BMJ Open Quality

Quality improvement project for improving inpatient glycaemic control in non-critically ill patients admitted on medical floor with type 2 diabetes mellitus

Adeel Ahmad Khan,[1] Aamir Shahzad,[1] Samman Rose,[1] Dabia Hamad S H Al Mohanadi,[2] Muhammad Zahid[1]

To cite: Khan AA, Shahzad A, Rose S, *et al*. Quality improvement project for improving inpatient glycaemic control in non-critically ill patients admitted on medical floor with type 2 diabetes mellitus. *BMJ Open Quality* 2020;**9**:e000982. doi:10.1136/bmjoq-2020-000982

Received 28 March 2020
Revised 4 June 2020
Accepted 21 July 2020

Check for updates

© Author(s) (or their employer(s)) 2020. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

[1]Department of Internal Medicine, Hamad Medical Corporation, Doha 3050, Qatar
[2]Department of Endocrinology, Hamad Medical Corporation, Doha 3050, Qatar

Correspondence to
Dr Adeel Ahmad Khan;
adeel_1026@yahoo.com

ABSTRACT

A significant number of patients admitted to the medical floor have type 2 diabetes mellitus (DM). Lack of a standardised inpatient hyperglycaemia management protocol leads to improper glycaemic control adding to morbidity in such patients. American Diabetes Association, in its 2019 guidelines, recommends initiation of a regimen consisting of basal insulin (long-acting insulin) or basal plus correctional insulin for non-critically ill hospitalised patients with poor or no oral intake. A combination of basal insulin, bolus (short-acting premeal or prandial) insulin and correctional scale insulin is recommended for inpatient hyperglycaemia management in non-critical patients with type 2 DM who have proper oral intake. Baseline data of 100 patients with diabetes admitted to Hamad General Hospital Doha, Qatar, showed that although insulin was used in the majority of patients, there was lack of uniformity in the initiation of insulin regimen. Adequate glycaemic control (7.8–10 mmol/L) was achieved in 45% of patients. Using Plan–Do–Study–Act (PDSA) model of improvement, a quality improvement project was initiated with the introduction of a standardised inpatient hyperglycaemia management protocol aiming to achieve 50% compliance to protocol and improvement in inpatient glycaemic control from baseline of 45% to 70%. Interventions for change included development of a standardised inpatient hyperglycaemia management protocol and its provision to medical trainees, teaching sessions for trainees and nurses, active involvement of medical consultants for supervision of trainees to address the fear of hypoglycaemia, regular reminders/feedbacks to trainees and nurses about glycaemic control of their patients and education about goals of diabetes management during hospitalisation for patients with diabetes. Overall, glycaemic control improved significantly with target glycaemic control of 70% achieved in 4 of the 10 PDSA cycles without an increase in the number of hypoglycaemic episodes. We conclude that development of a standardised inpatient insulin prescribing protocol, educational sessions for medical trainees and nurses about goals of diabetes management during hospitalisation, regular reminders to healthcare professionals and patient education are some of the measures that can improve glycaemic control of patients with type 2 DM during inpatient stay.

PROBLEM

Prevalence of diabetes mellitus (DM) in the world is on the rise, amounting to 8.4% in adults over the age of 18 years[1]. Synergistically, a significant number of patients admitted to hospital have DM with data from the USA showing around 7.7 million patients with diabetes being hospitalised in a single year.[2] Uncontrolled hyperglycaemia during hospital stay adds to morbidity, mortality and length of stay.[2–4] As a result, appropriate control of blood glucose levels is the cornerstone to patient management.

We assessed the control of blood sugar levels as well as different types of insulin regimens in use to manage hyperglycaemia in patients with diabetes admitted on the medical floor. Baseline data showed that only 45% of patients had median blood glucose levels within the target range of 7.8–10 mmol/L (refer to Glycaemic targets during hospital stay section for details).

Factors contributing to uncontrolled hyperglycaemia during inpatient stay were identified using Fishbone analysis (figure 1). One of the main factors responsible for inadequate glycaemic control during hospital stay was found to be lack of proper inpatient diabetes management protocol for medical teams. Second, the lack of proper knowledge among medical residents/trainees was another factor that could lead to inadequate blood glucose management. In collaboration with the endocrinology department, a proposed draft enlisting guideline on how to manage patients with diabetes admitted to the medical floor was prepared. Quality improvement (QI) project was launched with the help of a team consisting of a lead Internal Medicine consultant and Internal Medicine residents.

