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Article

A Multidisciplinary Perioperative Diabetes Optimisation Pathway: Glycaemic and Hospital Pathway Outcomes in a Prospective Cohort

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Abstract

Aims/Background: Suboptimal glycaemic control may delay surgery and increase perioperative risk, yet national guidance provides limited detail on how preoperative diabetes optimisation should be organised. This study evaluated a multidisciplinary perioperative diabetes optimisation pathway in a tertiary hospital. **Methods:** This prospective single-centre cohort included 174 consecutive adults referred to The Queen Elizabeth Hospital Birmingham, United Kingdom, between 1 January and 31 December 2024, with glycated haemoglobin (HbA1c) >69 mmol/mol (>8.5%) before elective surgery. The pathway comprised diabetologist assessment, individualised treatment adjustment, diabetes specialist nurse follow-up, education, repeat HbA1c measurement and communication with surgical teams. Primary outcomes were change in HbA1c and achievement of HbA1c ≤69 mmol/mol (≤8.5%). Secondary outcomes included progression to surgery and factors associated with target achievement and follow-up HbA1c. Multivariable logistic and linear regression examined target achievement and follow-up HbA1c, respectively. **Results:** Paired data were available for 149/174 patients (85.6%). Mean HbA1c decreased from 96.2 ± 14.0 to 73.1 ± 14.1 mmol/mol, a reduction of 23.1 mmol/mol (2.1 percentage points; $p < 0.001$); 77/149 patients (51.7%) achieved the target. Higher baseline HbA1c was associated with lower odds of target achievement (odds ratio 0.96 per mmol/mol, 95% confidence interval 0.94–0.99; $p = 0.006$), although patients with the highest baseline values achieved the largest absolute reductions. After adjustment for baseline HbA1c and other covariates, each additional diabetes-team appointment was associated with a 0.58 mmol/mol lower follow-up HbA1c (95% confidence interval −0.98 to −0.18; $p = 0.005$). Overall, 124/174 patients (71.3%) proceeded to surgery. **Conclusion:** Referral to the pathway was associated with substantial improvement in preoperative HbA1c; just over half of patients achieved the preoperative target and most proceeded to surgery. Baseline HbA1c identified patients less likely to reach the fixed target despite larger absolute reductions, while more frequent specialist contact was modestly associated with lower follow-up HbA1c. Coordinated specialist follow-up, including pragmatic basal insulin initiation and titration where clinically indicated, provides a reproducible hospital-based model for preoperative diabetes optimisation.

Keywords: perioperative medicine; diabetes mellitus; HbA1c; preoperative optimisation; elective surgery; clinical pathway

1. Introduction

Diabetes is one of the largest single contributors to hospital workload, with around one in five inpatient beds in the United Kingdom occupied by people living with diabetes [1]. This far exceeds their prevalence in the general population, and people with diabetes form a substantial proportion of those presenting for elective surgery [2,3]. With global prevalence projected to approach 850 million adults by 2050 [4], the demands this places on elective and inpatient pathways are set to steadily increase. A significant minority of affected patients remain undiagnosed, underscoring the hidden burden and potential perioperative risk in this population [2].

Perioperative dysglycaemia is associated with adverse postoperative outcomes, including infection, cardiovascular events and mortality [5,6,7]. Diabetes itself is also associated with postoperative complications, prolonged hospitalisation and mortality after non-cardiac surgery [8]. Suboptimal glycaemic control can result in delay, postponement or cancellation of surgery, increased length of stay and readmission, with associated economic consequences [3,9]. Optimising glycaemic control before surgery therefore serves not only to reduce avoidable perioperative risk but also to ensure that people with diabetes are not disadvantaged in their access to surgery.

UK guidance from the Centre for Perioperative Care (CPOC), the Joint British Diabetes Societies for Inpatient Care (JBDS) and the National Institute for Health and Care Excellence (NICE) recommends identification and optimisation of diabetes before elective surgery [9,10,11]. The American Diabetes Association's current hospital-care standards also emphasise structured and coordinated management of people with diabetes during hospital admission [12]. Recent international perioperative guidance has also emphasised medication-specific safety planning for patients taking sodium-glucose cotransporter-2 inhibitor

(SGLT2i) and glucagon-like peptide-1 (GLP-1) receptor agonists, particularly around perioperative ketoacidosis, delayed gastric emptying and aspiration-risk assessment [13,14,15,16]. A glycated haemoglobin (HbA1c) threshold of 69 mmol/mol (8.5%) is widely used to trigger specialist review or inform decisions about proceeding, although no absolute evidence-based cancellation threshold has been established [9,10]. This guidance sets out the key principles but gives limited detail on how hospitals should organise and deliver optimisation in practice, including repeated treatment adjustment, patient education, communication with surgical teams and reassessment within the available preoperative period.

Important gaps remain between national recommendations and their consistent implementation in routine perioperative care. The National Confidential Enquiry into Patient Outcome and Death (NCEPOD) Highs and Lows report described fragmented ownership and inconsistent inter-specialty communication [17], while the National Diabetes Inpatient Audit found that only around three in ten hospital sites had a team responsible for organising perioperative diabetes care [1]. The Getting It Right First Time diabetes report subsequently recommended that all trusts establish clear, audited perioperative pathways from preassessment through to discharge [18].

Published evaluations of service models that bridge the interval between preoperative assessment and surgery remain limited, particularly in the complex, high-volume populations seen at tertiary centres. Previous quality-improvement initiatives have demonstrated the potential benefits of coordinated perioperative diabetes care, but reported models have varied and have not been consistently adopted across healthcare systems [19,20,21,22].

This study therefore evaluated a locally implemented multidisciplinary perioperative diabetes optimisation pathway at a major tertiary centre. The primary outcomes included the change in HbA1c from baseline to follow-up and achievement of follow-up HbA1c ≤69 mmol/mol (≤8.5%).

