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Improving the peri-operative pathway of people with diabetes undergoing elective surgery: the IP3D project

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Abstract

Aim To determine whether outcomes for people with diabetes undergoing elective surgery improve following the introduction of innovations in the peri-operative care pathway.

Methods Following a baseline audit of 185 people with diabetes listed for elective surgery (July to December 2017) with a length of stay > 24 hours, a number of changes in practice were implemented. These included dissemination of a 'diabetes peri-operative passport' to participants preoperatively, formation of a diabetes surgery working group, recruitment of surgical diabetes champions and the roll-out of surgical diabetes study days. Crucial was recruitment of a diabetes peri-operative nurse, whose role included engaging and educating others and supporting individuals throughout their peri-operative diabetes care. Records of 166 individuals listed for surgery during the implementation period (July to December 2018) were then audited using the same methodology.

Results The availability of a recent HbA_{1c} measurement significantly increased (63% vs 92%; $P \leq 0.001$). The mean HbA_{1c} of those seen for optimizations by the diabetes peri-operative nurse significantly decreased [84 mmol/mol (9.8%) vs 62 mmol/mol (7.8%); $P \leq 0.001$]. Recurrent hypoglycaemia significantly decreased (7.0% vs 0.6%; $P = 0.002$) and the mean number of hyperglycaemic events in people experiencing hyperglycaemia almost halved (3.0 vs 1.7; P=0.007). The mean length of hospital stay significantly decreased (4.8 vs 3.3 days; P=0.001) and, crucially, 30-day readmissions did not increase (12% vs 9%; P=0.307). Postoperative complications significantly decreased (28% vs 16%; P=0.008), including a composite of dysglycaemic complications, poor wound healing, wound infection and other infections (12% vs 5.4%; P=0.023).

Conclusion The new pathway improved important peri-operative outcomes for people with diabetes undergoing elective surgery with the potential for cost savings. These findings could have important implications for peri-operative care on a wider scale.

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Introduction

The management of people with diabetes undergoing surgery has long been recognized as challenging and it is well known that they have a longer length of hospital stay and poorer clinical outcomes after surgery than those without diabetes [1]. Over 323 000 operations take place in the UK each year on people with diabetes [2], yet diabetes is frequently ignored before surgery, glycaemia is often poorly managed during the admission, and postoperative complications are frequent [1,3]. The 'Highs and Lows' report from the National Confidential Enquiry into Patient Outcomes and Death (NCEPOD) identified many areas for improvement in the multi-step peri-operative journey [1].

The NCEPOD report found that 41% of referral letters included no information on the patient's diabetes management and a study in East Anglia found that only 7.7% contained a recent HbA_{1c} result [4]. Those with poor glycaemic control before surgery are more likely to remain hyperglycaemic during and after surgery, which is a risk factor for infections, poor wound healing and increased length of hospital stay [5,6]. Despite clear guidelines advocating that all such individuals should have an HbA_{1c} measured within 3 months prior to surgery to identify those who would benefit from interventions to improve control [7], Underwood *et al.* [8] showed this occurred in only 35% of cases.

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What's new?

- A whole-pathway approach was developed and implemented in our Trust to improve the outcomes of people with diabetes undergoing elective surgery
- The pathway used a number of innovative interventions including the dissemination of a 'diabetes peri-operative passport' to individuals preoperatively, the formation of a diabetes surgery working group, and roll-out of surgical diabetes study days.
- Crucial was the recruitment of a diabetes peri-operative nurse, whose role included engaging and educating others and supporting people with diabetes throughout their peri-operative journey.
- The results demonstrate important benefits in many aspects of peri-operative diabetes care, with the potential for wider adoption by other National Health Service trusts.

There also remains unwarranted variation in the information people receive at their preoperative assessment on how surgery may impact their diabetes and what medication adjustments may be needed prior to admission. In one Dutch study conducted in six hospitals, only half the participants reported they had received information about peri-operative diabetes treatment [9].

