Remote delivery of diabetes care within hospital: A natural experiment

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ABSTRACT

Aim: This study aimed to assess if changes in the way healthcare was delivered during the recent COVID-19 pandemic resulted in a deterioration in the specialist support for people with diabetes in hospital. Was the provision of remote specialist inpatient diabetes care associated with measurable change in the quality of diabetes care provided in hospital?

Method: We compared outcomes of the PWCD group with the Patients With COVID-19 (PWC) group, without diabetes. We also compared the quality of care of a subset of PWCD with a matched group of people with diabetes but no COVID-19 infection (PWD).

Results: 74 of 411 people with COVID-19 admitted, had diabetes (PWCD). Mean length of stay was slightly longer for the PWCD group. The diabetes group were significantly older and had a significantly higher BMI.

Prescription errors were significantly higher in the PWCD group compared to PWD (29 vs. 14). Diabetes medication administration errors were also found to be higher in the PWCD group compared to PWD (84 vs. 20). Interestingly, number of good glucose days (4 to 12 mmol/L) was marginally better in the PWCD group (15) compared to PWD (13).

Conclusion: The novel finding of this study is that the quality of diabetes care was worse for the COVID and diabetes cohort. These data emphasise that direct contact between the specialist diabetes team, the PWD and the ward team remains very important in delivering good care. Consideration needs to be given to reducing risk if care is delivered remotely.

Introduction

The management of people in hospital with diabetes is a rapidly developing sub-speciality area of diabetes care. In comparison with other diabetes specialities, it is an area with a relatively poor evidence base to support change. This is because of the difficulty in designing controlled studies in such a complex population with variably comorbidities and varying health needs.

With the increasing use of information technology, the inpatient diabetes team now can oversee the diabetes care of a greater proportion of the hospital population and provide care for people with diabetes in hospital remotely [1-3]. This concept is now being extrapolated to the development of virtual wards where hospital specialists deliver care to people at sites outside of the hospital.

One of the key roles of the inpatient diabetes team is monitoring and adjusting diabetes treatment in the face of acute illness to produce optimal glucose control. A second key role is training

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and supporting the ward staff to understand why a particular regimen is suggested and what potential problems may develop with this treatment. It is possible therefore that although remote delivery of care may allow access to a wider group of people, the care of this group may not be as good. Designing an experiment to test this hypothesis would be complex and, to date, has not been performed. The COVID pandemic forced a sudden and dramatic change to the way that inpatient diabetes care was delivered with a sudden switch to care being delivered almost entirely remotely for one group of patients, with standard care being simultaneously provided for a second group. This provided the opportunity to compare the two models of care.

The COVID-19 pandemic led to rapid and unexpected changes in the way that we deliver healthcare. Because of the risk of spreading infection face to face contact with infected individuals was reduced. Patient care was provided in isolated wards with complex procedures for donning and removing personal protective equipment. This resulted in difficulties in communication between health-care professionals directly delivering care on the ward and specialists outside of the ward supporting that care. In addition, specialists that would normally support diabetes care in hospital were redeployed to cover staff sickness or provide non-specialist roles. It is possible that the changes in the delivery of diabetes care associated with the pandemic may in themselves have contributed to poor outcomes for people with diabetes in hospital. It is clear from a large number of studies that diabetes mellitus in itself is associated with poor outcomes following COVID- 19 infection [4-11]. Our study asks the question; did a change to remote delivery of healthcare result in a deterioration in the specialist support for people with diabetes in hospital. Was the provision of remote specialist inpatient diabetes care associated with measurable change in the quality of diabetes care provided in hospital.

Methodology

There were two parts to this study. The first was an analysis of initial presentation and subsequent outcome for People With Diabetes (PWD) and COVID-19 based on a register of all patients admitted to University Hospital Plymouth (UHP) with COVID-19 between January and June 2020. This group was compared with the total population of PWD admitted to hospital in the same period. The second part of the study involved a detailed notes-based analysis of the provision of diabetes care to a subset of the COVID-19 diabetes population. This group were compared with a gender and aged matched group of PWD admitted with other acute medical conditions but excluding COVID-19.

