Quality Improvement Project

Implementing a Diabetic Algorithm for Ophthalmology Surgery Patients: A Quality Improvement Initiative

Simrenjeet Sandhu,[1] Aleena Virani,[2] Hilary Salmonson,[1] Karim Damji,[1,3] Pamela Mathura,[3] Rany Al-Agha[4]

[1]Department of Ophthalmology and Visual Sciences, University of Alberta, Edmonton, AB, Canada
[2]Queen's University, Kingston, ON, Canada
[3]Department of Ophthalmology and Visual Sciences, Aga Khan University, Karachi, Pakistan
[4]Department of Medicine, University of Alberta, Edmonton, AB, Canada

Address correspondence to Simrenjeet Sandhu (simrenje@ualberta.ca).

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ABSTRACT

Introduction: The objective of this quality improvement, interventional study regarding patients with diabetes undergoing diabetic ophthalmology outpatient surgery aimed to develop, implement, and evaluate a new diabetic algorithm to improve safety, operating room efficiency, and decrease supply cost. **Methods:** A multidisciplinary study team was assembled, including ophthalmologists, endocrinologists, anesthesiologists, management, and nurses to review the current diabetic protocol. From August 2016 to July 2017, 13 patient safety concerns or incident reports were reviewed that identified two serious cases of hypoglycemia. Using the concerns data, frontline perspectives, and reviewing best practice guidelines, a new diabetic algorithm was developed and trialed for 24 months. The new algorithm limited the use of an existing preoperative insulin protocol and reduced the number of nurses required. The number of adverse events, nursing setup process steps, setup time, and preoperative insulin infusion protocols used were collected. An evaluation of the supply costs was performed. **Results:** After implementing the new diabetic algorithm, zero safety incidents were reported, and a 97.5% reduction in the use of preoperative insulin protocol resulted. Nursing staff perceived that the new diabetic algorithm was easier to configure, 23 minutes faster to set up, and required one nursing staff member. Supply cost was reduced by $30.63 (Canadian Dollars, CAD) per patient. **Conclusion:** Perioperative glucose irregularities may threaten patient safety and surgical outcomes. Healthcare professionals must improve patient safety, decrease healthcare expenditure, and prevent unnecessary delays. Multidisciplinary frontline staff experiential knowledge aided in the recognition of potential problems and comprehensive solutions to optimize patient care.

Keywords: diabetes, cataract, multidisciplinary, surgery, quality improvement

INTRODUCTION

Diabetes mellitus represents a group of metabolic diseases defined by chronic hyperglycemia stemming from inadequate insulin production and/or use.[1] According to the International Diabetes Federation, 463 million adults were living with diabetes in 2019, and an estimated 700 million people will have diabetes by 2045.[2] In 2019, diabetes caused $760 billion in health expenditures.[2] Furthermore, one in two people with diabetes was undiagnosed.[2]

Poor glycemic control can lead to numerous and potentially serious ocular complications, including cataracts, macular edema, neovascularization, retinal detachments, and others.[3–10] A lack of control can result in anesthetic complications and compromise surgical outcomes. Specifically, studies have shown an increased risk of infection, inflammation, wound healing, and postoperative hyperglycemia in patients with diabetes.[3–10] Perioperative glucose irregularities may threaten patient safety and surgical outcomes. Guidelines regarding managing preoperative glycemic control vary among institutions, and general consensus are lacking.

