Background

Data from the National Inpatient Diabetes Audit (NADia) in 2017 suggest that one in 15 people in the total United Kingdom population have a diagnosis of diabetes, and approximately one in six hospital beds are occupied by patients with diabetes.1 Diabetes is a significant problem in hospitalised patients as they are generally older, have multiple comorbidities and often experience an increased duration of inpatient stay.2 In hospitals, acutely unwell patients with diabetes are more susceptible to hyperglycaemia, hypoglycaemia and ketosis due to acute illness, stress, dehydration, inactivity, diet, changes in nutrition status and medication-related issues, including errors.2–5

Diabetes inpatient specialist nurses (DISNs) are trained to manage specific problems that patients with diabetes may experience while in hospital to provide more specialised care than general ward staff. They aim to provide patient-centred care that helps identify and alleviate potential diabetes-related issues before they result in harm to the patients.6 Interventions provided by DISNs typically include monitoring blood glucose, managing medication and providing support and advice to both the patient and the primary care team, with a strong emphasis on education.7 Point-of-care testing (POCT) is used by DISNs to enable clinical decisions to be made at the time of assessment, allowing fast diagnosis, monitoring and treatment.2,8 Studies have reported that POCT is associated with improved patient satisfaction and better
glycaemic control. This is important because patients with diabetes who are admitted into hospital are associated with poorer clinical outcomes, including having an increased length of stay (LOS) and a higher risk of readmission and mortality within 30 days. In addition to the excess cost associated with increasing LOS, increased LOS can predispose patients to increasing hospital-related pathologies, such as thromboembolism and hospital-related infections.

Further, previous data for 2008 to 2010 showed that emergency readmission rates within 28 days for patients with diabetes were 59% higher than for the non-diabetic hospital population. The NADDa audit published in 2011 found that the risk of death for patients with type 1 diabetes was 2.6 times higher than for the general patient population and 1.6 times higher for those with type 2 diabetes. However, it is unclear whether the introduction of a point-of-care (POC) system in acute emergency medical wards that highlights significant hypoglycaemia, hyperglycaemia or ketosis to trigger ward visits by the Diabetes Inpatient Specialist Nurse Outreach (DISN) service improves LOS, 30-day readmission and mortality rates.

Methods
This was a retrospective clinical data analysis performed at The Royal Derby Hospital. A POC-DISN proactive review service was introduced to the hospital in January 2018; an Abbott FreeStyle Precision Pro System was installed across all wards and set up an ‘out of range’ dashboard alerting the DISN of all glucose values <4mmol/L or >27.8mmol/L and of all positive ketones. The DISN reviews this dashboard every morning and will intervene to change medications; education is provided to patient and ward staff through distance management or by face-to-face, whichever is appropriate.

Patient data were collected from two time periods: six months (February to July) in 2017 pre-intervention and six months (February to July) in 2018, post the introduction. Four acute emergency wards were investigated: the intensive care unit (ICU), the medical assessment unit (MAU) and two high dependency units (HDUs).

All patients admitted to the hospital with type 1 diabetes or type 2 diabetes who had a glucose or ketone test recorded in February to July inclusive, for both 2017 and 2018, were included. This included patients admitted during the given month or whose hospital stay overlapped into or over it. It was decided that patients who proved to be hypoglycaemic (<4mmol/L) or hyperglycaemic (>15mmol/L) or who had raised ketones (>0.6mmol/L) during their hospital stay would be included in the study. (Figure 1.)

The medical records of each selected patient were used to extract the data on the outcome measures including LOS, 30-day readmission rate and 30-day mortality rate. The LOS recorded included the days on which the patient was admitted and discharged. The 30-day readmission included any patient readmitted to the hospital within 30 days after the day of discharge, not including routine clinics and appointments. The 30-day mortality rate included patients who died during the hospital stay or within 30 days after the day of discharge. Data were also collected on the patient’s age at admission, diabetes management strategy (insulin, drugs and diet), and blood test results (C-reactive protein [CRP], urea, creatinine, eGFR [estimated glomerular filtration rate], HbA1c and albumin). HbA1c was, however, subsequently excluded from analysis as this test was not routinely performed in many patients.

Statistics
Means with standard deviation (SD) for normal distribution were calculated for LOS, followed by an independent t-test to compare the two groups. Chi-squared tests and odds ratios with 95% confidence intervals (CI) were used to analyse 30-day readmission and 30-day mortality data. Tests were considered statistically significant at p<0.05. Means and SDs were calculated for age and blood test results, and percentages were calculated for diabetic management strategy in each year. The same analysis was carried out to compare outcome measures in the subgroups ‘insulin-managed patients’ (including patients using ‘insulin only’ or ‘insulin and drugs’) and ‘non-insulin-managed patients’ (patients using ‘drugs
only' or 'diet only') between the two years. All data were analysed using IBM SPSS Statistics software for Windows version 24.0.