University hospital Plymouth is a 950-bed teaching hospital. It provides the regional centre of cardiothoracic surgery, neurosurgery, stroke services and renal transplantation. There are approximately 200 PWD in hospital each day. The inpatient diabetes team looking after acute admissions consists of six part time specialist diabetes nurses supported by two health care assistants. At the time of this study, the team provided a five day/week service. A specialist diabetes consultant and registrar provide six hours/day of ward support with 1 hour/day on weekends. A separate team of three specialist nurses provide support for PWD undergoing elective procedures and surgery. The electronic patient management system flags all PWD admitted to hospital. All point of care glucose and ketone measurements performed throughout the hospital are recorded centrally and reviewed daily by the diabetes team [12]. The ward-based teams can refer directly to the diabetes team by telephone or an electronic referral system. The day-to-day clinical work of the team involves responding to referrals as well as identifying patients that require review based on out-of-range point of care glucose or ketone measurements. At the time of this analysis there was variable disruption to the inpatient diabetes nurse team due to redeployment and ill health within the team. There was no disruption to the specialist doctor team over the study period.

We have retrospectively studied the care of people with COVID-19 admitted to UHP in the first six months of the pandemic. A hospital register of all patients who were diagnosed with COVID-19 based on polymerase chain reaction analysis was maintained from the time that patients started attending the hospital. We have included all people admitted to hospital between January and June 2020 with a diagnosis of COVID-19 at the time of admission or who were subsequently diagnosed with COVID-19 during the admission. We have compared the COVID-19 group without a diagnosis of diabetes with a group of all individuals with a diagnosis of COVID-19 and diabetes at or prior to the time of admission. Detailed data relating to comorbidities, severity of illness at admission

and subsequent outcomes were available for these two groups. We compared length of stay and mortality for these two groups with the entire hospital population admitted in that six-month period based on hospital coding data.

A subset of these populations were then studied in more detail to assess quality of diabetes care and diabetes specific outcomes. A sample of 30 PWD and COVID-19 were selected from the total cohort for further analysis. An age and gender matched group of 30 PWD admitted acutely with diagnosis other than that of COVID-19 were analysed. Due to problems with data quality only 29 of this group were included in the final analysis. This group had negative tests for COVID-19 on admission and were not suspected to have this condition. Subsequent COVID-19 tests performed during the admission for this group were negative.

A prospective electronic record of all PWD that are managed by the inpatient specialist diabetes team is maintained. This contains details of the type and number of contacts that the team has in caring for that person. This could be a direct face to face contact on the ward or a telephone conversation with ward staff to obtain clinical information and provide advice. All point of care glucose and ketone measurements are uploaded to a central source. An alternative for the diabetes team was a virtual review of glucose control performed at a distance from the ward (usually the diabetes office). In addition to contacts with the diabetes team a paper notes-based analysis of diabetes medication prescription, diabetes medication administration and the clinical record detailing decisions about diabetes care was performed. At that time, the prescription of medications was paper based. All the glucose and ketone tests performed for each individual were analysed and compared with the prescription chart to ensure the appropriateness of the prescription. Optimal glucose control was considered to be readings between 6-12 mmol/L with readings between 4-6 mmol/L acceptable. The number of glucose readings above or below the target range and the number of days of readings with glucose within target range were recorded. Diabetes medication prescription and administration errors were recorded using the methodology developed by the National Diabetes Inpatient Audit (NADIA). Examples of prescription errors would include the incorrect name of the insulin type, the medication not signed for, or the medication prescribed at the wrong time. Examples of administration errors would include medication not being adjusted down in response to hypoglycaemia or adjusted up in response to hyperglycaemia (without explanation in the clinical record for the decision).