2. Methods

2.1 Study Design and Setting

This prospective single-centre cohort study was conducted at a large tertiary hospital (The Queen Elizabeth Hospital Birmingham) in the West Midlands, United Kingdom, receiving local and regional referrals across multiple surgical specialties. The study evaluated an established perioperative diabetes optimisation pathway delivered during routine elective surgical care between 1 January and 31 December 2024. Data were analysed as a service evaluation of this clinical pathway.

No formal sample size calculation was performed because the evaluation included all consecutive eligible referrals during the predefined study period. The sample size was therefore determined by the number of patients referred to the pathway.

2.2 Inclusion and Exclusion Criteria

All consecutive adults referred during the predefined study period were included if they were aged 18 years or older, were being prepared for elective surgery, and were referred to the perioperative diabetes optimisation pathway because of suboptimal preoperative glycaemic control, defined by local policy as HbA1c >69 mmol/mol (>8.5%). Patients on emergency surgical pathways were excluded from all analyses.

For the paired HbA1c and regression analyses, patients were additionally excluded where baseline or follow-up HbA1c values or required covariates were missing; such patients were retained in the descriptive analyses of pathway activity and surgical progression where outcome data were available. No additional exclusions were applied to the overall descriptive cohort.

2.3 Pathway Development and Delivery

The pathway was developed by the diabetes and perioperative assessment teams to operationalise national perioperative diabetes guidance within the elective surgical pathway [9,10,11]. It provided a defined referral route, consultant diabetologist assessment, individualised treatment optimisation, diabetes specialist nurse follow-up and communication with surgical and anaesthetic teams. The pathway is summarised in Fig. 1 and detailed in **Supplementary Material 1**. Initial assessment included review of diabetes type, current glucose-lowering therapy, home capillary glucose readings, hypoglycaemia risk, renal function, comorbidity, frailty where relevant, and anticipated surgical timing. Patients were followed by diabetes specialist nurses, usually weekly and either face-to-face or remotely, with frequency and duration individualised according to clinical response, treatment changes and surgical timing. Education included glucose monitoring, hypoglycaemia management, treatment adherence, sick-day guidance where relevant and procedure-specific medication advice.

In insulin-naïve patients requiring treatment intensification, once-daily basal insulin was the predominant escalation strategy. In routine practice, basal insulin was usually initiated pragmatically at 10 units once daily, using either isophane insulin or insulin glargine. Diabetes specialist nurses titrated basal insulin weekly by 2–4 units, aiming for fasting and pre-meal capillary glucose values of 6–10 mmol/L (108–180 mg/dL), where safely achievable. Basal insulin was reduced after capillary glucose <4 mmol/L or recurrent hypoglycaemia. Treatment decisions were individualised rather than protocol-mandated, reflecting the heterogeneity of the referred surgical population.

Other glucose-lowering therapies were reviewed during pathway follow-up. Procedure-specific perioperative diabetes medication advice was delivered as part of the pathway and communicated to the surgical and anaesthetic teams. Metformin, dipeptidyl peptidase-4 (DPP-4)