BMJ Open Qual: first published as 10.1136/bmjoq-2020-000982 on 13 August 2020. Downloaded from http://bmjopenquality.bmj.com/ on April 17, 2024 by guest. Protected by copyright.

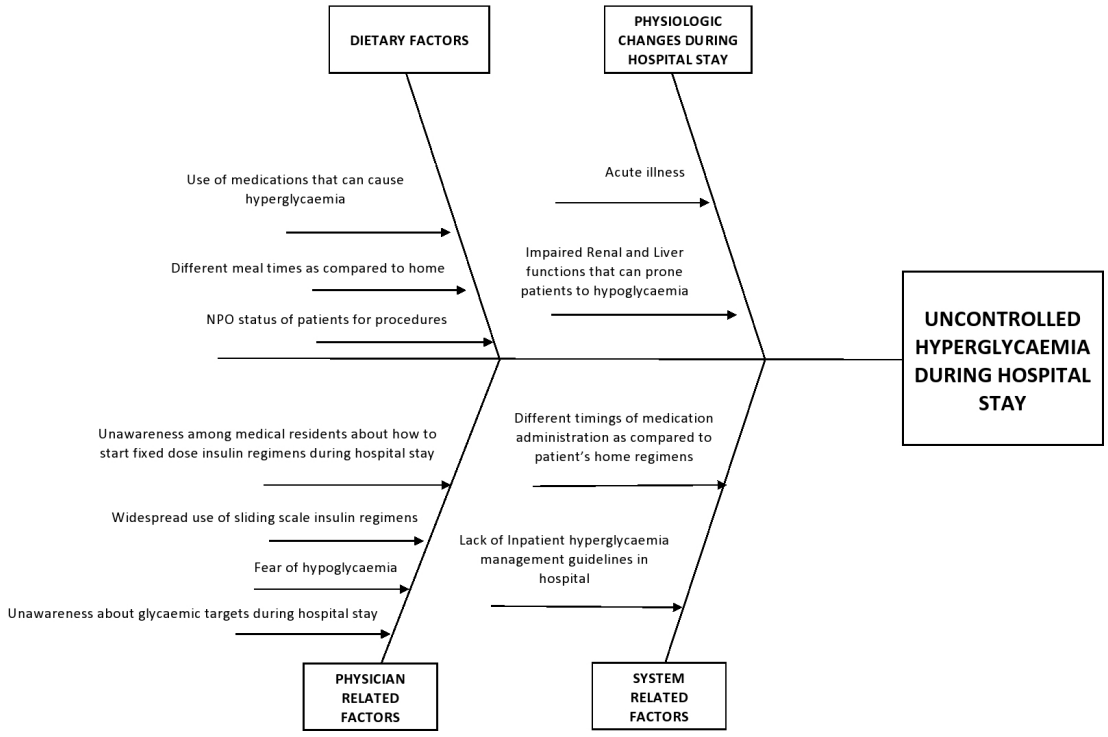

Figure 1 Fishbone diagram.

Using SMART (Specific, Measurable, Applicable, Realistic, Timely) statement, a QI project was initiated with the introduction of a standardised inpatient hyperglycaemia management protocol aiming to achieve 50% compliance to protocol and improvement in inpatient glycaemic control from baseline of 45% to 70% over 3 months.[5]

BACKGROUND

On hospitalisation, patients with DM undergo several physiological changes that expose them to alteration in their glycaemic control, including the stress of intercurrent illness, changes in dietary schedule and reduction in physical activity. Both hypoglycaemia and uncontrolled hyperglycaemia pose a challenge to managing DM during a hospital stay. Tight glycaemic control exposes patients to the risk of developing severe hypoglycaemia which, in turn, is associated with alteration in levels of consciousness, seizures, cardiac arrhythmias and death.[6–8] On the other hand, uncontrolled hyperglycaemia has shown to increase the length of stay increasing cost, delaying wound healing and recovery from infections, thereby adding to morbidity and mortality.[2–4] Furthermore, 30-day readmission rates are significantly higher in diabetes as compared with non-diabetes.[9] Patients with diabetes admitted to the healthcare facility require adequate glycaemic control to minimise the harmful effects of uncontrolled hyperglycaemia.