Differences between groups were compared using one way analysis of variance or the Kruskal-Wallis test depending upon the distribution of the data (SPPS *vs* 25). Categorical variables were compared using fisher's exact test. The study was approved and registered with the audit department at plymouth hospitals NHS trust CA_2020-21-017. Ethical review and consent were not required for this study.

Results

Between January and June 2020 411 people with COVID-19 were admitted to university hospital plymouth. Seventy-four people had an additional diagnosis of diabetes mellitus. Over the same period 6050 other PWD but without COVID-19 were admitted to hospital for elective and emergency care. **TABLE 1** compares the demographic data for these three groups of inpatients. The two groups with COVID-19 diagnoses were significantly older and had a significantly longer length of stay compared with the total hospital population. Mortality was significantly higher for the COVID-19 groups. Comparison within the two COVID-19 groups showed that PWD were the same age but did have a longer length of stay. There was a trend towards higher mortality in the COVID-19 PWD group, but this did not achieve significance.

TABLE 2 examines markers of severity of illness at presentation for the complete population of those admitted with COVID-19 and COVID-19 PWD. This is compared with a subset of 29 PWD admitted as medical emergencies but without COVID-19. There was trend towards higher weight and body mass index, but this did not achieve significance. Respiratory rate was higher for the two COVID-19 groups as would be expected with an illness presenting as respiratory disease. The National Early Warning Score (NEWS) is used in the United Kingdom as a composite measure of vital signs [13]. There was a trend towards higher score for the COVID-19 groups, but this did not achieve significance. Lactate, creatinine, CRP were all significantly higher in the COVID-19 groups with a lower total white blood cell count than the other acute admission group.

TABLE 1: Demographic data for the three cohorts.					
	COVID-19	COVID-19 and Diabetes	Diabetes without COVID-19	P for difference between three groups	P for difference between COVID groups
N	337	74	6050		
Gender male (%)	178 (52.8)	42 (56.7)	3298 (54.5)	0.116	-
Age years mean (SD)	75.5 (16.4)	77.7 (13.4)	71.6 (13.5)	<0.001	0.836
Number COVID diagnosed during hospital admission (%)	89 (26.4)	19 (25.7)	N/A	-	0.183
Length of stay Mean (SD) Median IQR)	15.0(14.5) 10 (15)	19.1 (17.4) 14 (16.7)	5.0 (7.7) 2 (5)	<0.001	<0.001
Mortality in hospital (%)	84 (24.9)	21 (29.6)	600 (9.9)	<0.001	0.493

TABLE 2: Markers of severity of illness on admission for the 3 groups.					
	COVID-19	COVID-19 PWD	PWD without COVID-19 (Subset of 29 patients)	P for difference between groups	P for difference between Covid groups
N	337	74	29		
Observations on admission					
Weight Kg (SD)	82.2 (23.8)	85.0 (24.1)	76.9 (20.7)	0.301	-
Body mass index Kg/m^2 (SD)	28.5 (6.8)	29.8 (7.6)	28.3 (6.2)	0.518	-
Systolic BP Mean (SD)	132 (20)	138 (25)	134 (24)	0.061	-
Diastolic BP Mean (SD)	76 (13)	77 (16)	77 (15)	0.242	-
Heart Rate Mean (SD)	89 (20)	90 (22)	82 (22)	0.213	-
Respiratory Rate Median (IQR)	22 (8)	21 (6)	19 (6)	0.007	0.102
Temperature Mean (SD)	37.7 (1.1)	37.5 (1.2)	NA	0.384	-
NEWS Mean (SD)	4.3 (3.1)	4.3 (2.8)	2.9 (3.8)	0.095	-
Laboratory findings					
Oxygen saturation Median IQR	94 (7)	94 (6)	NA		0.748
Lactate Median IQR	1.30 (0.85)	1.60 (1.10)	1.40 (1.25)	0.047	0.012
Creatinine Median IQR	88 (48)	107 (58)	104 (63)	<0.001	0.001
CRP Median IQR	78 (112)	84 (116)	11 (88)	0.001	0.987
WBC Median IQR	7.6	7.5	10.9	0.001	0.906
HbA1c Mean (SD)	40 (5)	69 (26)	64 (23)	<0.001	<0.001

