Software]. Retrieved from https://www.jamovi.org). Significance was set at p-value < 0.05.

Results

During this pilot, the digitally enabled flash glucose monitoring devices were offered to 25 inpatients with COVID-19 and diabetes, of whom 20 patients (80% uptake) accepted and used the devices during their hospitalization. Three patients declined to use a flash glucose monitoring device, one patient improved rapidly and was discharged before starting to use a device, and a further patient deteriorated rapidly and unfortunately passed away before starting to use a device.

Table 2. Baseline antidiabetic treatment of monitored inpatients.

Baseline Antidiabetic Treatment	Number of patients
Metformin	8
Gliptin	3
Gliclazide	2
Insulin	2
Diet control	7

Of the 20 inpatients that used a digitally enabled flash glucose monitoring device, 10 patients (50%) were male, with 19 patients (95%) having type 2 diabetes and one patient type 1 diabetes. The mean average age of these inpatients was 70.6 years (standard deviation: +/- 14.6), with a mean average HbA1c of 68.2 mmol/mol (8.4%) and a mean average BMI of 28.2 kg/m^2. All these inpatients had at least 2 co-morbidities, with 15 (75%) having at least 3 co-morbidities. The baseline antidiabetic treatment/medications of the monitored inpatients is presented in Table 2 below:

The average length of stay for was 15.85 days, with no fatality or ICU hospitalization in this cohort of 20 inpatients. In total, over 2788 h of continuous glucose monitoring were recorded for these inpatients with COVID-19 and diabetes, with a mean average of 139.4 h per patient. The mean average time the sensor was recorded as being on the patient during the study period was 76%. The breakdown of time in range, time in hyperglycaemia and time in hypoglycaemia is presented in Table 3 below.

Table 4 below presents the (%) median and mean time in hyperglycaemia and hypoglycaemia, as well as the time in range.

Following multiple linear regression analysis, the percentage of time in hypoglycaemia ($p = 0.12$), percentage of time in hyperglycaemia ($p = 0.27$), percentage of time in range ($p = 0.12$), average glucose ($p = 0.21$), HbA1c ($p = 0.24$), and BMI ($p = 0.92$) did not significantly predict length of stay for the inpatients in this cohort (overall model; R^2: 0.25, $p = 0.81$). Moreover, as presented in Table 5, there was no significant association between the length of stay and any of the other tested variables (all p-values >0.05). Percentage of time in hyperglycaemia exhibited statistically significant associations with both percentage of time in hypoglycaemia ($p = 0.035$) and percentage of time in range ($p = 0.005$), as well as with HbA1c ($p = 0.004$) and average glucose ($p < 0.0001$). Finally, the average glucose was also significantly associated with percentage of time in hypoglycaemia ($p = 0.003$), percentage of time in range ($p = 0.01$), and HbA1c ($p = 0.046$).

Table 3. Percentage (%) of patients in time in range, time in hyperglycaemia and time in hypoglycaemia during the flash glucose monitoring.

	Percentage (%) of patients in each category
≥ 50% of readings out of range	25%
≥ 20% of readings out of range	75%
≥ 10% of readings out of range	90%
≤ 10% of readings out of range	10%
≥ 50% of readings in hyperglycaemia	20%
≥ 20% of readings in hyperglycaemia	30%
≥ 10% of readings in hyperglycaemia	40%
≤ 10% of readings in hyperglycaemia	60%
≥ 50% of readings in hypoglycaemia	5%
≥ 20% of readings in hypoglycaemia	15%
≥ 10% of readings in hypoglycaemia	50%
≤ 10% of readings in hypoglycaemia	50%

Table 4. Median and mean time in hyperglycaemia, hypoglycaemia and in range for the monitored in patients (*approx. 5% of missing data).

Time in hyperglycaemia, hypoglycaemia and in range*		
	Median	Mean*
Time in hyperglycaemia (%)	5.03	23.4
Time in hypoglycaemia (%)	9.56	11.3
Time in normal range (%)	56.7	60.2

Discussion

Here, we report the first - to our knowledge - pilot implementation at a teaching NHS hospital of digitally enabled flash glucose monitoring for inpatients with diabetes hospitalized due to COVID-19. This study demonstrates the feasibility of this approach based on the high uptake rate amongst inpatients with diabetes, and the high proportion of time where the inpatients of our cohort had a sensor in use successfully recording glucose levels during their hospitalization. The use of such digital flash glucose monitoring devices in the inpatient setting represents an innovative approach to the hospital care of inpatients with diabetes that is highly relevant in the context of the COVID-19 pandemic. Indeed, the inpatient mortality of COVID-19 with a co-existent diagnosis of diabetes is high, with inpatient mortality estimates around 28%.21 In this pilot, there were no recorded deaths among the recruited patients, potentially due to the applied eligibility criteria that excluded patients hospitalized in the ICU setting. Initially, we had an enhanced approach for the review of all the monitored inpatients, including support from redeployed medical students who were trained to support the implementation of these glucose monitoring devices and report any problems back to the diabetes team. Given the lack of significant problems reported, this enhanced approach was deemed no longer necessary in future iterations of the project and the diabetes team would support to troubleshoot where specific problems were raised by nursing teams.