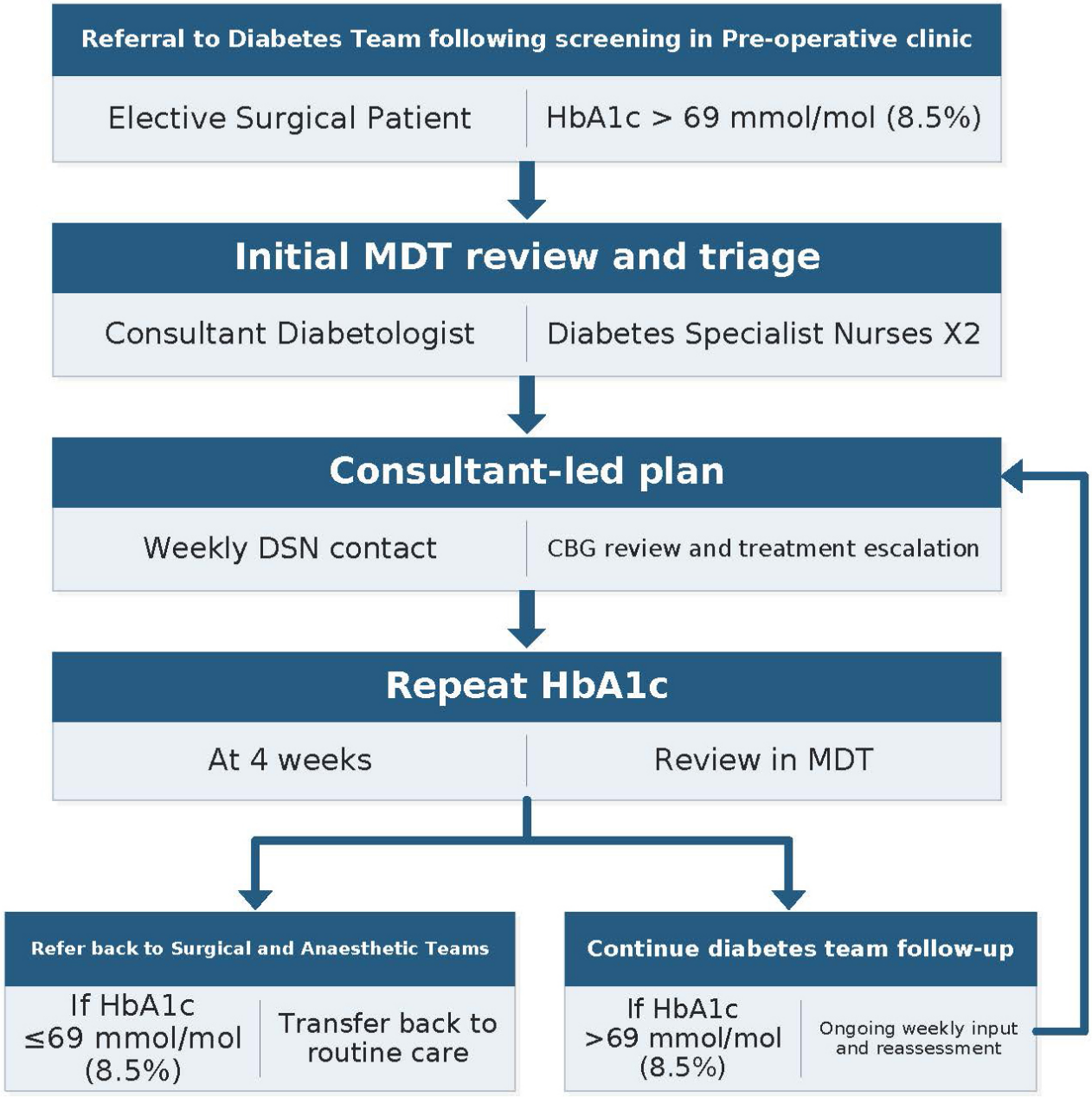

Fig. 1. Perioperative diabetes optimisation pathway. The pathway begins with identification of HbA1c >69 mmol/mol (>8.5%) during preparation for elective surgery, followed by specialist diabetes assessment, individualised treatment adjustment, diabetes specialist nurse follow-up and repeat HbA1c measurement. Patients achieving HbA1c ≤69 mmol/mol (≤8.5%) were referred back to the surgical and anaesthetic teams and returned to routine care, while those remaining above target continued weekly diabetes-team follow-up and reassessment. Abbreviations: CBG, capillary blood glucose; DSN, diabetes specialist nurse; HbA1c, glycated haemoglobin; MDT, multidisciplinary team.

inhibitors, sulfonylureas and other oral glucose-lowering agents were omitted on the day of surgery in accordance with local perioperative medication practice [9,10]. SGLT2is were stopped 3 days before surgery because of the risk of perioperative euglycaemic ketoacidosis, consistent with contemporary perioperative medication-safety guidance [12,13,16]. Glucagon-like peptide-1 receptor agonists (GLP-1RAs) were managed according to local perioperative safety practice at the time, with weekly preparations generally stopped 1 week before surgery, reflecting concerns around delayed gastric emptying and aspiration risk [14]. Subsequent guidance has emphasised individualised risk assessment and shared decision-making for perioperative GLP-1RA management [15,16].

Outcomes and perioperative recommendations were then communicated to the referring surgical and anaesthetic teams.

2.4 Data Collection and Outcomes

Data were obtained from local electronic health records. Variables included age, sex, ethnicity, diabetes type, referring specialty, baseline diabetes treatment, baseline and final follow-up HbA1c, number of diabetes-team appointments, insulin initiation and surgical pathway outcome.

The primary outcomes were change in HbA1c among patients with paired measurements and the proportion achieving HbA1c ≤69 mmol/mol (≤8.5%). Secondary outcomes were factors associated with target achievement, factors associated with follow-up HbA1c and progression to surgery. Surgical progression was treated as a descriptive pathway outcome because it could be influenced by non-glycaemic factors.

Repeat HbA1c was undertaken at approximately 4-week intervals during pathway follow-up, according to clinical response and anticipated surgical timing. Because HbA1c reflects glycaemia over the preceding 2–3 months, early repeat testing was interpreted as a directional marker of improvement rather than a steady-state measure. Follow-up HbA1c was defined as the final available HbA1c value recorded after pathway referral and before return to the surgical decision pathway or surgery.

Surgical progression was defined using the final documented pathway outcome. Patients were classified as having proceeded to surgery if surgery was recorded as completed after pathway involvement, referred back if the diabetes team returned the patient to the surgical or anaesthetic team for shared decision-making, and not proceeded/deferred if surgery was recorded as not completed, postponed or deferred at final pathway review. "No active pathway input or declined engagement" was defined as referral to the pathway without subsequent active optimisation because the patient declined specialist input, did not engage with planned follow-up, or could not be contacted despite attempted follow-up.

Specific calendar dates for pathway contacts, repeat HbA1c measurement and surgery were not available. Therefore, formal time-to-target or time-to-surgery analyses were not performed. The number of diabetes-team appointments was analysed as a measure of pathway exposure and follow-up intensity rather than as a formal time-to-event outcome.

2.5 Statistical Analysis

Normality was assessed using the Shapiro–Wilk test. Continuous variables are presented as mean ± standard deviation when approximately normally distributed and as median with interquartile range when distributional assumptions were not met. Categorical variables are presented as number and percentage. Appointment counts were non-normally distributed and are therefore summarised using median and interquartile range. Baseline and follow-up HbA1c values were compared using a paired-samples *t*-test after assessment of the distribution of within-patient HbA1c change.

Two multivariable models were constructed. Logistic regression examined factors associated with achieving a follow-up HbA1c ≤69 mmol/mol (≤8.5%), while multiple linear regression examined factors associated with follow-up HbA1c after adjustment for baseline HbA1c. Both models included baseline HbA1c, number of diabetes-team appointments, age, sex and insulin initiation during the pathway. Results are reported as regression coefficients, standard errors, odds ratios, 95% confidence intervals and *p*-values as appropriate. Model fit for the linear regression model is reported using R^2 and adjusted R^2.

Diabetes type was not included in the primary models because most patients had type 2 diabetes and the number of patients with type 1 or other diabetes was small, limiting model stability. Sensitivity analyses were performed by additionally including diabetes type in both the logistic and linear regression models, coded as type 2 versus non-type 2 diabetes, to assess whether inclusion of diabetes type materially altered the main findings. Complete results of these sensitivity analyses are presented in **Supplementary Tables 1,2**.

An exploratory descriptive subgroup analysis examined target achievement and absolute HbA1c change across baseline HbA1c categories of 70–85 mmol/mol (8.6–9.9%), 86–100 mmol/mol (10.0–11.3%) and >100 mmol/mol (>11.3%). Paired and regression analyses were performed using complete cases. A two-sided *p*-value < 0.05 was considered statistically significant.

All analyses were performed using Python version 3.13.5 (Python Software Foundation, Wilmington, DE, USA), with pandas version 2.3.0 (NumFOCUS, Austin, TX, USA), SciPy version 1.16.0 (SciPy developers), and statsmodels version 0.14.4 (statsmodels developers).