In the UK, the diabetes 'Get it Right First Time' (GIRFT) programme [10] found an excess length of stay of 3 days for surgical admissions (personal communication with GIRFT team). Many factors may contribute to this, but poor inpatient diabetes control is an important factor. People's ability to self-manage is key to successful diabetes care [11], yet diabetes management is often taken out of the patient's hands by staff inexperienced in diabetes management, often resulting in treatment errors. The National Diabetes Inpatient Audit found medication errors in treatment charts of almost one-third of inpatients with diabetes, with these being more common on surgical wards [12]. Diabetes inpatient specialist nurse input can help reduce such errors [13], but the inpatient diabetes load is so great that much of their time is spent on complex medical patients rather than on surgical wards. Guidelines also point to regularly monitoring capillary blood glucose levels; however, the NCEPOD study showed that 14% of patients did not have adequate capillary blood glucose monitoring whilst in theatre and intra-operative hypoglycaemia occurred in 4.7% [1].

On discharge, diabetes follow-up arrangements tend to be sparse. One study found just 15% of individuals were followed up, with 10% needing an unplanned readmission [14], which is both costly and distressing.

It is clear, therefore, that, despite numerous guidelines aimed at making this multi-step complex diabetes peri-operative pathway easier to navigate, major gaps still exist between recommended care and current practice. The aim of the present study was to assess the impact of the 'Improving the Peri-operative Pathway of People with Diabetes' (IP3D) project, which was designed to resolve these gaps by putting the person with diabetes at the centre, improving communication at all steps of the journey, promoting joint ownership of diabetes care between specialities, and increasing staff knowledge.

Participants and methods

The IP3D intervention is a whole-pathway approach to managing people with diabetes undergoing elective surgery at Ipswich Hospital that includes a number of initiatives based around a diabetes 'peri-operative passport' designed to empower the person with diabetes and promote communication and staff education.

During the 6-month baseline period (July to December 2017) and in the same calendar period after implementation (July to December 2018) the electronic records of all individuals who were listed for elective surgery and had a diagnosis of diabetes (International Classification of Disease 10th Revision codes E10–E14) were retrospectively audited. People undergoing obstetric, paediatric and emergency surgery were excluded. Length of hospital stay for people without diabetes listed in the same periods was also analysed to account for any changes in overall peri-operative care processes that may have influenced outcomes in the cohort with diabetes.

Baseline: routine care

Previously, primary care referrals required manual entry of the diagnosis of diabetes and most recent HbA_{1c} value onto the referral form or letter. At the pre-assessment, people with a raised HbA_{1c} level were de-referred to their general practitioner to improve control. For those progressing to elective surgery, information addressing pre-admission eating and drinking and diabetes medication adjustment was provided on a pre-printed form. On admission, patients were started on a diabetes care pathway, the Diabetes Inpatient Care and Education (DICE) chart. Referrals to the diabetes inpatient specialist nurse team could be made for those requiring further support. A point-of-care capillary web-based blood glucose monitoring system was developed to alert the team to people who experienced a hypoglycaemic event in hospital.

Interventions

Diabetes peri-operative passport

The new pathway was based on a patient-held diabetes peri-operative passport containing essential information pertain-

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ing to their surgical inpatient stay and questions they may wish to ask about their care. Designed to empower the person with diabetes on their surgical journey, it included pages for them to fill in about their diabetes care, a section for healthcare professionals to complete on preadmission care, and information for patients about what diabetes care to expect whilst in hospital. Devised as a collaborative tool for people with diabetes and healthcare professionals, this has been shown to be valued by people with diabetes and improves their involvement [15]. The passport was disseminated to all preoperative assessment clinics where patients were asked to complete relevant sections and to bring the passport with them to all appointments and to the admission ward.

Diabetes peri-operative specialist nurse

A part-time diabetes peri-operative specialist nurse (DPSN) was employed to support the new pathway. This nurse was recruited from a surgical ward and had no prior training in diabetes. During the baseline period the DPSN received training from the wider diabetes team. The DPSN role included supporting patients preoperatively (face-to-face or via telephone), optimizing diabetes control before surgery, reviewing postoperative control of selected patients and educating and advising patients and staff. Key to the role was linking into preoperative assessment to support timely referrals and input into diabetes plans. A referral criterion was developed to identify people with inadequate glucose control who would most benefit from interventions. Much of the optimization work was carried out via telephone appointments and the DPSN was supported by diabetologists to make adjustments to medication doses. For those people whose diabetes care was normally provided by primary care, the DPSN liaised with their general practitioner to suggest medication changes. To be able to proceed to surgery, the HbA_{1c} level ideally needed to be < 69 mmol/mol (8.5%).