Glycaemic targets during hospital stay

Target blood glucose level during hospital stay has been a matter of debate, mainly due to the risk of hypoglycaemia associated with tighter glycaemic control. There is a paucity of data comparing the outcome of tight glycaemic control versus less strict targets in non-critically ill hospitalised patients. However, studies done in intensive care unit (ICU) have shown no beneficial effect of tighter glycaemic control. Investigators of NICE-SUGAR study compared outcomes among patients with tighter glycaemic control of 81 mg/dL to 108 mg/dL (4.5–6.0 mmol/L) with conventional target blood glucose level of <180 mg/dL (10.0 mmol/L) among patients in ICU. They concluded that tighter glycaemic control was associated with a higher risk of hypoglycaemia and mortality. Patients with target glycaemic control <180 mg/dL had lower mortality as compared with the group of patients with target blood glucose level 81–108 mg/dL.[10] American Diabetes Association (ADA) recommends starting antidiabetic medications during hospital stay if the blood glucose level is persistently above 180 mg/dL (10 mmol/L), intending to achieve blood glucose levels between 140 mg/dL and 180 mg/dL (7.8–10 mmol/L) to avoid the complications of hyperglycaemia while at the same time minimising the risk of hypoglycaemia (blood glucose <70 mg/dL or 3.9 mmol/L).[11] Joint British Diabetes Society recommends target blood glucose levels between 6 mmol/L and 10 mmol/L (108–180 mg/dL) and also states that level as high as up to 12 mmol/L (72–216 mg/dL) may be acceptable.[12]

ADA, in its 2019 guidelines, recommends initiation of a regimen consisting of basal insulin (long-acting insulin) or basal plus correctional insulin for non-critically ill hospitalised patients with poor or no oral intake. A combination of basal insulin, bolus (short-acting premeal or prandial) insulin and correctional scale insulin is recommended

BMJ Open Qual: first published as 10.1136/bmjoq-2020-000982 on 13 August 2020. Downloaded from http://bmjopenquality.bmj.com/ on April 17, 2024 by guest. Protected by copyright.

for inpatient hyperglycaemia management in non-critical patients with type 2 DM who have good oral intake.[11] One of the most common barriers to initiation of fixed-dose insulin regimens during hospital stay is lack of knowledge and confidence among medical residents about the protocol of insulin therapy. This adds to fear of hypoglycaemia leading to the prevalence of 'sliding scale' insulin rather than a basal–bolus regimen (long-acting and short-acting insulin). Development of inpatient diabetes management protocol and educational sessions for junior physicians and other healthcare providers have proven to be of significance in this regard. A QI project focusing on providing proper education to medical trainees showed improvement in glycaemic control without significant increase in risk of hypoglycaemia.[13] Sriphrapradang *et al* also reported significant improvement in blood glucose levels of patients after implementation of educational sessions for medical trainees.[14] Both these projects further validate that development of inpatient diabetes management protocol, and a comprehensive educational programme has significant impact on improving glycaemic control of admitted patients.

Glycaemic control clinical andon board (CAB) providing information to physicians about glycaemic control of their patients has shown to improve prescription of appropriate insulin. Franco *et al* reported improvement in prescribing necessary insulin as a result of regular feedbacks via CAB to physicians about blood glucose levels of their patients.[15] We used a similar intervention, although manually using face-to-face meetings, of providing daily feedback to medical trainees about glycaemic control of their patients and the need to prescribe appropriate insulin regimens resulting in improvement in compliance to the protocol as well as blood glucose control.

MEASUREMENT

To assess the control of blood sugar levels in hospitalised patients with type 2 DM, we collected the data of 100 patients with diabetes admitted under general medicine teams. Median of 5 days readings of blood sugar levels was recorded. Forty-five per cent of the patients had median of blood glucose readings within target range of 7.8–10 mmol/L, whereas 55% of the patients had median of blood glucose readings above 10 mmol/L. Out of 1866 blood glucose readings, 11 hypoglycaemic episodes were observed (0.0058%)

DESIGN

QI team comprised of a lead Internal Medicine consultant and 10 Internal Medicine residents. Using the Plan–Do–Study–Act (PDSA) model of improvement, the following interventions for change were introduced in sequential order.