Table 1. Current initiation of diabetic protocol

Capillary Glucose Reading, mmol/L	Insulin Rate, mL/hr	Action
≤ 5	Hold	Notify prescriber Repeat capillary glucose in 1 hr and initiate insulin once capillary glucose >5
5.1–8	0.7	Repeat capillary glucose in 2 hr
8.1–12	1	
12.1–15	1.2	
15.1–18	1.5	Repeat capillary glucose in 1 hr
18.1–20	2	
> 20	As directed by prescriber	Notify prescriber Repeat capillary glucose

The ophthalmology outpatient surgery service at the Royal Alexandra Hospital in Edmonton, Alberta, Canada, provides surgical care to approximately 25 patients daily. Of those, two to four patients require intravenous insulin infusion. Patients with diabetes scheduled for eye surgery have their glucose level tested on the morning of their surgery. Patients are instructed to withhold oral antihyperglycemic agents and insulin on the day of surgery. For all patients with diabetes, the current preoperative insulin infusion protocol was used regardless of blood glucose levels. There were several concerns raised regarding patient safety due to the complexity of the current protocol; specifically, there were two serious cases of hypoglycemia.

Further, multiple preoperative delays occurred throughout the day, affecting the flow of surgical patients in the operating room. Consequently, nursing staff would have to stay later than anticipated, depleting healthcare resources and dollars. This quality improvement (QI) initiative aimed to develop and implement a new diabetic algorithm for patients undergoing ophthalmology outpatient surgery to improve patient safety and decrease preoperative delays. Specifically, we aimed to reduce the incidence of adverse events to zero for patients presenting for outpatient surgery over 2 years. A secondary aim was to evaluate the associated costs, comparing the current preoperative insulin infusion protocol usage and the new diabetic algorithm.

MATERIALS AND METHODS

Ethics approval was obtained via the University of Alberta in Edmonton, Alberta, Canada. A multidisciplinary study team was assembled, including ophthalmologists, endocrinologists, anesthesiologists, management, and nurses to review the current diabetic protocol shown in Tables 1–3. This study had a pre–post study design, and the Model of Improvement framework guided all QI activities to establish a clear QI aim for the study team.[11–13] As well, trial an intervention through plan-do-study-act (PDSA) cycles, tracking adaptations of the new algorithm to the local surgical context. Specifically, we aimed to reduce the incidence of adverse events to zero for patients presenting for outpatient surgery over 2 years.

Table 2. Current rate adjustment when capillary glucose drops by 3 mmol/L or more from previous reading

Capillary Glucose Reading, mmol/L	Insulin Rate, mL/hr	Action
≤ 8	Infuse at 0.5	Repeat capillary glucose in 1 hr
8.1–12	Infuse at 1	
> 12	Infuse at 1.5	

*See Table 3 as appropriate for subsequent rate adjustments.

Table 3. Current rate adjustment (not to be used if capillary glucose drops by ≥ 3 mmol/L)

Capillary Glucose Reading, mmol/L	Adjust Insulin Rate, mL/hr	Action
≤ 5	Decrease by 0.5*	Notify prescriber Repeat capillary glucose in 1 hr
5.1–8	Decrease by 0.3*	Repeat capillary glucose in 2 hr
8.1–12	No change to rate*	Repeat capillary glucose in 4 hr
12.1–15	Increase by 0.5*	
15.1–18	Increase by 1*	Repeat capillary glucose in 2 hr
18.1–20	Increase by 1.5*	
> 20	Increase by 2*	Notify prescriber Repeat capillary glucose

*If insulin infusion is stopped, restart at 0.5 mL/hour when capillary glucose rises to greater than 12 mmol/L. See Table 2 for subsequent rate adjustments.

The QI team reviewed all adverse events documented by healthcare providers from the previous year and collected by the unit manager (Table 4). In addition, a process flow map was constructed (Fig. 1). Nursing concerns were brought forward regarding the current protocol process steps at the initiation of this study. Nurses were interviewed to garner feedback about the current protocol to understand the nursing perspective.