Surgical study days

A whole-day study day was introduced for staff working in surgical areas to promote safe diabetes care. The training mirrored the structure of the peri-operative passport and included multidisciplinary talks from diabetologists, diabetes inpatient specialist nurses, the DPSN, the diabetes foot care team, the pharmacy and pre-admission nurses. Three study days were held during implementation, and staff knowledge and confidence scores were measured before and after.

IP3D group

A bi-monthly multidisciplinary group of consultants in surgery, anaesthesia and diabetes, nurses, Health Care Assistants and pharmacists was established to work together to develop the pathway to improve the quality of peri-operative care. The results from the audit data were shared and areas for improvement were identified, discussed and actioned.

Diabetes peri-operative champions

Diabetes champions were established to promote safe diabetes peri-operative care in each of their surgical areas. These were enthusiastic individuals from the surgical wards, theatres or pre-assessment units who were recruited from the study days. They formed a crucial link for the DPSN to disseminate information and initiatives from the IP3D project and championed good diabetes care in their areas and at their weekly huddles.

New referral system

Through the Clinical Commissioning Group's communications to its general practitioner membership, the quality of surgical referrals was highlighted and a new referral system that was being introduced was adapted so that the most recent HbA_{1c} was auto-populated into the referral. Unfortunately, transfer to the new system took longer than anticipated and was not fully active until 5 months after implementation.

Outcomes

For patients admitted for >24 h, length of stay, postoperative complications, 30-day readmissions and adherence to key recommendations from the Joint British Diabetes Society [7] were compared with the baseline period. Diabetes harms, including hypoglycaemic (≤3.9 mmol/l) and severe hyperglycaemic events (≥17 mmol/l) were also assessed (Table 1 and 2).

Secondary outcome measures were changes in staff knowledge and confidence, and patient experience. The latter was assessed using the 26-item questionnaire we previously developed to assess experience/empowerment of surgical patients with diabetes [15]. This was mailed to people who had undergone the new pathway and consented to being contacted. Comprising some dichotomous items, the majority required the participants to rate various aspects of their peri-operative diabetes care on a 10-point scale. The results were compared with those previously reported in the peri-

Table 1 Participant characteristics

Domain	Baseline *N* = 185	Intervention *N* = 166	*P*
Mean (SD; range) age, years	70.0 (12.4; 33–92)	71.3 (10.9; 33–96)	0.294
Men, *n* (%)	96 (51.9)	100 (60.2)	0.116
Type of diabetes, *n* (%)			
Type 1	13 (7.0)	10 (6.0)	
Type 2	169 (91.4)	155 (93.4)	
Steroid-induced	3 (1.6)	1 (0.6)	0.618
Taking insulin, *n* (%)	46 (24.9)	46 (27.7)	0.546
Priority status at listing, *n* (%)			
Routine	121 (65.4)	98 (59.0)	0.219
Urgent	64 (34.6)	68 (41.0)	

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operative passport pilot [15]. Staff knowledge and confidence levels were surveyed using a 23-item questionnaire, which was originally piloted on nurses then revised based on feedback. These were a mixture of confidence levels (scored 0–7) and knowledge questions covering key aspects of diabetes peri-operative care, including recognition and treatment of hypoglycaemia and hyperglycaemia, medication adjustments and safe management of insulin infusions. The questionnaire was administered to surgical nurses at the start and end of the study day and then again at the end of the implementation period. Staff were overseen without intervention whilst completing the questionnaire to prevent them researching the answers.

These outcomes were compared using chi-squared tests (categorical data), *t*-tests (continuous data) or ANOVA as appropriate using STATA software. An α level of 5% was used with no adjustment for multiplicity of tests.

Ethics

The IP3D project was deemed to be an assessment of service improvement by the Trusts Research and Governance Committee and was therefore approved as a quality improvement initiative by the hospital's audit committee.

Results

A total of 185 people in the baseline and 166 people in the intervention periods went on to have elective surgery with a stay of >24 h. The groups were well matched (Table 1). The majority (92%) had type 2 diabetes and were referred by primary care. Around one-quarter (26%) were insulin-treated.