**Results**

Among 979 patient admissions, 443 were included from 2017 (pre-intervention) and 536 from 2018 (post-intervention). The mean ages were 59.3 in 2017 and 61.9 in 2018. In 2017, 46.3% of admissions were type 1 diabetes related, 48.5% of admissions were type 2 diabetes related and 5.2% of admissions were for unspecified diabetes. In 2018, 40.1% of admissions were type 1 diabetes related, 55.5% of admissions were type 2 diabetes related and 6.3% of admissions were for unspecified diabetes. Of all recordings collected for this study, 9% and 10.9% were identified as out of range in 2017 and 2018, respectively. In addition, referrals due to hypoglycaemia were 40.98% and 34.8% of DISN referrals for 2017 and 2018, respectively.

Across both groups, eGFR, urea, CRP and albumin were in similar ranges. (Table 1.) In addition, proportions of different diabetes management treatments were similar across both groups in 2017 and 2018, with no significant differences found. (Figure 2.)

In 2017, 130 of the 443 (29.3%) patients were readmitted within 30 days compared to 108 of the 536 (20.1%) patients in 2018 – a reduction of 9.2% (OR 1.646, 95% CI 1.227–2.208, chi-squared test p=0.039). (Table 2.)

In 2017, the 30-day mortality rate was 11.5% compared to 10.8% in 2018, a reduction of 0.7% (OR 1.072, 95% CI 0.719–1.598, chi-squared test p=0.719). The mean LOS was not significantly different between 2017 (9.92±13.22, n=443) and 2018 (10.21±13.11, n=536), (p=0.737).

**Subgroup analysis**

In the pre-intervention period (n=443), a large proportion of the patients with diabetes were managed using ‘insulin only’ (59.6%), followed by ‘drugs only’ (15.8%), ‘insulin and drugs’ (18.1%) and ‘diet only’ (6.6%). The post-intervention period (n=536) showed comparable results: ‘insulin only’ 56.0%; ‘drugs only’ 15.0%; ‘insulin and drugs’ 23.3%; and ‘diet only’ 5.8%.

The readmission rate decreased from 29.9% in 2017 to 20.1% in 2018 for patients who used insulin to manage their diabetes. The readmission rate also decreased for non-insulin-managed patients from 28.1% in 2017 to 20.4% in 2018. The percentage decrease for both these subgroups (insulin and non-insulin) was the same as the
change for the overall cohort of patients pre- and post-intervention. (Table 3.)

Including patients from the ICU and HDUs only (2017 n=199; 2018 n=170), the readmission rate decreased from 26.6% pre-intervention to 21.4% post-intervention. This magnitude of decrease was larger for inpatients using insulin as part of their diabetes management (26.8% in 2017 to 16.4% in 2018). Patients using insulin were on average 85.9% more likely to be readmitted within 30 days in 2017 than in 2018 (OR 1.859, 95% CI 1.043–3.313, p=0.054). For patients on non-insulin management for diabetes, the reduction in the readmission rate remained significant, decreasing from 26.6% in 2017 to 22.2% in 2018, but showing no change from the rate in the overall cohort.

**Discussion**

Our study showed that a significant reduction in the 30-day readmission rate was achieved following the introduction of the POC-DISN proactive review service in MAU and HDU wards. This is particularly relevant among patients who are insulin-admitted to HDU. However, the results showed that the 30-day mortality rate and LOS did not significantly reduce from 2017 to 2018. Demographic data and independent variables for all the patients were collected and compared to ensure that the groups were similar in the pre- and post-DISN intervention phases. This included data collected on age at admission, blood test results (creatinine, urea, CRP, albumin, eGFR) and diabetes treatment, which serve as surrogate markers of ill health and the duration of diabetes. The analysis showed that these data were similar across both groups, indicating that both groups were equally ill and had a similar duration of diabetes.

A decrease in the 30-day readmission rate following the POG-DISN intervention was expected, given the findings in the relevant literature. This could be explained by a number of reasons: primarily, the interventions that a DISN is able to provide, as well as the outpatient follow-up and telephone contact provided by DISNs after discharge, prevented the need for further hospitalisation. Studies have shown that patient education performed by a specialised team, specifically diabetes specialist nurses, decreases readmission rates by improving patient adherence to treatment and improving glycaemic control, even after the patient has been discharged.8,15,18 Improved self-management can make the transition after discharge easier for patients and improve the chances of a normal recovery without the need for further hospital intervention.19,20 Therefore, ensuring the safe and effective transition of inpatients to outpatient care through education is an important aspect of the POC-DISN intervention.