3. Results

3.1 Cohort Characteristics

A total of 174 consecutive patients were included. Paired baseline and follow-up glycaemic measurements were available for 149 patients, who were included in the paired HbA1c and regression analyses. The remaining 25 patients were retained in descriptive and surgical-pathway analyses where outcome data were available. The study selection and analysis flow are summarised in Fig. 2.

Mean age was 59.1 ± 12.9 years (range 21–88 years), and 88/174 (50.6%) were male. Type 2 diabetes accounted for 152/174 cases (87.4%). At referral, 99/174 patients (56.9%) were receiving insulin, 38/174 (21.8%) a sodium-glucose cotransporter-2 inhibitor (SGLT2i) and 16/174 (9.2%) a glucagon-like peptide-1 receptor agonist (GLP-

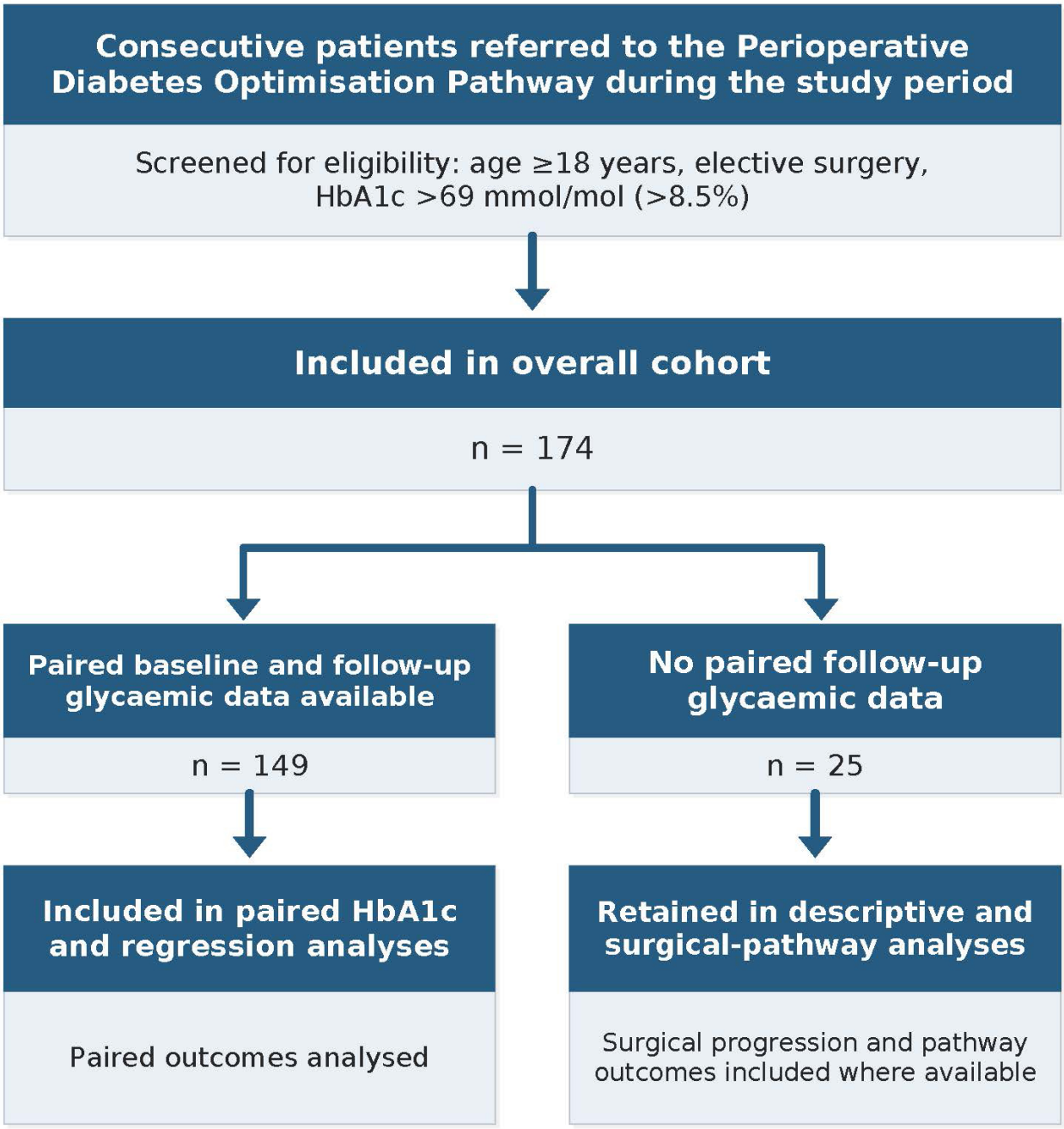

Fig. 2. Study selection and analytical cohort flowchart. All consecutive eligible patients referred to the perioperative diabetes optimisation pathway during the study period were included in the overall cohort. Patients with paired baseline and follow-up HbA1c data were included in the paired glycaemic and regression analyses, while those without paired follow-up data were retained in descriptive and surgical-pathway analyses. Abbreviations: HbA1c, glycated haemoglobin.

1RA); these medication categories were non-mutually exclusive. Referrals arose from 13 surgical specialties; the largest represented groups were general surgery (16.0%), neurosurgery (14.9%) and cardiothoracic surgery (12.6%). Baseline characteristics are shown in Table 1.

3.2 Glycaemic Outcomes

Paired baseline and final follow-up HbA1c measurements were available for 149/174 patients (85.6%). Mean HbA1c decreased from 96.2 ± 14.0 mmol/mol (11.0 ± 1.3%) to 73.1 ± 14.1 mmol/mol (8.8 ± 1.3%), representing a mean reduction of 23.1 mmol/mol (2.1 percentage points). The distribution of within-patient change was approximately normal (Shapiro–Wilk W = 0.984; p = 0.078), and the re-

Table 1. Baseline demographic and clinical characteristics.