1. Standardised inpatient hyperglycaemia management protocol was developed using ADA guidelines in collaboration with the endocrinology department.
2. Protocol algorithm was provided to medical residents/nurses in printed as well as in a soft copy format. This was to ensure that health professionals can easily access the protocol.
3. Teaching sessions were arranged for residents/nurses targeting goals and objectives of inpatient diabetes management as well as addressing their concerns and questions regarding the treatment protocol that was introduced.
4. One of the most important factors contributing to hesitancy among junior doctors about initiating fixed-dose insulin regimen was the fear of hypoglycaemic episodes. Medical residents in our hospital have 24/7 consultant supervision. Active involvement of medical team consultants was ensured to implement the protocol which ensured that residents were adequately supervised and felt confident on initiating fixed-dose insulin regimens.
5. Education of patients regarding glycaemic control was carried out. As mentioned in fishbone analysis, patient factors have a major role to play in achieving appropriate blood glucose control during the hospital stay. Patients were educated about the causes of hyperglycaemia, differences between home management of diabetes and management during hospital stay and the importance of following dietary restrictions.
6. Regular electronic reminders to residents about importance of glycaemic control of their patients were arranged every week. To avoid the phenomenon of alert fatigue, different visual clues were used in these reminders each time. Dedicated members of QI project team met with medical residents at the end of each PDSA cycle and provided them feedback on glycaemic control of their patients.

Medical residents in Hamad Medical Corporation are divided into 10 teams, each led by a medical consultant responsible for supervision of trainees and overall patient management. After every 4 weeks, residents and consultant in a medical team are shuffled and rotated to different teams (consultant and trainees) and medical specialties (trainees). For implementing QI project, two medical teams were selected. Each PDSA cycle would last for 2 weeks. After every two PDSA cycles, residents and consultants in medical teams would change.

After each PDSA cycle, QI team collected data retrospectively, focusing on types of insulin started within 24 hours of admission and recorded patient's blood glucose readings (fasting, prelunch, predinner and at bedtime). Minimum 5 days readings were collected and median of these readings was recorded to measure whether patient's blood glucose levels were within target range or not. Moreover, number of hypoglycaemic episodes were also recorded.

Patient characteristics

Baseline data

Sixty-four per cent of patients were males and 36% were females. Average duration of DM was 14.66 years. About 44.1% patients had HbA1c above 8.0%.

BMJ Open Qual: first published as 10.1136/bmjoq-2020-000982 on 13 August 2020. Downloaded from http://bmjopenquality.bmj.com/ on April 17, 2024 by guest. Protected by copyright.

PDSA cycles

Fifty-nine per cent of patients were males and 41% were females. Average duration of DM was 13 years. Overall, over the 10 PDSA cycles, 45.6% patients had HbA1c above 8.0%. Each PDSA cycle included a minimum of five patients. All patients admitted with type 2 DM in the selected medical team during the 2-week period were included in that PDSA cycle. Same patients were not included in the successive cycles.

STRATEGY

PDSA cycles 1 and 2

These PDSA cycles were carried out on the same medical teams. Intervention involved provision of inpatient diabetes management protocol to medical trainees for use during their daily work.

Besides, small educational sessions were conducted for trainees to communicate the importance of improved glycaemic control and to train them on how to apply the protocol to their daily practice. Compliance to the protocol was 40% in PDSA cycle 1, and glycaemic control was at 60%. After PDSA cycle 2, compliance with protocol increased to 60% and glycaemic control of patients improved to 80%.

Lesson learnt: implementation of a standardised protocol for inpatient glycaemic control and educational sessions for medical trainees helped in achieving glycaemic targets in hospitalised patients with diabetes. Although we understand that clinical pathways and educational sessions alone cannot bring improvement in any process, but provision of a standard protocol will reduce variability and provide healthcare providers a guide to manage patients with diabetes. Educational sessions will help junior doctors and nurses to understand the basic concept of inpatient management of diabetes.

PDSA cycles 3 and 4

These cycles involved the same interventions, as mentioned in cycles 1 and 2. Compliance to the protocol was found to be 40% in PDSA cycle 3 and 80% in PDSA cycle 4. Glycaemic control was 50% in PDSA cycle 3 and increased to 80% in PDSA cycle 4.

Lesson learnt: drop in compliance and glycaemic control was noted in PDSA cycle 3 as this was a new medical team. However, with continued intervention, both the measures improved in PDSA cycle 4 emphasising that continuous implementation of interventions leads to an improvement in outcome. One of the goals of the QI team is to reduce variability as explained by Deming in his theory of profound knowledge.[16] In a tertiary care teaching centre, residents and supervising consultants rotate as per defined schedule, so it is not possible to control this variability. We suggested the department to appoint specialist nurses in diabetes to implement the standard protocol. This change will reduce variability and help in achieving sustainable improvement.

PDSA cycles 5 and 6

PDSA cycle 5 again involved the start of a new month and new medical trainees in the team due to regular rotation. As a result, compliance with protocol saw a drop to 60% and in glycaemic control to 50%. However, two hypoglycemic episodes were observed in this cycle. Although compliance with insulin protocol increased to 80% in PDSA cycle 6, insulin dose was not titrated for hyperglycaemia due to fear of inducing hypoglycaemia. This resulted in only a small increase in glycaemic control to 60%.