Interestingly, the present findings demonstrate relatively extended periods of time during which the recruited inpatients were out of the glucose target range, with 20% of inpatients being in hyperglycaemia for over half of the time under monitoring with the applied glucose sensors (Table 2). Of note, despite the fact that, with the exception of one patient, the recruited inpatients had T2DM, there was also a relatively high proportion of time spent in hypoglycaemia, with over half of these patients having ≥10% of the recorded readings in hypoglycaemia. These are important and clinically relevant observations - as it has been noted that well-controlled blood glucose levels result in better outcomes in patients with COVID-1922 - which may have been lost if the typical "finger-prick" based glucose monitoring approach was followed during the hospitalization of these patients with T2DM. The increased time in hypoglycaemia may be, at least in part, due to decreased appetite of hospitalized individuals with COVID-19, whilst a number of inpatients were also on baseline treatment with gliclazide and insulin; however, due to the small number of participants in this pilot, it is not possible to draw definite conclusions on the cause(s) contributing to this increased time in hypoglycaemia. Of note, this pilot was performed before the widespread use of dexamethasone as a treatment for COVID-19, and, hence, it is plausible that later cohorts of patients receiving dexamethasone as COVID-19 treatment may subsequently exhibit increased glucose levels. As obesity is an additional key risk factor for adverse COVID-19 related outcomes,[23–27] these findings further highlight the need for careful glucose monitoring during the hospital care of patients with T2DM and COVID-19. The present findings did not show significant associations between the length of stay of the recruited inpatients and key glucose control parameters based on the flash monitoring readings, potentially due to the small

Table 5. Correlation matrix between selected variables of interest.

		Length of Stay	%HYPER	%HYPO	%TIR	BMI	HbA1C	Average Glucose
Length of Stay	Spearman's rho	–						
	p-value	–						
%HYPER	Spearman's rho	0.257	–					
	p-value	0.272	–					
%HYPO	Spearman's rho	0.359	−0.473	–				
	p-value	0.119	0.035*	–				
%TIR	Spearman's rho	−0.358	−0.587	0.206	–			
	p-value	0.1203	0.005**	0.383	–			
BMI	Spearman's rho	0.029	0.142	0.144	0.401	–		
	p-value	0.916	0.611	0.607	0.137	–		
HbA1C	Spearman's rho	0.278	0.607	−0.182	−0.351	0.148	–	
	p-value	0.235	0.004**	0.442	0.128	0.597	–	
Average Glucose	Spearman's rho	0.2057	0.8903	−0.624	−0.56	−0.139	0.451	–
	p-value	0.384	< .0001***	0.003**	0.01*	0.62	0.046*	–

%HYPER: percentage of time in hyperglycaemia; %HYPO: percentage of time in hypoglycaemia: %TIR: percentage of time in range; BMI: Body Mass Index; HbA1c: glycated haemoglobin. * $p < .05$; ** $p < .01$; *** $p < .001$.

sample size of this pilot. Finally, statistically significant associations were also noted between different measures of glycaemic control (including time in range, time in hyperglycaemia time in hypoglycaemia, average glucose, and HbA1c; Table 3), which are important surrogate markers shown to have an impact on outcomes for patients with COVID-19 and diabetes[23–26]. Notably, the FDA has issued guidance for the US on the potential use of flash glucose monitoring devices in the hospital setting during the COVID-19 pandemic (www.fda.gov/medical-devices/blood-glucose-monitoring-devices/faqs-home-use-blood-glucose-meters-utilized-within-hospitals-during-covid-19-pandemic), and approaches similar to the one we describe in this UK pilot are also being explored abroad, mainly in the US[26–31].

Study limitations

This pilot study has certain limitations. As aforementioned, the relatively small sample size may explain the lack of statistically significant associations between the length of stay of the recruited inpatients and recorded glucose control parameters. A large, multi-centre study would help identify whether inhospital use of digital flash glucose monitoring may impact on such outcomes (e.g. length of stay) for inpatients with diabetes and COVID-19. In addition, all, but one, of the recruited inpatients of our cohort had T2DM, thus further studies are clearly required to explore this approach for inpatient glucose monitoring for patients with T1DM and COVID-19.