Characteristic	Value
Age, years	59.1 ± 12.9
Age range, years	21–88
Male sex	88 (50.6%)
Female sex	86 (49.4%)
White ethnicity[1]	114 (65.5%)
Asian ethnicity	26 (14.9%)
Black ethnicity	11 (6.3%)
Other or not specified ethnicity	23 (13.2%)
Type 2 diabetes	152 (87.4%)
Type 1 diabetes	20 (11.5%)
Other diabetes[2]	2 (1.1%)
Insulin therapy at baseline	99 (56.9%)
Insulin pump therapy	3 (1.7%)
SGLT2i therapy at baseline	38 (21.8%)
GLP-1RA therapy at baseline	16 (9.2%)
Baseline HbA1c, mmol/mol	95.6 ± 14.7
Baseline HbA1c, %	10.9 ± 1.3
Referring specialty	
General surgery	28 (16.0%)
Neurosurgery	26 (14.9%)
Cardiothoracic surgery	22 (12.6%)
Colorectal	20 (11.5%)
Urology	20 (11.5%)
ENT	15 (8.6%)
Orthopaedics	15 (8.6%)
Ophthalmology	11 (6.3%)
Other	5 (2.9%)
Upper GI	5 (2.9%)
Maxillofacial	4 (2.3%)
Transplant surgery	2 (1.1%)
Gynaecology	1 (0.6%)

Data are presented as mean ± standard deviation or n (%). Baseline HbA1c values are reported for the full referred cohort where available. Medication classes are non-mutually exclusive because patients could receive more than one glucose-lowering medication class at baseline; insulin pump therapy is included within the overall insulin therapy category. Only selected medication classes are presented; therefore, the category totals are not expected to equal or exceed the overall cohort size. Referring specialty categories were mutually exclusive, with each patient assigned to a single final surgical specialty.

Abbreviations: ENT, ear, nose and throat; GI, gastrointestinal; HbA1c, glycated haemoglobin; GLP-1RA, glucagon-like peptide-1 receptor agonist; SGLT2i, sodium-glucose cotransporter-2 inhibitor.

[1]Includes White British and White Other categories. [2]Includes type 3c and steroid-induced diabetes.

duction was statistically significant (paired t(148) = 16.43; $p < 0.001$). Baseline and follow-up HbA1c distributions, with summary values, are shown in Fig. 3.

Among patients with paired measurements, 77/149 (51.7%) achieved a final HbA1c ≤69 mmol/mol (≤8.5%). In an unadjusted comparison, patients who achieved the target attended a median of 6.0 diabetes-team appointments (interquartile range 5.0–9.0), compared with 4.0 appointments (interquartile range 0.0–9.0) among those who did not.

3.3 Factors Associated With Target Achievement

In multivariable logistic regression, higher baseline HbA1c was independently associated with lower odds of achieving a follow-up HbA1c ≤69 mmol/mol (≤8.5%) (odds ratio 0.960 per mmol/mol, 95% confidence interval 0.940–0.990; $p = 0.006$). The number of diabetes-team appointments showed a positive but non-significant association with target achievement (odds ratio 1.060 per appointment, 95% confidence interval 0.990–1.130; $p = 0.085$). Age, sex and insulin initiation were not significantly associated with target achievement. The full multivariable model is shown in Table 2.

3.4 Factors Associated With Follow-Up HbA1c

After adjustment for baseline HbA1c, each additional diabetes-team appointment was independently associated with a 0.580 mmol/mol lower follow-up HbA1c (β = −0.580, 95% confidence interval −0.980 to −0.180; $p = 0.005$). Baseline HbA1c was also independently associated with outcome, with each 1 mmol/mol higher baseline value corresponding to a 0.250 mmol/mol higher follow-up HbA1c (95% confidence interval 0.090–0.400; $p = 0.002$). Insulin initiation was associated with a numerically lower follow-up HbA1c, but this was not statistically significant (β = −3.640 mmol/mol, 95% confidence interval −8.740 to 1.450; $p = 0.160$). Age and sex were not significantly associated with follow-up HbA1c. The full multivariable model is shown in Table 3. Sensitivity analyses additionally including diabetes type as type 2 versus non-type 2 produced materially similar findings to the primary models. Diabetes type was not significantly associated with target achievement or follow-up HbA1c, and the direction and interpretation of the principal associations were unchanged (**Supplementary Tables 1,2**).

3.5 Exploratory Outcomes by Baseline HbA1c Severity

In an exploratory subgroup analysis, target achievement declined as baseline HbA1c increased. A final HbA1c ≤69 mmol/mol (≤8.5%) was achieved by 68.6% (24/35) of patients with baseline HbA1c 70–85 mmol/mol, 53.1% (34/64) of those with baseline HbA1c 86–100 mmol/mol, and 38.0% (19/50) of those with baseline HbA1c >100 mmol/mol. The corresponding baseline HbA1c ranges were 8.6–9.9%, 10.0–11.3% and >11.3%, respectively. Conversely, mean absolute HbA1c reduction increased across the baseline HbA1c groups, from 11.4 mmol/mol in the 70–85 mmol/mol group to 20.2 mmol/mol in the 86–100