The COVID-19 PWD group had a higher lactate and creatinine than the COVID-19 group suggesting more severe illness at presentation for diabetes and COVID-19 combined. The COVID-19 PWD group had worse glucose control prior to admission; HbA1c was higher for the COVID-19 PWD group than for the comparator group of PWD without COVID-19.

TABLE 3 compares demographic data for the two groups of PWD admitted as an emergency who were then used to compare quality of diabetes care. The two groups were well matched for gender and age. The COVID-19 group had a longer length of stay (in agreement with the whole cohort data in **TABLE 1**. Despite being well matched for weight and body mass index the COVID-19 group were significantly frailer at the time of admission with a median Rockwood score of 6 (moderate frailty–people need help with all outside activities and keeping house) vs. 4 (described as vulnerable but independent) prior to admission [14].

TABLE 4 compares diabetes treatment, insulin usage, insulin dosing prior to admission and blood glucose measurement at the time of admission. There were no significant differences between groups for any of these measures.

TABLE 5 compares the quality measures of diabetes management for the two cohorts of PWD that underwent a detailed notes-based review of diabetes care. There were a wide range of glucose readings for both groups, but very low rates of hypoglycaemia as might be expected with cohorts of individuals with predominantly type 2 diabetes. Comparing the first three days of the admission there were no significant differences in glucose control. administration errors in the COVID-19 groups. Examples of common errors included missing doses Diabetes prescription charts for the full length of each admission were analysed and cross-references with the glucose readings and clinical notes. There was no difference in prescription error rates between the two groups although the rates were relatively high for both groups (approximately one prescription error for each person admitted. There were however a significantly higher number of diabetes medication of oral medication/ insulin or delaying dosing of medication. If capillary glucose was consistently high and medication was not adjusted without justification in the clinical notes, then this was also recorded as an administration error. Rates of administration errors were relatively high for both groups but particularly for the COVID-19 group (3.7 errors per individual). Glucose testing was performed appropriately for most people in both groups with no difference between groups. Having measured blood glucose, medication was adjusted in response to hyperglycaemia in a much lower proportion of days resulting in approximately half of the admission having glucose values within the expected range. There was no difference between groups in overall glucose control.

TABLE 3: Characteristics of a subset of the diabetes groups used to compare quality of diabetes care during the admission.

	COVID-19 PWD	PWD without COVID-19	P for difference
N	30	29	
Gender male (%)	19(63)	18 (62)	0.92
Age years mean (SD)	76.5 (12.7)	77.6 (11.2)	0.727
Length of stay Mean Median	15.8 (14.4) 10.5 (13.5)	8.9 (6.5) 7 (6.5)	<0.001
Weight mean (SD)	85.5 (19.5)	76.9 (20.7)	0.255
BMI mean (SD)	30.0 (6.2)	29.8 (7.6)	0.407
Rockwood score Median (IQR)	6.0 (1.8)	3.9 (1.7)	0.027

TABLE 4: Diabetes medications and glucose control on admission.

	COVID and Diabetes	Diabetes without COVID	
N	30	29	
Type of diabetes	T1-1, T2-29	T1-1, T2-28	
Oral medications			
Metformin	12	15	
Pioglitazone	1	0	
Gliclazide	6	3	
DPP4	8	4	
SGLT2i	4	2	
GLP1	2	0	
Type of insulin			
Basal	10	5	
Basal bolus	1	6	
Pre- mixed	3	4	
			p for difference
Total Insulin units/day on admission mean (SD)	39 (34)	41 (19)	0.865
Insulin maximum units/ day during the admission mean (SD)	41 (33)	32 (19)	0.533
Glucose on admission mean (SD)	11.3 (6.7)	12.7 (8.7)	0.503

TABLE 5: Quality measures of diabetes management during the admission.