An additional study limitation is that during this pilot, due to the pressures from the pandemic on the hospital wards, objective data/measurements were not collected regarding the staff's reduced exposure to the monitored inpatients with COVID-19, or the potential for staff time saved, as a consequence of using these glucose monitoring devices. Anecdotally, the implementation of these devices in the context of this pilot was also successful in relationship to such exposure/time saving aspects, as also indirectly evidenced by a large volume of received requests from ward nursing teams for such glucose monitoring devices to support their patients. Developing a further understanding of the use of these devices to support busy ward nursing teams both in relation to COVID-19 and more generally would represent important further work.

Conclusions and proposals for relevant future research

The COVID-19 pandemic has created particular challenges for the management of inpatients with diabetes. Good glycaemic control has been shown to be crucial for COVID-19 related outcomes in such patients. The use of digitally enabled flash glucose monitors in the manner described in this pilot study facilitates monitoring of glucose levels more frequently on a real-time basis, allowing prompt interventions to maintain glucose targets during the hospitalization. While here we demonstrate the feasibility of this approach in the setting of an NHS hospital, further research is needed to explore the benefit of digitally enabled flash glucose monitoring in the inpatient setting in relation to COVID-19 outcomes.

Moreover, this approach reduces the healthcare staff exposure to potentially infectious patients with COVID-19. Additional research is also required to further study this aspect and quantify the potentially reduced risk of staff members treating such patients with COVID-19 in the hospital setting. We propose that such further work could include considering patient and staff perceptions of the use of flash glucose devices in the inpatient care setting. Wider use in this setting would require education of staff members, and potentially changes to the design of devices so that a single reader could be used to evaluate multiple different patients simultaneously wearing a sensor, with feedback to a central database with direct links to electronic patient records.

Finally, due to the objectives of this study, all glucose monitoring sensors were removed from patients at the time of discharge from the hospital. However, it is likely that COVID-19 may result in longer term problems for patients with diabetes following discharge due to a number of potential problems, such as fatigue and impaired appetite, which can potentially further impact on glycaemic control. Moreover, there is emerging evidence that the underlying pathophysiology of the SARS-CoV-2 infection may negatively influence the pancreas and glycaemic control in patients with COVID-19[32–34]. We therefore propose that urgent research work is also needed to consider the use of these digitally enabled glucose monitoring devices in patients with diabetes and COVID-19 following discharge from the hospital, supporting a more effective integrated care based approach for management of such patients following the acute SARS-CoV-2 infection.

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References

1. Willan J, King AJ, Jeffery K, et al. *Challenges for NHS hospitals during covid-19 epidemic*. London: British Medical Journal Publishing Group, 2020.
2. Muniyappa R and Gubbi S. COVID-19 pandemic, coronaviruses, and diabetes mellitus. *American Journal of Physiology-Endocrinology and Metabolism* 2020; 318: E736–E741.
3. Apicella M, Campopiano MC, Mantuano M, et al. COVID-19 in people with diabetes: understanding the reasons for worse outcomes. *The lancet Diabetes & endocrinology* 2020; 8: 782–792.
4. Barron E, Bakhai C, Kar P, et al. Associations of type 1 and type 2 diabetes with COVID-19-related mortality in England: a whole-population study. *The lancet Diabetes & endocrinology* 2020; 8: 813–822.
5. Holman N, Knighton P, Kar P, et al. Risk factors for COVID-19-related mortality in people with type 1 and type