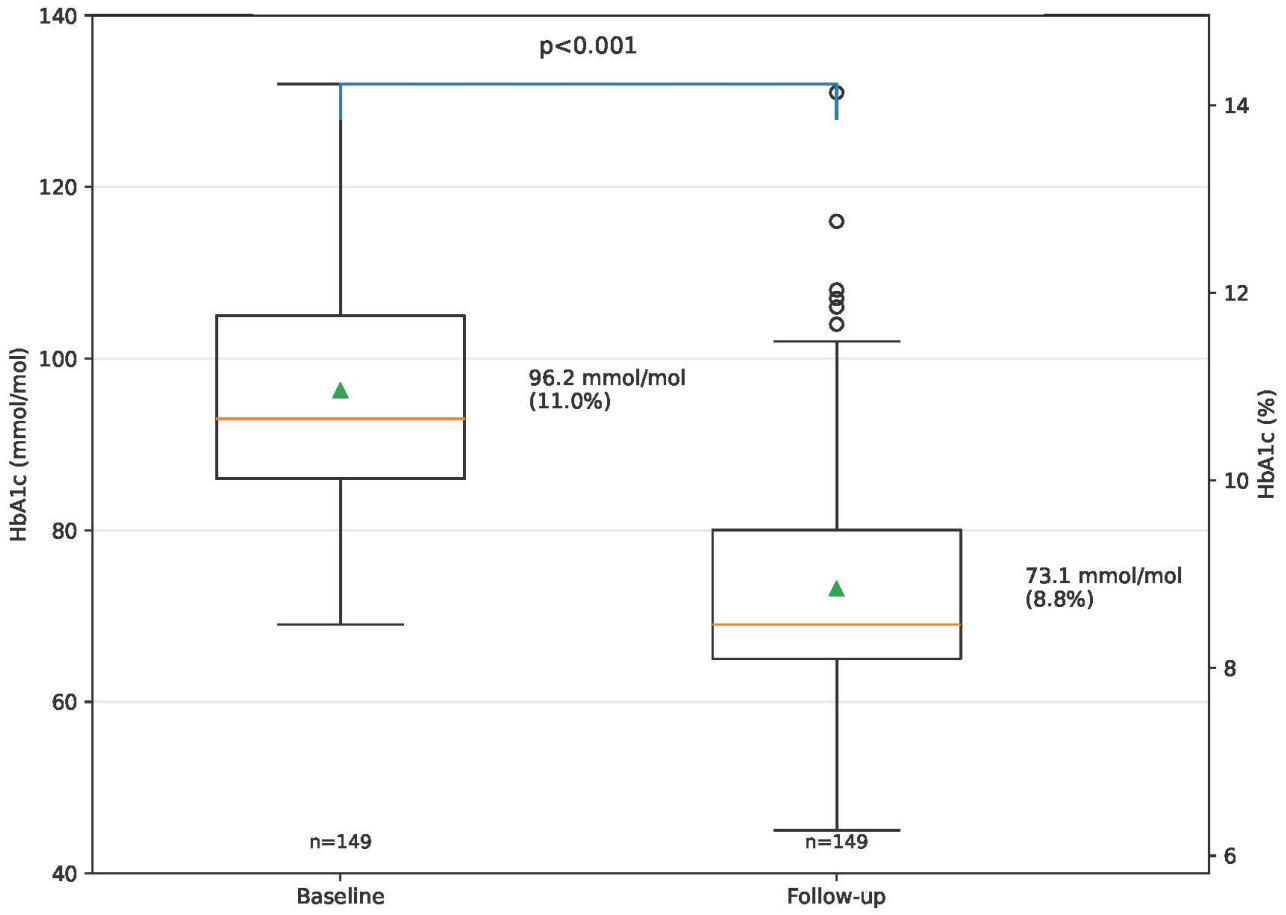

Fig. 3. Baseline and follow-up HbA1c after pathway involvement. Distribution of baseline and final follow-up HbA1c values among 149 patients with paired measurements. Abbreviation: HbA1c, glycated haemoglobin.

Table 2. Multivariable logistic regression for achievement of follow-up HbA1c ≤69 mmol/mol (≤8.5%).

Variable	β	SE	OR	95% CI for OR	*p*-value
Baseline HbA1c, per mmol/mol	−0.036	0.013	0.960	0.940–0.990	0.006
Diabetes-team appointments, per appointment	0.059	0.034	1.060	0.990–1.130	0.085
Age, per year	−0.012	0.015	0.990	0.960–1.020	0.411
Male sex	−0.329	0.348	0.720	0.360–1.420	0.345
Insulin initiation during pathway	0.237	0.409	1.270	0.570–2.820	0.562

Reference categories: female sex for "Male sex"; no insulin initiation for "Insulin initiation during pathway". The model included 149 patients with complete paired HbA1c and covariate data. Abbreviations: HbA1c, glycated haemoglobin; β, regression coefficient; SE, standard error; OR, odds ratio; CI, confidence interval.

mmol/mol group and 35.0 mmol/mol in the >100 mmol/mol group. Exploratory outcomes according to baseline HbA1c severity are presented in Table 4.

3.6 Surgical Progression and Other Pathway Outcomes

Across the full cohort, patients attended a median of 5.0 diabetes-team appointments (interquartile range 0–8). Of the 75 patients who were not receiving insulin at referral, 45 (60.0%) had insulin initiated during pathway follow-up. Among the 99 patients already receiving insulin at referral, treatment was reviewed and adjusted where clinically indicated. No hypoglycaemic events were documented in the available study datasets, although hypoglycaemia was not systematically collected as an outcome. Eight patients (4.6%) had no active pathway input or declined engagement.

After pathway intervention, 124/174 patients (71.3%) proceeded to surgery, 18/174 (10.3%) were referred back to the surgical team for further decision-making and 32/174 (18.4%) did not proceed or had surgery deferred at the point

Table 3. Multivariable linear regression for follow-up HbA1c.

Variable	β	SE	95% CI	*p*-value
Baseline HbA1c, per mmol/mol	0.250	0.078	0.090 to 0.400	0.002
Diabetes-team appointments, per appointment	−0.580	0.203	−0.980 to −0.180	0.005
Age, per year	0.130	0.091	−0.050 to 0.310	0.148
Male sex	0.480	2.211	−3.890 to 4.850	0.828
Insulin initiation during pathway	−3.640	2.577	−8.740 to 1.450	0.160

Reference categories: female sex for "Male sex"; no insulin initiation for "Insulin initiation". The model included 149 patients with complete paired HbA1c and covariate data. Model $R^2 = 0.147$; adjusted $R^2 = 0.117$. Abbreviations: HbA1c, glycated haemoglobin; β, regression coefficient; SE, standard error; CI, confidence interval.

Table 4. Exploratory outcomes by baseline HbA1c severity.