There was a significant increase in referral letters mentioning diabetes (54% vs 76%; $P<0.001$) and containing a

Table 2 Primary outcome measures

Domain	Baseline *N*=185	Intervention *N*=166	Between-group difference	*P*
Quality of referral letter, *n* (%)				
Diabetes mentioned	99 (53.5)	126 (75.9)	22.4	<0.001
HbA_{1c} mentioned	19 (10.3)	37 (22.3)	12.0	0.002
Mean (SD) HbA_{1c} at referral				0.396
mmol/mol	56 (1.39)	60 (1.59)	4.0	
%	7.28	7.61		
HbA_{1c} on admission				
HbA_{1c} at preoperative assessment (within 3 months) , *n* (%)	117 (63.2)	152 (91.6)	28.4	<0.001
Mean (SD) HbA_{1c} at preoperative assessment	7.09 (1.11)	7.05 (1.35)	0.04	0.787
HbA_{1c} >69 mmol/mol (> 8.5%), *n* (%)	16 (13.7)	17 (11.2)	–2.5	0.537
Theatres, *n* (%)				
On first third of the operating list	112 (60.5)	100 (60.2)	–0.3	0.954
Mean (SD) length of hospital stay, days	4.85 (5.68)	3.33 (2.40)	–1.5	0.001
Blood glucose monitoring, *n* (%)				
Capillary blood glucose tested on wards	166 (89.7)	161 (97.0)	7.3	0.007
Capillary blood glucose tested in theatre	117 (63.2)	115 (69.3)	6.1	0.233
Harms, *n* (%)				
Patients experiencing hypoglycaemia ≤3.9 mmol/l	22 (11.9)	12 (7.2)	–4.7	0.140
Patients experiencing hypoglycaemia ≤ 2.2 mmol/l	3 (1.6)	1 (0.6)	–1.0	0.369
Patients experiencing recurrent (> 1 episode) hypoglycaemia	13 (7.0)	1 (0.6)	–6.4	0.002
Mean (SD) number of hypoglycaemic events*	2.36 (2.55)	1.17 (0.58)	–1.2	0.061
Patients experiencing hyperglycaemia ≥17 mmol/l, *n* (%)	42 (22.7)	36 (21.7)	–1.0	0.819
Mean (SD) number of hyperglycaemic events in patients*	3.02 (2.61)	1.74 (1.04)	–1.3	0.007
Complications, *n* (%)				
Unplanned admission to Critical Care Unit	12 (6.5)	8 (4.8)	–1.7	0.501
Any complication	52 (28.1)	27 (16.3)	–11.8	0.008
Glycaemic-related complication	11 (5.9)	3 (1.8)	–4.2	0.048
Glycaemic, wound or infection-related complication	23 (12.4)	9 (5.4)	–7.0	0.023
30-day readmission	23 (12.4)	15 (9.0)	–3.4	0.307
Cancellations/delisting, *n* (%)	33 (17.8)	35 (21.1)	3.3	0.717
Diabetes input				
Input from DPSN preoperatively, *n* (%)	n/a	23 (13.9)	n/a	n/a
Mean reduction in HbA_{1c} result of those referred to DPSN for optimization†	n/a		n/a	<0.001
mmol/mol		22		
%		1.93		
Input from DPSN whilst inpatient, *n* (%)	n/a	91 (54.8)	n/a	n/a
Input from Diabetes Inpatient Team, *n* (%)	33 (17.8)	46 (27.7)	9.9	0.027
DICE (care pathway) chart, *n* (%)	161 (87.0)	160 (96.4)	9.4	0.002

*In those patients who experienced hypoglycaemic/hyperglycaemic events.
†From referral to surgery in those patients referred to the DPSN for optimisation due to having a HbA_{1c} >8.5% (69 mmol/mol) mean HbA_{1c} decreased from 84 mmol/mol (9.8%) to 62 mmol/mol (7.8%)

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Table 3 Patient experience questionnaire results