Table 4. Adverse event description

Adverse Event Description	Result
Wrong rate or frequency	Severe case of hypoglycemia resulting in decreased LOC
Orders signed but missed by nursing staff	No apparent harm
Wrong rate or frequency	No apparent harm
Returned from OR not on protocol	No apparent harm
Inaccurate assembly	Severe case of hypoglycemia
Intravenous interstitial	Minimal harm: hypoglycemia
Wrong rate or frequency (read wrong table)	Minimal harm: hypoglycemia
Orders not signed by physician	No apparent harm
Returned from OR not on protocol	No apparent harm
Wrong rate or frequency	No apparent harm
Returned from OR not on protocol	No apparent harm
Wrong rate or frequency	Minimal harm: hypoglycemia
Inaccurate assembly	Minimal harm: hypoglycemia

LOC: loss of consciousness; OR: operating room.

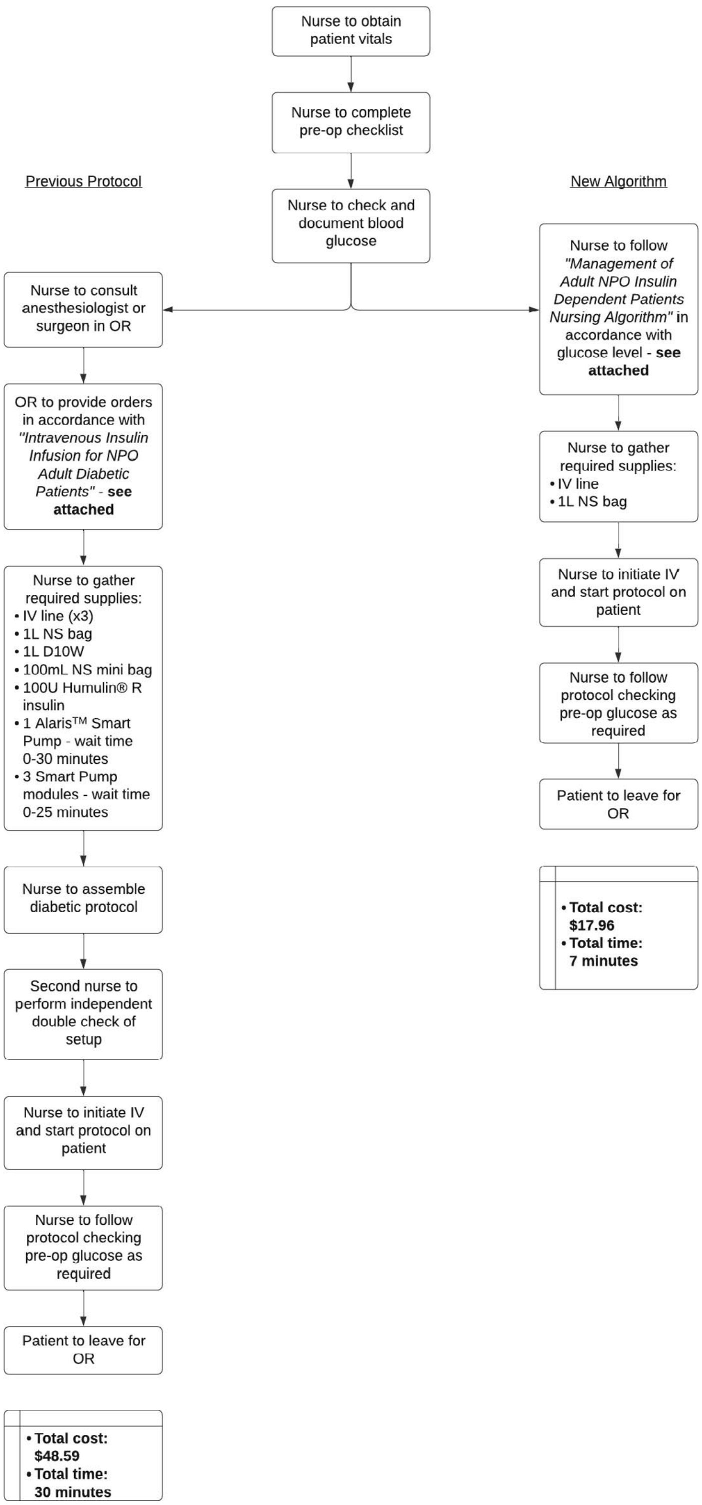

Figure 1. Process flow exercise: Old protocol versus new diabetic algorithm. D10W: Dextrose 10% in water IV solution; IV, intravenous; OR, operating room; NPO: nothing by mouth; NS: normal saline.