Baseline HbA1c category	n	Achieved HbA1c ≤69 mmol/mol, n (%)	Mean absolute HbA1c reduction, mmol/mol
70–85 mmol/mol (8.6–9.9%)	35	24 (68.6%)	11.4
86–100 mmol/mol (10.0–11.3%)	64	34 (53.1%)	20.2
>100 mmol/mol (>11.3%)	50	19 (38.0%)	35.0

Analyses include the 149 patients with paired baseline and follow-up glycaemic measurements. Absolute HbA1c reduction was calculated as baseline minus follow-up HbA1c. Abbreviation: HbA1c, glycated haemoglobin.

Table 5. Main outcomes of the perioperative diabetes optimisation pathway.

Outcome	Value
Paired HbA1c measurements available	149/174 (85.6%)
Mean HbA1c reduction	23.1 mmol/mol (2.1 percentage points)
Achieved HbA1c ≤69 mmol/mol (≤8.5%)	77/149 (51.7%)
Proceeded to surgery	124/174 (71.3%)
Referred back to surgical team	18/174 (10.3%)
Did not proceed or surgery deferred	32/174 (18.4%)
Newly initiated on insulin	45/75 (60.0%)
Receiving insulin at referral and reviewed for dose adjustment	99/174 (56.9%)
Number of diabetes-team appointments, median (interquartile range)	5.0 (0–8)
No active pathway input or declined engagement	8/174 (4.6%)

Data are presented as n (%), mean ± standard deviation, median (interquartile range) or mean change, as appropriate. HbA1c outcomes are based on patients with paired measurements (n = 149) unless otherwise stated. Newly initiated insulin is reported among patients not receiving insulin at referral (n = 75). Abbreviation: HbA1c, glycated haemoglobin.

of final pathway review. The main glycaemic and pathway outcomes are summarised in Table 5.

Among the 32 patients who did not proceed to surgery, reasons for non-progression were coded into mutually exclusive categories, with each patient assigned according to the principal documented reason or final recorded outcome. These included ongoing diabetes optimisation or specialist review in 11 (34.4%), non-engagement or inability to contact in 6 (18.8%), surgical postponement or continued waiting in 6 (18.8%), non-glycaemic medical or optimisation factors in 3 (9.4%), and death in 2 (6.3%). Persistent poor glycaemic control was explicitly documented as the reason for cancellation in 1 patient (3.1%), while surgery was no longer required in 1 (3.1%), and the final reason or outcome was unclear in 2 (6.3%).

4. Discussion

In this prospective evaluation of a tertiary-centre perioperative diabetes service, referral to a multidisciplinary optimisation pathway was associated with a mean HbA1c reduction of 23.1 mmol/mol (2.1%) in patients awaiting elective surgery. Just over half of patients with paired measurements achieved target HbA1c ≤69 mmol/mol (≤8.5%), and 71.3% of the full cohort subsequently proceeded to surgery. Higher baseline HbA1c was associated with a lower likelihood of reaching the target threshold, whereas more diabetes-team appointments were associated with a lower follow-up HbA1c after adjustment for baseline glycaemia.

Baseline HbA1c was important in interpreting response. Preoperative HbA1c and perioperative hyperglycaemia have been associated with postoperative complica-

tions [23,24,25,26], supporting their use in perioperative risk assessment and as potential targets for intervention. Patients starting nearer the referral threshold were more likely to achieve an HbA1c ≤69 mmol/mol, whereas the exploratory baseline-severity analysis showed that those with the highest baseline values experienced the largest absolute reductions but were less likely to cross the fixed threshold. Failure to reach the target HbA1c should therefore not necessarily be interpreted as failure of optimisation or an automatic reason to postpone surgery, particularly when substantial improvement has occurred and the urgency and benefits of surgery favour proceeding [25]. Baseline severity may also help services anticipate the intensity and duration of support required and target resources more effectively.

Repeat HbA1c testing during the pathway was used pragmatically as a directional marker of glycaemic improvement. Because HbA1c reflects glycaemia over the preceding 2–3 months, values repeated after approximately 4 weeks should not be interpreted as full steady-state measures. However, in the elective surgical pathway, an early downward trend may still support clinical reassessment and shared decision-making about surgical readiness.

More frequent diabetes-team contact was associated with better follow-up glycaemic control, consistent with previous reports of structured preoperative diabetes optimisation programmes [19,20]. The pathway combined proactive treatment escalation with repeated reassessment, education and communication with surgical teams. In insulin-naïve patients requiring substantial treatment intensification, once-daily basal insulin was the predominant escalation strategy, providing a pragmatic approach that could be initiated promptly and titrated through frequent specialist follow-up. However, the linear regression model explained only a modest proportion of the variability in follow-up HbA1c (adjusted $R^2 = 0.117$), indicating that important determinants of glycaemic outcome were not captured. Potential unmeasured factors include baseline insulin dose and treatment intensity, body mass index, treatment adherence, hypoglycaemia, surgical urgency and other markers of clinical complexity. Furthermore, appointment frequency should not be interpreted as a causal exposure: patients with poorer glycaemic control or more complex treatment requirements may have received more frequent follow-up. Appointment count may therefore represent a marker of treatment intensity or clinical complexity, and residual confounding and reverse causality cannot be excluded.

No hypoglycaemic events were documented in the available study datasets; however, hypoglycaemia and serial capillary glucose readings were not prospectively or systematically captured, and undocumented events cannot therefore be excluded. Accordingly, the absence of documented hypoglycaemic events should not be interpreted as evidence that hypoglycaemia did not occur. Patients undergoing treatment intensification were typically reviewed weekly and had direct access to the specialist team for advice and dose adjustment, providing a safety-netting mechanism particularly following insulin initiation or titration.

These findings help address the recognised gap between national recommendations and the practical delivery of preoperative diabetes optimisation. Core components of a similar service are likely to include a defined referral threshold, clear clinical ownership, timely specialist treatment review, capacity for repeated diabetes specialist nurse follow-up and reliable communication with surgical and anaesthetic teams [9,10,19,20]. Timely referral is essential to allow sufficient opportunity for treatment adjustment and reassessment, as late referral may limit the time available for optimisation. The incorporation of remote review within the pathway may help reduce the burden of repeated contact.