	Baseline score, *N*=35 Mean (SD)	Implementation score, *N*=37 Mean (SD)	Between-group difference	*P*
Number of days spent in hospital	6.5 (7.2)	3.4 (1.6)	–3.1	0.035
How well informed were you of the surgical procedure?	9.0 (1.6)	8.9 (1.6)	–0.1	0.831
How well controlled was your diabetes prior to surgery?	8.3 (2.6)	8.5 (1.5)	0.2	0.709
How well informed were you of the importance of having good control?	7.1 (3.2)	8.2 (2.1)	1.1	0.074
How helpful was the information about diabetes that you received at preop?	4.6 (3.7)	8.9 (1.3)	4.3	<0.001
How helpful was the advice you received pre-surgery on diabetes medication adjustment?	8.1 (2.5)	8.9 (1.7)	0.8	0.133
How helpful was the advice you received pre-surgery on what you could eat/drink before surgery?	8.7 (2.0)	9.2 (1.2)	0.5	0.177
How involved did you feel in the planning of your diabetes care?	5.0 (3.3)	8.0 (2.3)	3.0	<0.001
How anxious were you about how your diabetes would be managed whilst in hospital?*	2.8 (2.6)	3.5 (2.5)	0.7	0.214
If you received support from the diabetes team, how helpful was the diabetes team support?	7.0 (2.0)	8.7 (1.6)	1.7	0.021
When in hospital, how much did you worry about your diabetes?*	2.8 (2.6)	3.3 (1.8)	0.5	0.499
How well informed did you feel about managing your diabetes after discharge?	7.0 (3.3)	9.1 (1.8)	2.1	0.004
How satisfied are you with the overall care of your diabetes whilst in hospital?	8.4 (2.2)	9.1 (1.4)	0.7	0.141

Questions were scored on a scale of 1 to 10, with 10 being most favourable for all questions apart from those with an asterisk, where 1 was most favourable.

recent HbA_{1c} (10% vs 22%; *P*=0.002). More people with diabetes had an HbA_{1c} result within 3 months of surgery in the intervention period (63% vs 92%; $P \leq 0.001$) and there was a nonsignificant decrease in people with an HbA_{1c} level >69 mmol/mol (8.5%): 14% vs 11% ($P = 0.537$). However, of those who received optimization support from the DPSN, there was a significant decrease in mean HbA_{1c}, from 84 mmol/mol (9.8%) to 62 mmol/mol (7.8%; $P \leq 0.001$). Inpatient contact with the regular diabetes inpatient team increased from 18% to 28% ($P = 0.027$). In addition, 55% of patients were visited on the ward by the DPSN during the intervention period. These visits consisted mostly of reviewing glycaemic control and revising diabetes treatments.

There was an increase in those whose details were completed on a DICE chart (87% vs 96%; *P*=0.002) and in those who underwent capillary blood glucose testing on the ward (90% vs 97%; *P*=0.007). There was no difference in capillary blood glucose testing in theatre (63% vs 69%; *P*=0.233) or listing on the first third of the operating list (61% vs 60%; *P*=0.954).

Recurrent hypoglycaemia decreased (7.0% vs 0.6%; $P = 0.002$). The mean number of recurrent hypoglycaemic events fell from 2.36 to 1.17 ($P = 0.061$) and the mean number of recurrent hyperglycaemic events reduced from 3.02 to 1.74 ($P = 0.007$). Unplanned admissions to Critical Care Unit did not change. The proportion of people who experienced in-hospital complications fell from 28% to 16% (*P*=0.008), including a decrease in those who experienced a composite of dysglycaemic complications, poor wound healing, wound infection and other infections (12.4% vs 5.4%; *P*=0.023)

Length of hospital stay reduced from 4.8 to 3.3 days (*P*=0.001), with no increase in 30-day readmissions (12 vs 9%; *P*=0.307). Length of stay in inpatients without diabetes did not change (3.1 vs 3.3 days).

Only 37 of the participants in the implementation group returned the experience questionnaire. Nevertheless the results (Table 3) were similar to the findings of the previous study [15], with the majority of domains showing improvement, including helpfulness of information about their preoperative diabetes care, involvement in planning their diabetes care and being better informed on discharge.