Multiple in-person meetings were held with frontline staff to obtain their perspectives on the current protocol. A new diabetic algorithm to safely treat diabetic patients before and during eye surgery was developed using the concerns data, frontline perspectives, a review of best practices from literature reviews, and other institutions.[14–22]

The new algorithm was pilot trialed for 24 months (August 1, 2017, to August 1, 2019). All staff members were informed of the change and encouraged to prospectively report adverse events, process impacts, and to offer comments and suggestions to the unit manager regarding the new protocol. The QI team made any required algorithm adjustments and communicated them to the staff. Specifically, the team met and developed the initial algorithm and tested PDSA cycle 1 on 5 patients over 1 month. The team met again to review concerns and feedback and adjusted the initial algorithm. Specifically, when the blood glucose levels were higher than 20 mmol/L, the primary contact person was changed. Also, a slight adjustment was made to the flow volume as well. PDSA cycle 2 was for 1 month, and no adjustments were needed. Finally, PDSA cycle 3 lasted 22 months.

Data collection using a paper-based tracking tool included the following variables: the number of adverse events, nursing process steps for setup, and the number of preoperative insulin infusion protocols used. The time for setup was measured by a member of our study team for both protocols on one occasion. Descriptive statistics supported the analysis of the tracking tool variables, and a cost–benefit analysis was performed to evaluate and compare preoperative insulin infusion protocol usage.

From August 2016 to July 2017, 13 reports revealed patient safety concerns and/or incidents, specifically about using the preoperative diabetic protocol (Table 4). Moreover, there were two serious cases of hypoglycemia. After much consultation with medical leaders and multidisciplinary surgical team members, it was determined that most issues were related to the initial setup process steps in the current preoperative insulin infusion protocol and incorrect management in the operating room. The nursing staff identified that the setup required for the current protocol was time-consuming, complex, and required two members from the nursing team, which interrupted surgical workflow throughout the day.

Developing a new diabetic algorithm involved recognizing and including two salient principles. Ophthalmic surgeries are generally shorter in duration compared with other specialties, and using local anesthetic is mostly preferred over general anesthetic. In addition, our study team reevaluated the safety range for blood glucose levels that caused concern. The team decided to use a more straightforward insulin dosing regimen, with pumps or infusions used only when required. As such, the new diabetic algorithm was created (Fig. 2), maintaining the current preoperative insulin protocol; however, updating when to use the preoperative protocol based on the blood glucose level. Therefore, for patients with diabetes with a blood glucose higher than 20 mmol/L, the preoperative protocol would be used, and for blood

Table 5. Adverse events previous protocol versus new protocol

Protocol (Date range)	No. of Adverse Events
Previous (Aug 1, 2016–Jul 31, 2017)	13
New (Aug 1, 2017–Aug 1, 2019)	0

glucose levels between 4.1 and 20 mmol/L, normal intravenous saline was initiated.

The new diabetic algorithm was trialed from August 1, 2017, to August 1 2018, and implemented thereafter. After 2 years of algorithm usage, there were no reported adverse events when implementing the new diabetic protocol (Table 5).

RESULTS

Results revealed that an average of 2 (2.5%) patients with diabetes per month require the preoperative insulin infusion protocol after implementing the new algorithm. This is a 97.5% reduction in the use of preoperative insulin protocol for patients with diabetes.

From a nursing staff perspective, the new diabetic algorithm was much simpler to set up, less time consuming, and only required one staff member (Tables 6, 7).

A simplified cost analysis was performed for our study focusing on insulin supply usage (Table 8). We recognize that a complete cost analysis would evaluate materials used and incorporate costs associated with healthcare and staff time, patient-related costs, and many others.