2 diabetes in England: a population-based cohort study. *The lancet Diabetes & endocrinology* 2020; 8: 823–833.
6. Lancet T. COVID-19: protecting health-care workers. *Lancet (London, England)* 2020; 395: 922.
7. Lim S, Bae JH, Kwon H-S, et al. COVID-19 and diabetes mellitus: from pathophysiology to clinical management. *Nature Reviews Endocrinology* 2020; 17: 1–20.
8. Bornstein SR, Rubino F, Khunti K, et al. Practical recommendations for the management of diabetes in patients with COVID-19. *The lancet Diabetes & endocrinology* 2020; 8: 546–550.
9. Sinclair A, Dhatariya K, Burr O, et al. Guidelines for the management of diabetes in care homes during the Covid-19 pandemic. *Diabetic medicine : a journal of the British Diabetic Association.* 2020; 05: 1090–1093.
10. Kyrou I, Robbins T and Randeva HS. COVID-19 and diabetes: no time to drag our feet during an untimely pandemic. *J Diabetes Complicat* 2020; 34: 107621.
11. Rayman G, Lumb A, Kennon B, et al. Guidelines for the management of diabetes services and patients during the COVID-19 pandemic. *Diabetic Med* 2020; 37: 1087–1089.
12. Zha L, Li S, Pan L, et al. Corticosteroid treatment of patients with coronavirus disease 2019 (COVID-19). *Med J Aust* 2020; 212: 416–420.
13. Alessi J, De Oliveira GB, Schaan BD, et al. Dexamethasone in the era of COVID-19: friend or foe? An essay on the effects of dexamethasone and the potential risks of its inadvertent use in patients with diabetes. *Diabetol Metab Syndr* 2020; 12: 1–11.
14. Hasan SS, Kow CS, Bain A, et al. Pharmacotherapeutic considerations for the management of diabetes mellitus among hospitalized COVID-19 patients. *Expert Opin Pharmacother* 2020; 12: 1–12.
15. Rayman G, Lumb A, Kennon B, et al. Dexamethasone therapy in COVID-19 patients: implications and guidance for the management of blood glucose in people with and without diabetes. *Diabetic Med* 2021; 38: e14378.
16. Matthay MA and Thompson BT. Dexamethasone in hospitalised patients with COVID-19: addressing uncertainties. *The Lancet Respiratory Medicine* 2020; 8: 1170–1172.
17. Leelarathna L and Wilmot E. Flash forward: a review of flash glucose monitoring. *Diabetic Med* 2018; 35: 472–482.
18. Blum A. Freestyle libre glucose monitoring system. *Clin Diabetes* 2018; 36: 203–204.
19. Bidonde J, Fagerlund BC, Frønsdal KB, et al. FreeStyle Libre Flash Glucose Self-Monitoring System: A Single-Technology Assessment 2017.
20. Iacobucci G. *NHS England tells CCGs to end postcode lottery over diabetes glucose devices*. London: British Medical Journal Publishing Group, 2018.
21. Bode B, Garrett V, Messler J, et al. Glycemic characteristics and clinical outcomes of COVID-19 patients hospitalized in the United States. *J Diabetes Sci Technol* 2020; 14: 813–821. doi: 10.1177/1932296820924469.
22. Zhu L, She Z-G, Cheng X, et al. Association of blood glucose control and outcomes in patients with COVID-19 and pre-existing type 2 diabetes. *Cell Metab* 2020; 6: 1068–1077.
23. Hamer M, Gale CR and Batty GD. Diabetes, glycaemic control, and risk of COVID-19 hospitalisation: population-based, prospective cohort study. *Metab Clin Exp* 2020; 112: 154344.
24. Wilmot E, Lumb A, Hammond P, et al. Time in range: a best practice guide for UK diabetes healthcare professionals in the context of the COVID-19 global pandemic. *Diabetic Med* 2020; 38: e14433.
25. Naruse K. Does glycemic control rescue type 2 diabetic patients from COVID-19-related deaths? *J Diabetes Investig* 2020; 11: 792–794.
26. Wallia A, Prince G, Touma E, et al. Caring for hospitalized patients with diabetes mellitus, hyperglycemia, and COVID-19: bridging the remaining knowledge gaps. *Curr Diab Rep* 2020; 20: 1–11.
27. Ushigome E, Yamazaki M, Hamaguchi M, et al. Usefulness and safety of remote continuous glucose monitoring for a severe COVID-19 patient with diabetes. *Diabetes Technol Ther* 2021; 23: 78–80.
28. Shehav-Zaltzman G, Segal G, Konvalina N, et al. Remote glucose monitoring of hospitalized, quarantined patients with diabetes and COVID-19. *Diabetes Care* 2020; 43: e75–e76.
29. Reutrakul S, Genco M, Salinas H, et al. Feasibility of inpatient continuous glucose monitoring during the COVID-19 pandemic: early experience. *Diabetes Care* 2020; 43: e137–e138.
30. Singh LG, Satyarengga M, Marcano I, et al. Reducing inpatient hypoglycemia in the general wards using real-time continuous glucose monitoring: the glucose telemetry system, a randomized clinical trial. *Diabetes Care* 2020; 43: 2736–2743.
31. Fortmann AL, Bagsic SRS, Talavera L, et al. Glucose as the fifth vital sign: a randomized controlled trial of continuous glucose monitoring in a non-ICU hospital setting. *Diabetes Care* 2020; 43: 2873–2877.
32. Mallapaty S. Mounting clues suggest the coronavirus might trigger diabetes. *Nature* 2020; 583: 16–17.
33. Liu F, Long X, Zhang B, et al. ACE2 Expression in pancreas may cause pancreatic damage after SARS-CoV-2 infection. *Clin Gastroenterol Hepatol* 2020; 18: 2128.
34. Muniangi-Muhitu H, Akalestou E, Salem V, et al. Covid-19 and diabetes: a Complex bidirectional relationship. *Front Endocrinol (Lausanne)* 2020; 11: 758.