Knowledge and confidence questionnaires were completed by 70 staff at the start and 57 at the end of the study day; and 40 at the end of the project (6–12 months after the study day). Significant improvements were seen across most metrics (Table 4) but, in particular, in confidence in omitting insulin on the day of surgery [3.7 (pre-study) vs 5.5 (end of project); *P*<0.001], accessing the hyperglycaemic protocol [79% (pre-study) vs 100% (end of project); *P*=0.004] and managing insulin infusions, all of which were sustained at the end of the project.

Discussion

Consistent with previous studies, the baseline data showed a number of areas where improvements could be made in the peri-operative pathway of people with diabetes. Referrals frequently lacked diabetes-related details and many individuals presented to pre-assessment with poor control. Despite guidance, not all people with diabetes had a DICE chart and

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Table 4 Staff knowledge questionnaire results

	Pre study day score *N* = 70 (% who answered correctly)	End of study day score *N*=57 (% who answered correctly)	*P* (before vs end of study day)	Post project *N*=40 (% who answered correctly)	*P* (pre- vs post project)
Mean confidence in understanding the difference between type 1 and type 2 diabetes	4.7	5.6	<0.001	5.7	<0.001
Mean confidence in advising on insulin adjustments on the day of surgery	3.5	5.1	<0.001	5.1	<0.001
Mean confidence in omitting insulin of the day of surgery	3.7	5.1	<0.001	5.5	<0.001
Mean confidence in administering insulin on the day of surgery	4.0	5.4	<0.001	5.5	<0.001
Mean confidence in advising the patient on what to do with their oral medication on the day of surgery	4.4	5.6	0.001	5.6	0.017
Should a person with diabetes who is normally on insulin commence on a Variable rate intravenous insulin infusion (VRIII) if they are likely to remain nil by mouth (NBM) for two or more meals?	50 (71.4)	51 (89.5)	0.012	37 (92.5)	0.009
When should a patient with diabetes on a VRIII be returned to a normal regime?	63 (90.0)	56 (98.2)	0.057	40 (100)	0.039
Would you give basal insulin alongside a VRIII?	28 (40.0)	47/56 (83.9)	<0.001	29/35 (82.9)	<0.001
At what time should a person with diabetes foot check be completed?	63/69 (91.3)	49/55 (89.1)	0.679	39 (97.5)	0.203
At what time of day is surgery best performed for a person with type 1 diabetes?	57 (81.4)	55/56 (98.2)	0.003	38 (95.0)	0.046
Postoperatively how often would you check a patient's blood sugar that is on a sliding scale?	50 (71.4)	41/55 (74.5)	0.697	29 (72.5)	0.904
Postoperatively how often would you check a patient's blood sugar that's not on a VRIII?	27 (38.6)	33/56 (58.9)	0.023	20 (50.0)	0.244
Mean confidence in discontinuing a VRIII post-surgery	4.3	5.3	0.001	5.2	0.044
Would you give long acting insulin alongside a VRIII?*	46 (65.7)	51/55 (92.7)	<0.001	35/39 (89.7)	0.006
Mean confidence in identifying and managing diabetic ketoacidosis and Hypersmolar hyperglycemic state (HHS)	3.0	5.0	<0.001	4.4	<0.001
At what capillary blood glucose level would you intervene with Actrapid in type 1 diabetes?	28 (40.0)	47/56 (83.9)	<0.001	31/37 (83.8)	<0.001
At what capillary blood glucose level would you intervene with Actrapid in type 2 diabetes?	40 (57.1)	45/56 (80.4)	0.006	31/39 (79.5)	0.019
Where would you access information on the hyperglycaemia protocol?	55 (78.6)	52/56 (92.9)	0.026	38 (100)	0.002
Below what level should a patient with diabetes have treatment for hypoglycaemia?	59 (84.3)	55/56 (98.2)	0.008	34 (85.0)	0.921
Where is your wards orange hypo box located?	62/89 (89.9)	44/53 (83.0)	0.268	34/35 (97.1)	0.188
Are you able to locate the equipment to perform a ketone test and identify when to complete one on a patient with diabetes?	57/69 (82.6)	48/53 (90.6)	0.208	35/37 (94.6)	0.082
How might you prevent night time hypoglycaemia after surgery?	70 (100)	56 (100)	-	39 (100)	-
Mean confidence in discharging a patient post-surgery if their medication or insulin has been altered during their stay	3.9	5.0	<0.001	5.0	0.012

All confidence questions were scored on a scale of 1–10, with 10 being most confident.
*Both basal and long-acting were used as separate questions as many of the staff were not familiar with the correct terminology.

capillary blood glucose testing was frequently omitted. Less than one-fifth of people with diabetes received input from the Diabetes Team despite over one-third experiencing hypoglycaemic or hyperglycaemic events. Nearly one-quarter experienced complications, many of which could be associated with poor diabetes control.