	COVID and Diabetes	Diabetes without COVID	P for difference
N	30	29	
CBG range first 3 days	3.9- 37.0	3.2- 43.0	
Minimum glucose	7.6 (3.2)	7.1 (2.8)	0.559
Maximum glucose mean (SD)	14.5 (6.6)	12.9 (7.9)	0.332
Diabetes medication prescription errors total errors	37	24	
Mean (SD)	1.2 (1.6)	0.8 (0.9)	0.196
Diabetes medication administration errors total errors	100	25	
Mean (SD)	3.7 (4.6)	0.9 (1.5)	0.009

Number of days of appropriate glucose testing Mean (SD)	11.0 (12.4)	6.8 (5.9)	0.133
Number of days of appropriate testing as proportion of total stay	0.9 (0.7)	0.8 (0.3)	0.569
Number of good glucose days (4 to12mmol/L) Mean (SD)	6.0 (10.0)	4.5 (5.6)	0.59
Number of good glucose days as a proportion of total stay	0.5 (0.4)	0.4 (0.3)	0.761
Contact with the diabetes team			
Diabetes team involved in care	Yes 9	Yes 17	0.025
	No 21	No 12	
Total contacts per individual Mean (SD) Median (IQR)	 1.5 (1.7) 0 (2)	 2.2 (2.4) 1 (4)	 0.323
Total number of face-to-face contacts Mean (SD) Median (IQR)	 0.2 (0.7) 0 (0)	 1.0 (1.3) 1 (2)	 0.003
Total number of virtual contacts Mean (SD) Median (IQR)	 0.4 (1.0) 0 (0)	 0.4 (0.8) 0 (1)	 0.953
Total number of telephone contacts Mean (SD) Median (IQR)	 0.9 (1.8) 0 (1.2)	 0.7 (1.0) 0 (1.0)	 0.584

Despite the COVID-19 group having more severe illness and worse diabetes control at the time of admission they had less input from the specialist diabetes team. A significantly higher proportion of the group without COVID-19 were reviewed by the specialist diabetes service. Analysing the type of contact there was significantly less direct contact with a diabetes specialist for COVID-19 PWD group. This was matched by a trend towards slightly more telephone contacts for this group although this did not achieve significance.

Discussion

The novel finding of this study is that diabetes care was primarily delivered to this acutely unwell group of PWD remotely and achieved similar levels of blood glucose control to the traditional model of face-to-face care delivery. There was however a deterioration in the delivery of diabetes care to the remote delivery group. There was a higher rate of medication administration errors. One of the key roles of the diabetes team is one to one training and support for the clinical teams delivering ward care. The absence of this does have a measurable effect on care delivery.

We have analysed the presentation and outcome of the complete hospital population of people with diabetes that presented with COVID-19 over a six-month period at the start of the pandemic in the UK. We have compared this group with the group of all people presenting with COVID-19 and the total hospital population

admitted with diabetes mellitus. We conclude, in line with most previous publications, that PWD and COVID-19 have worse outcomes than a simultaneous group of PWD without COVID-19 and worse outcomes than a cohort of people with COVID-19 but without diabetes [4-11]. Length of stay and mortality are both higher for the COVID-19 PWD group. While these data essentially confirm the findings of previous studies, they do support the view that the cohort being studied is comparable with other cohorts. This suggests that the novel findings relating to quality and outcomes of diabetes care in hospital would also be applicable across other sites.