For patients who did not reach HbA1c ≤69 mmol/mol, the pathway supported further multidisciplinary discussion rather than automatic cancellation. Reasons for non-progression were heterogeneous and included ongoing optimisation, patient non-engagement, surgical delay, non-glycaemic medical factors and death; only one available record explicitly attributed cancellation to persistent poor glycaemic control. Surgical progression should therefore not be interpreted as a direct measure of glycaemic pathway effectiveness. Decisions about proceeding required consideration of the degree of glycaemic improvement, current capillary glucose profile, hypoglycaemia risk, surgical urgency, anaesthetic risk, comorbidity and the potential harm of delaying surgery. This is particularly relevant for patients requiring cancer, cardiac, neurosurgical or other time-sensitive procedures, where delay may carry competing clinical risks.

Previous coordinated perioperative diabetes initiatives have reported encouraging but variable findings. A dedicated preoperative diabetes optimisation programme demonstrated improved glycaemic control in presurgical patients with suboptimal diabetes control [19], while evaluation of the IP3D intervention suggested improvements in elective surgical pathway outcomes [21]. Other initiatives have improved perioperative diabetes processes, although effects on broader clinical outcomes have been less consistent [20,22]. Wider adoption may have been limited by the need for dedicated specialist staffing, fragmented ownership across diabetes, anaesthetic and surgical services, variable local infrastructure and the absence of definitive evidence identifying the most effective and cost-effective model. The present study adds evidence of substantial preoperative HbA1c improvement across a broad tertiary surgical population.

Progression to surgery was included as a clinically meaningful hospital-pathway outcome but should not be interpreted as a purely glycaemic endpoint. Decisions to proceed were also influenced by operative urgency, medical fitness, disease progression and theatre capacity. Never-

theless, most patients ultimately underwent surgery; however, without a comparator, the contribution of the pathway to surgical progression cannot be determined. Although improved glycaemic control is biologically and clinically relevant, this study did not assess postoperative complications, hypoglycaemia, length of stay or readmission. Therefore, the findings should be interpreted as evidence of improved preoperative glycaemic status and pathway progression, rather than direct evidence of improved postoperative outcomes.

Strengths include consecutive inclusion, prospective collection of routine clinical data, representation of 13 surgical specialties and evaluation of both glycaemic and pathway outcomes. The main limitations were the single-centre uncontrolled design, incomplete paired HbA1c data in 25 patients, and the absence of systematically recorded medication changes, insulin doses, timing of pathway contacts and surgery, and postoperative outcomes. Reasons for non-progression were identifiable from available documentation but were not prospectively or systematically collected; patient-reported experience was also not assessed. These limitations should be considered when interpreting the observed associations and the extent to which glycaemic improvement translates into broader perioperative outcomes.

Future studies should assess treatment timelines, postoperative outcomes, reasons for delay or cancellation, resource use and patient experience. Multicentre controlled studies would help determine whether the pathway offers benefits beyond usual care. Future work should also consider whether serial capillary glucose data or perioperative continuous glucose monitoring can better characterise short-term glycaemic change, hypoglycaemia and perioperative glucose variability, although current evidence for CGM in noncardiac surgery remains limited [27].

5. Conclusion

A locally developed multidisciplinary perioperative diabetes optimisation pathway was associated with substantial improvement in HbA1c, while most referred patients subsequently proceeded to elective surgery. Baseline HbA1c identified patients less likely to achieve the fixed preoperative target, whereas more frequent diabetes-team contact was modestly associated with lower follow-up HbA1c after adjustment for baseline glycaemia. These findings support coordinated specialist follow-up, including pragmatic initiation and titration of basal insulin where clinically indicated, as a practical hospital-based approach to preoperative diabetes optimisation.

Key Points

• In 149 patients with paired measurements, mean HbA1c decreased by 23.1 mmol/mol (2.1 percentage points) after referral to the pathway.

• Just over half of patients with paired measurements achieved the commonly used preoperative target of HbA1c ≤69 mmol/mol (≤8.5%).

• Higher baseline HbA1c was associated with a lower likelihood of target achievement, although patients with the highest baseline values experienced the largest absolute reductions.

• A greater number of diabetes-team appointments was modestly associated with a lower follow-up HbA1c after adjustment for baseline HbA1c.

• Most referred patients (71.3%) subsequently proceeded to surgery, although surgical progression was influenced by both glycaemic and non-glycaemic factors.

Availability of Data and Materials

The dataset contains routinely collected clinical information and is not publicly available because of patient confidentiality and local information-governance requirements. De-identified aggregate data may be available from the corresponding author subject to institutional approval.

Author Contributions

KDG contributed to the literature review, data analysis and interpretation, and drafting of the manuscript. SM contributed to interpretation of the study findings and critical revision of the manuscript. BL and MK contributed to delivery of the pathway, maintenance of pathway integrity and manuscript review. FB conceived the study, contributed to study design, supervised the work, performed data analysis and interpretation, and critically revised the final manuscript. All authors contributed to critical editorial revisions, read and approved the final manuscript, and agreed to be accountable for the work.

Ethics Approval and Consent to Participate

This study evaluated an established clinical service using anonymised routinely collected data. In accordance with local institutional policy, the work was classified as a service evaluation; formal research ethics committee approval and individual participant consent were therefore not required.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used ChatGPT, developed by OpenAI, and Claude, developed by Anthropic, to assist with language editing, manuscript organisation and refinement of wording. After using AI-assisted tools, the authors thoroughly reviewed, verified, and revised the manuscript to ensure the accuracy, originality, and integrity of its content and take full responsibility for the content of the publication. AI tools were not used to generate the study data or determine the reported statistical results.

Supplementary Material

Supplementary material associated with this article can be found, in the online version at https://doi.org/10.31083/BJHM55387.

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