The results of the present study suggest that the interventions were effective and well received by patients. There was an improvement in the quality of referral letters, with three-quarters noting diabetes as a comorbidity. The rate of inclusion of an HbA_{1c} result in the referral doubled, and was three times greater than reported elsewhere [4]. Nevertheless, it remained relatively low (22%), but may have been better had the new referral system been in place sooner. More people with diabetes had a recent HbA_{1c} result available prior to surgery and those with a raised HbA_{1c} level who had input from the DPSN had a significant improvement in HbA_{1c} prior to surgery, suggesting the plans put in place for optimization were effective.

Recurrent hypoglycaemia and hyperglycaemia events reduced, suggesting that the DPSN was able to put in place satisfactory prevention plans to limit these harms which are potential risks factors for infection and complications [5]. Results from the staff knowledge questionnaires suggest staff felt more confident to act on poor glycaemic control. Furthermore, greater attention was paid to diabetes as shown by the increase in capillary blood glucose testing, initiation of the DICE pathway and overall input into

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diabetes care. Those metrics that did not show significance still showed trends in the right direction and, crucially, readmissions did not increase.

Based on 350 elective procedures per year at our 600-bed hospital, the reduction in length of stay has implications in terms of cost savings. A 1.5-day reduction in length of stay equates to saving 525 hospital bed-days/£157,000 per year when conservatively costed at £300 per bed-day. This would repay the cost of the intervention several times over, without taking into consideration the considerable cost were complications to result in litigation.

With the intervention being a whole-pathway approach, it is difficult to isolate which individual parts of the intervention made the most difference, but some of the improvements are likely to be attributed to an increase in staff knowledge and confidence. Behaviourism says that learning is a change in behaviour in the desired direction that happens due to a variety of techniques including encouragement, repetition feedback and reinforcement [16]. The combination of the study days, using the passport for patients, and the support and feedback of the DPSN enabled a 'skill and drill' approach, which we believe to have been instrumental in improving and sustaining staff knowledge and behaviour.

Limitations of this study include the possibility that the improvements could be simply attributable to novelty bias, that is, the tendency for performance to initially improve when a new approach is adopted because of the interest factor rather than the innovations themselves, the risk being that diabetes will then slip back down the agenda once this novelty factor has worn off. However, through the passport, patients are able to hold staff to account to an expected level of diabetes care to make sure diabetes does not shift off the agenda. A further limitation is the non-randomized design of the study. We included all people listed for elective overnight surgery to avoid selection bias, but it is possible that there were differences in the case mix and changes in the surgical pathways between the two time periods. However, we included patients without diabetes to control for these. There was no change in the length of stay in the non-diabetes population, suggesting that the improvement was specific to diabetes. Importantly, the pathway eliminated the excessive length of stay which is a characteristic of elective surgical diabetes care.

In conclusion, the new pathway successfully addresses many of the challenges experienced by people with diabetes undergoing elective surgery, and resulted in a reduction in length of hospital stay and in complications, echoed by improvements in staff knowledge and patient experience. Although it is not possible to determine which innovations were the most beneficial, it is likely that all contributed, bound together by the peri-operative passport and the work of the DPSN, and therefore should be adopted as a whole-pathway approach. It is worth noting that these improvements were made with the DPSN not previously having had a background in diabetes and being trained up for the role in a relatively short period of time, suggesting the model is easily transferrable. Moreover the DPSN was also in post on a part-time basis, which suggests that the enhancements to the pathway are not labour-intensive and that there may be potential for further improvements if the post was full-time. As this was a single-hospital study it needs to be seen whether the similar improvements can be achieved elsewhere; if so, this would have major implications for the elective peri-operative care of people with diabetes in the UK.

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Competing interests

None declared.

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