Table 8 reveals a total supply cost avoidance of $30.63 (Canadian Dollars, CAD) per patient using the new diabetic algorithm.

Two minor algorithm adjustments were made after trial implementation: the concentration of the intrave-

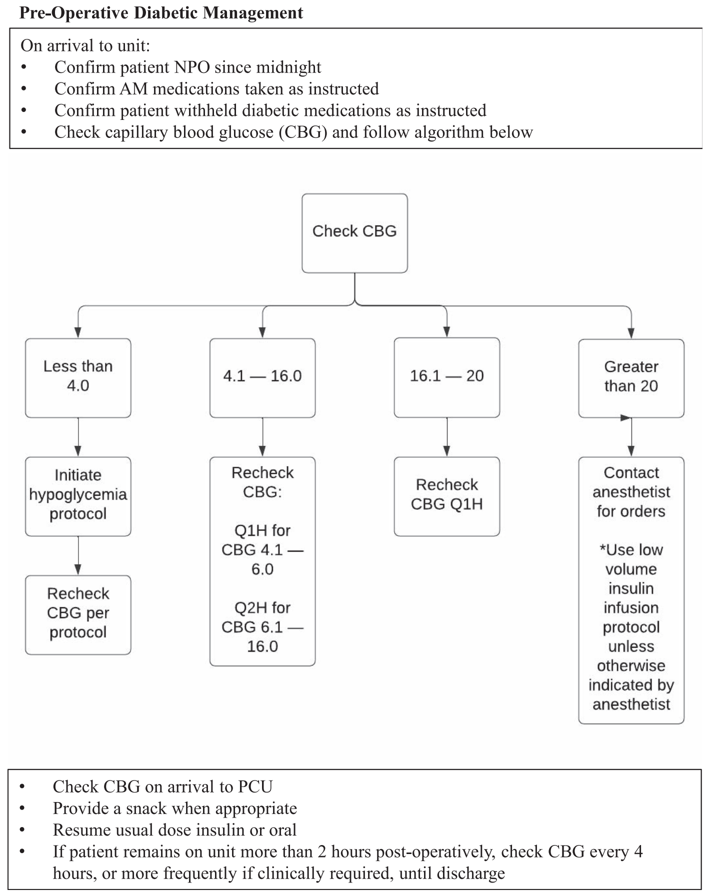

Figure 2. New diabetic algorithm. Ophthalmology outpatient surgery management of adult NPO insulin-dependent patients nursing algorithm. AM, morning; CBG: capillary blood glucose; NPO: nothing by mouth; PCU: primary care unit; Q1H: every hour; Q2H: every 2 hours.

Table 6. Nursing perspective: previous diabetic protocol versus new diabetic algorithm

Step	Previous Diabetic Protocol	New Diabetic Protocol
1	Patient chart gathered and patient met in room	Patient chart gathered and patient met in room
2	Vitals performed	Vitals performed
3	Preoperative checklist completed, including diabetic information	Preoperative checklist completed, including diabetic information
4	Glucose checked	Glucose checked
5	Computer charting completed and allergy bracelet placed on patient	Computer charting completed and allergy bracelet placed on patient
6	If elevated glucose $\geq$ 5.0 mmol/L, call anesthesiology to initiate protocol	If elevated glucose, diabetic algorithm followed: $>$ 20 mmol/L, call anesthesiology for low-volume insulin infusion 4.1–19.9 mmol/L, run normal saline
7	Supplies ordered	Supplies gathered: IV line and normal saline
8	Diabetic protocol assembled	Protocol started: IV initiated
9	Independent double check performed by another nursing staff member	Glucose monitored per diabetic algorithm until the patient leaves for operating room
10	Protocol started: IV initiated	Instillation of dilation eye drops (or others)
11	Glucose monitored per diabetic protocol until the patient leaves for operating room.	Patient leaves for operating room
12	Instillation of dilation eye drops (or others)	
13	Patient leaves for operating room	

IV: intravenous (line).