However, our neutral findings on the impact of the POC-DISN service on LOS and 30-day mortality contrast with previous studies on inpatient DISN intervention.11–14,21 For example, there is a significant association between blood glucose at admission and 28-day mortality, with the risk of mortality increasing as the blood glucose at admission increases. Hypoglycaemic episodes also have an association with mortality depending on their severity.13,14 However, it is important to note that, unlike other studies, which included generic inpatients, the present study only included patients admitted to acute medical emergency wards where patients by definition were more ill. Hence, the effects of LOS and 30-day mortality were driven primarily by the medical cause of admissions rather than specific issues related to diabetes. It has previously been reported that clinical outcomes in patients with diabetes were improved more in renal wards compared to others, such as surgery, following intervention.17 Thus, if this study were expanded to include other wards, it may be found that the POC-DISN intervention confers improvement in clinical outcomes.

It was hypothesised that there may be a difference in clinical outcome measurements for inpatients with diabetes who take insulin as part of their management strategy compared to those who do not use insulin. Insulin can be a surrogate predictor of clinical outcomes as it is associated with more complicated patients and longer disease duration.5 We found that the group of patients who used ‘insulin’ or ‘insulin and drugs’ as part of their management strategy had no significant changes in LOS or 30-day mortality between 2017 and 2018. However, 30-day readmission rates did significantly decrease after the POC-DISN proactive review intervention for both insulin- and non-insulin-treated patients. In addition, subgroup analysis performed on

| Table 3. Outcome results of readmission, mortality and length of stay with and without the intervention for subgroups |
|-----------------------------------------------------|-------------------|-------------------|
| All 4 wards (MAU, ICU, 403 and 407)               | 2017   | 2018   |
| Patients readmitted within 30 days                | 29.3%  | 20.1%  |
| Patients on ‘insulin’ or ‘insulin and drugs’      | 29.9%  | 20.1%  |
| Patients on ‘drugs’ or ‘diet’                     | 28.1%  | 20.4%  |
| 3 wards (ICU, 403 and 407)                         |        |        |
| Patients readmitted within 30 days                | 26.6%  | 21.4%  |
| Patients on ‘insulin’ or ‘insulin and drugs’      | 26.8%  | 16.4%  |
| Patients on ‘drugs’ or ‘diet’                     | 26.6%  | 22.2%  |
| MAU = medical assessment unit; ICU = intensive care unit; 403 = respiratory & respiratory high dependency unit; 407 = renal & medical high dependency unit. |  |  |
Diabetes inpatient specialist nurse proactive point-of-care review service

**KEY POINTS**

- It is well established that inpatients with diabetes are associated with poorer clinical outcomes.
- Point-of-care glucose and ketone assessment which triggers diabetes inpatient specialist nurse intervention was effective in reducing 30-day readmission rates for inpatients with diabetes.
- There was no significant impact on the 30-day mortality rate or average length of stay.
- Patients using insulin as part of their diabetes management were more likely to benefit from this intervention.

only patients from the HDU and ICU wards found that there was a more significant decrease in 30-day readmission rates for insulin-treated patients compared to non-insulin-treated patients. This implies a bigger impact of the POC-DISN proactive review service on the clinical outcomes for insulin-treated patients admitted to the HDU, who by definition would be more ill.

We speculate that acute illness affects sensitivity to insulin via an increase of counter-regulatory factors,19 such that insulin dose adjustments during illness and during recovery are issues that DISNs can focus on to improve patient outcomes. In addition, if used appropriately and managed closely, insulin can be very effective in maintaining an optimal blood glucose profile, thus decreasing the risk of hypo- and hyperglycaemia, as well as diabetes-related complications.22–26

We acknowledge significant limitations to this study. This study included only data from four highly acute wards in a single hospital across only six months and thus cannot be generalised to all inpatients with diabetes. A longer time period needs to be investigated to ensure that the results remain significant. It may well be found that after more time the POC-DISN strategy becomes more effective as the protocol is refined and improved with time and evaluation.

Furthermore, only collecting data from six months of the year could have introduced seasonal bias to the outcomes, such as winter-related illnesses and bed crisis problems; the clinical service may also be more stretched in the winter months.

Despite these limitations, the findings of this study highlight the importance of DISNs in providing input to inpatients with diabetes who are admitted into acute wards. The introduction of a POC-DISN system in hospitals is effective in significantly decreasing 30-day readmission rates for inpatients with diabetes in acute and high dependency wards through person-alised and effective diabetes management and patient education. LOS and 30-day mortality were not found to decrease after intervention, but further research is needed to investigate whether these findings extend to other diabetic inpatient populations within hospitals. The POC-DISN intervention has a more significant impact on inpatients using insulin as part of their management strategy across ICU and HDU wards, as 30-day readmission rates in this group decreased further compared to non-insulin users.

**Declaration of interests**

There are no conflicts of interest declared.

**References**