Having described the whole cohort, a more detailed analysis of the clinical records was then performed to compare the severity of illness at presentation for the three groups. Overall, the results show that people with COVID- 19 had more severe illness at presentation than the general population of PWD at the time of acute admission. But, in addition to this the group who also had diabetes mellitus were more unwell on admission. This is inferred by previous work, but few studies have directly reported this at the time of presentation [10,11,15]. Most published work has focussed on the group that were admitted to intensive care where data are gathered on the most acutely unwell at a slightly later stage in their admission. These data again suggest that the inflammatory response in this disease is greater in the PWD at the time of presentation [9].

Using the clinical notes, diabetes specialist team records and bedside charts we then analysed whether COVID-19 impacted on the quality of diabetes care provided in hospital. As analysis of paper notes is complex and requires a significant amount of specialist time a subset of the COVID-19 PWD were compared with a matched subset of acute admissions of PWD without COVID-19. The admissions for both groups were over the same period so that the diabetes team looking after both groups were the same. The two groups were well matched but the length of stay for the COVID-19 PWD remained significantly longer. The most significant finding from the analysis was that there were significantly more errors in administration of diabetes medication to the group with COVID-19. There was a trend towards more prescription errors although this did not achieve significance.

Despite demonstrating a problem with administration and adjustment of diabetes medication this did not translate into a difference in overall glucose control although this is perhaps not surprising with the significant variability in glucose measurements and both groups showing relatively poor glucose control. There was a trend towards higher glucose values over the course of the admission for the COVID-19 group but with considerable variation in glucose values and the difference did not achieve significance. Both groups showed relatively poor glucose control with approximately half of the time in hospital showing what is considered to be optimal levels (capillary glucose readings between 4-12 mmol/l) [16]. This compares with the most recent National Diabetes Inpatient Audit showing 73% (5.1 days out of a 7-day period) of UHP patients having glucose readings within the same range. The comparable national data for NADIA shows 66% of readings within range [17]. https://files.digital.nhs.uk/F6/49FA05/NaDIA%202019%20-%20Full%20Report%20v1.1.pdf. It is likely that changes in working practices forced by the pandemic had impacted on the care of both groups but more on the group with enhanced isolation procedures.

The response of the specialist diabetes team differed between the two groups. Those with COVID-19 PWD were less likely to be seen by the diabetes team. Only 30% of the COVID-19 PWD group had any contact with the diabetes team compared with 59% for the non-COVID-19 group. There were also significant differences in the type of contact with a very small number of face-to-face contacts for the COVID-19 group.

A strength of this study is the detail of the measurements available for each subject and the detail of specialist diabetes care that was provided. We have been able to demonstrate differences in several clinical measures at the time of admission supporting the view that the cohort of PWD had more severe disease before admission. For the first time we have been able to study the impact of changing working practices associated with the COVID-19 pandemic and the impact on care provided to individuals in hospital. As both groups studied were inpatients at the same time this reduces the impact of other factors such as varying staffing levels as a cause for the differences observed. Although there are several publications describing the remote delivery of diabetes out of hospital this is the first to focus on the impact of remote delivery of care within the hospital setting [18,19].

Conclusion

A limitation of the study is that we have only been able to show an association between care provided and diabetes outcomes. Hospital systems are complex, and it is possible that other differences in the way wards are run may have contributed to changes in the rates of medication errors. As one of the key roles of the diabetes specialist team is to support and coach the ward teams in the correct management of insulin and other diabetes medications it would seem intuitively likely that reduced contact with the patient and carers directly contributed to a deterioration in delivery of care.

There are some general conclusions that can be drawn. Information technology allows us to now deliver care at a distance. It is possible to remotely review glucose control and electronic prescriptions for the whole hospital without visiting a ward. This is more time efficient but may not deliver the same quality of care. These data emphasise that direct contact between the specialist diabetes team, the PWD and the ward team remains very important in delivering good care. With the rapid acceleration in the delivery of remote diabetes care these results are important. Consideration needs to be given to reducing these risks in the future.

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