Table 7. Minutes required by registered nurse to complete previous insulin protocol and the new diabetic algorithm

	Former Preoperative Insulin Protocol, min	New Diabetic Algorithm, min	Savings, min
Registered Nurse 1	20	7	13
Registered Nurse 2	10	-	10
Total per patient	30	7	23

Dash (-) indicates not applicable, as the nurse is not involved with this procedure.

Table 8. Supply cost comparing previous insulin protocol and the new diabetic algorithm

Supplies	Previous Insulin Protocol, $	New Diabetic Algorithm, $	Savings, $
IV lines (3 lines)	13.92	4.64	9.28
1-L normal saline (1 bag)	13.32	13.32	0
1-L D10W (1 bag)	18.84	-	18.84
100-mL normal saline (1 bag)	1.26	-	1.26
Humulin R insulin (100 U)	1.25	-	1.25
Total per patient	48.59	17.96	30.63

Cost values are Canadian Dollars (CAD). Dash (-) indicates not applicable.
IV: intravenous.

nous fluid and who the primary contact physician should be for cases in which blood glucose levels were greater than 20 mmol/L.

The feedback after 2 years of algorithm use has been positive as follows:

> I am very happy with the new diabetes care algorithm. This will improve patient care by reducing the risk of low blood sugars. It shows the benefit of collaboration between ophthalmologists, anesthesiologists, and internists.—Retina surgeon

> I'm very happy with the new nursing algorithm for ophthalmology [outpatient] surgery patients. It is straightforward, shows common sense, and is a huge improvement in patient safety for our diabetic patients.—Anesthesiologist

DISCUSSION

A new diabetic algorithm for patients undergoing ophthalmology outpatient surgery was developed by a multidisciplinary team to improve patient safety, prevent preoperative delays, and decrease costs. The previous usage of the preoperative insulin infusion protocol for all-outpatient surgery patients with diabetes, regardless of blood glucose levels, resulted in 13 reports revealing patient safety concerns and/or incidents from August 2016 to July 2017, including two severe hypoglycemia cases that led to the urgent need for reevaluation of protocol use. Two-year data from the implementation of the diabetic algorithm revealed zero adverse event reports. Results also showed a significant reduction in the number of patients with diabetes requiring the preoperative insulin infusion protocol after implementing the new algorithm. An average of two patients with diabetes per month required the insulin infusion protocol, resulting in a 97.5% reduction.

In addition, the time and nursing personnel required for the widespread usage of the preoperative insulin infusion protocol was compared with the new diabetic algorithm. Previously, two nurses were required with an average of 30 minutes per protocol. First, the nurse would gather the supplies to start the protocol and would then need to call the medical device reprocessing department to obtain all the modules or smart pumps required. Next, the nurse would assemble the diabetic supplies in the medical room. A second nurse would then verify the protocol setup was correct. Last the intravenous line would then be started. The nursing staff would continue to follow the protocol, monitoring the glucose levels until the patient was ready for the surgery.

The new diabetic algorithm minimizes the preoperative insulin infusion protocol and nursing staff as only one nurse is required. In addition, the nursing setup time required for the new algorithm is 7 minutes compared with the previous 30 minutes. For the new algorithm, the nurse gathers supplies, including an intravenous line and 1 L of normal saline bag, and then the intravenous line is started. The nursing staff would continue to follow the protocol, monitoring the glucose levels until the patient was ready for the surgery. This change resulted in increased availability of nursing staff, allowing nurses to direct their attention to patients requiring assistance or other care areas. When comparing the widespread usage of the preoperative insulin infusion protocol to the newly established algorithm, approximately 23 minutes was saved, and one less member of the nursing staff was required per patient. Conservatively, this would redirect nearly 200 nursing hours annually. During the pilot months of a new algorithm, all patients with diabetes were monitored very closely to minimize risk.

With increasing health costs and limited healthcare dollars, efforts must be made to decrease expenditures when possible. We performed a cost analysis comparing the previous diabetic protocol to the new diabetic algorithm. The previous protocol amounted to $48.59 CAD per patient versus $17.96 with the new algorithm, resulting in savings of $30.63. This could lead to an approximate cost savings of nearly $1500 CAD per year.

A Singapore study by Woo et al[23] performed a cross-sectional questionnaire regarding perioperative glycemic control for patients undergoing cataract surgery under local anesthesia. Of 129 ophthalmologists and anesthesiologists who replied to the survey, nearly 83% chose to withhold oral hypoglycemic agents, and 70% held insulin in addition to keeping the patient fasted preoperatively, similar to our recommendations. In addition, 86.0–93.0% of respondents indicated that a blood glucose level of 17 mmol/L or higher would lead them to a treat and delay surgery strategy. Our study uses a blood glucose level of 20 mmol/L or higher for initiating treatment. Woo et al[23] also reported that 37.2% of respondents would treat a blood glucose level ranging from 2 to 5 mmol/L, and 31.0% of respondents would treat a blood glucose level of 11 to 16 mmol/L.

Similarly, our study would treat a blood glucose level of less than 4 mmol/L. Most surgeons, 86.0–96.9% of respondents, would consider canceling cataract surgery if blood glucose levels were 23 mmol/L or higher. This topic remains controversial. Our algorithm does not discuss canceling surgery for glucose extremes. The Royal College of Ophthalmologists in the United Kingdom released a statement in May 2018 regarding diabetic control and safe cataract surgery stating the following:

> There is evidence to show that good long-term control of blood glucose will reduce the likelihood of long-term complications such is retinopathy/maculopathy, infections, and the need for cataract surgery. However, there is no published evidence on the adverse effects of high intraoperative blood glucose on outcome after cataract surgery. The data collected by the NOD [National Ophthalmology Database] national cataract audit is not sufficient currently to robustly answer this question.[24]

A study by Reddy et al[25] devised a perioperative glycemic management protocol for patients undergoing cardiac surgery and discussed successful strategies for implementation. Similarly, a multidisciplinary approach was used together with members from various services, including anesthesia, cardiac critical care, intensive care nurses, endocrinology, pharmacy, dietary, and an improvement team. Similar to our study, the group had frequent meetings to ensure addressing all stakeholder concerns and making progress. In addition, we used process flowcharts, which were also used by Reddy et al[25], to facilitate the identification of gaps. This similarity supports the idea that sharing methodology and experience for implementing meaningful change in one specialty can benefit other specialties.

The strengths of our study include the use of a multidisciplinary team, including ophthalmologists, endocrinologists, anesthesiologists, professional practice, management, and nurses guided by the Model of Improvement. This approach provided valuable input from various frontline healthcare team members that would directly and/or indirectly affect patient care. Deficiencies and other concerns could be addressed, and possible solutions could be discussed and cocreated to support change acceptance.

A limitation of this study was that the ophthalmology outpatient surgery service clinical context was analyzed. Therefore, generalizations and suggestions for other subspecialties and clinical context usage must be carefully examined. The setup time for the protocol could have been measured more than once using different nursing staff. A more intense critical appraisal regarding cost analysis could have been performed concerning non-disposable savings, such as nursing staff time.

CONCLUSION

The results of piloting the new diabetic algorithm were shared within the ophthalmology department and during program quality council meetings. Evaluation of the algorithm will continue and updates made as required. Further, we plan to share our study findings with other hospitals in Edmonton and surgical centers in the province. Perioperative glucose irregularities may threaten patient safety and surgical outcomes. Healthcare professionals are obligated to improve patient safety, decrease healthcare expenditure, and prevent unnecessary delays. Multidisciplinary frontline staff allow for the broad recognition of potential problems and provide comprehensive solutions to optimize patient care.

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