Lesson learnt: glycaemic control needs regular adjustment of patient's insulin regimen based on blood glucose levels. We did Fishbone analysis to track down the reasons for the drop in glycaemic control. One of the reasons was fear of inducing hypoglycaemia by use of insulin. We noted that junior doctors do not have enough experience in the use of insulin. Further education sessions were arranged for them regarding the use of insulin in patients with diabetes.

PDSA cycle 7

Fear of hypoglycaemia (as observed in PDSA cycle 6) results in inappropriate discontinuation of insulin regimens and exposes patients to hyperglycaemia. Further educational sessions were arranged for better understanding of inpatient diabetes control. The decision was made to involve senior decision-maker, that is, medical team consultants. Insulin doses were adjusted with input from senior decision-maker that helped in alleviating the fear of inducing hypoglycaemia. As a result, PDSA cycle 7 again saw a rise in compliance with the protocol to 80% and in glycaemic control to 80%. No hypoglycaemic episode was observed.

Lesson learnt: implementation of standard protocol and regular educational sessions helped but these measures alone were not enough. Variability in the system remained a big hurdle in achieving sustainable results. We asked the supervising consultants to take more active role in implementing the protocol and supervise junior doctors in the use of insulin.

PDSA cycle 8

PDSA cycle 8 was conducted on the same medical team and trainees as PDSA cycle 7. Compliance to initiation of insulin according to protocol remained at 80%, but glycaemic control unexpectedly decreased to 60%. One episode of hypoglycaemic was observed.

Lesson learnt: our Fishbone analysis identified hesitancy among some patients to the use of increased doses of insulin than usual in response to uncontrolled blood sugar levels. We involved the dietitian and diabetes educators to provide patients with more information regarding dietary changes according to their medical condition, target blood glucose levels during hospitalisation, importance of adequate glycaemic control and the means of achieving it. We found patients' education about their medical condition and their involvement

BMJ Open Qual: first published as 10.1136/bmjoq-2020-000982 on 13 August 2020. Downloaded from http://bmjopenquality.bmj.com/ on April 17, 2024 by guest. Protected by copyright.

in decision-making regarding management of diabetes during hospital stay was key to attain desired results.

PDSA cycles 9 and 10

Keeping in view the findings of PDSA cycle 8, education sessions were arranged for patients to alleviate the anxiety related to insulin use and hypoglycaemia as mentioned above. Compliance with protocol remained at 75% in cycle 9 and 80% in cycle 10. Glycaemic control was found to be 60% in PDSA cycle 9 and 75% in cycle 10.

Lesson learnt: we learnt that appreciation of the system, knowledge about variation in the system, theory of knowledge and understanding the interaction of system and people involved were key to bring the change. Deming's 14 points of management provide a basic framework of how to bring the change.[17] We tried to implement a standard protocol and provided education sessions to healthcare providers, appreciated the variations in the system and suggested a change to reduce the variability and created a system for senior decision-maker to take more responsibility to achieve sustainable results. Education sessions and closed supervisions of junior doctors helped alleviate their anxiety regarding the use of insulin and resulted in better control of diabetes. Education of patients and their involvement in decision-making was another major factor to improve glycaemic control during hospitalisation.

RESULTS

Process measure

Compliance to standardised inpatient hyperglycaemia management protocol improved and target of 50% compliance to the protocol was achieved in 8 out of 10 PDSA cycles (figure 2).

Outcome measure

Overall glycaemic control (7.8–10 mmol/L) improved with target glycaemic control of 70% achieved in 4 of the 10 PDSA cycles (total of 49 patients, figure 3). Out of total 1074 blood sugar readings taken to monitor glycaemic control in 49 patients, six (0.0055%) episodes of hypoglycaemia were observed.

Keeping in mind that residents in medical teams were rotated to the different medical teams or medical specialties after every 4 weeks, it is evident that residents of selected medical teams were part of two consecutive PDSA cycles. During PDSA cycle 1, glycaemic control was expected to be low, but it improved to the target level in PDSA cycle 2 carried out on the same medical team. For example, for PDSA cycle 1, glycaemic control was 60%, but it increased to 80% in PDSA cycle 2. PDSA cycle 3 showed a fall in glycaemic control to 50% but the drop is expected as the medical team is changed and hence, the continuity of interventions is interrupted. However, glycaemic control improved again to 80% in PDSA cycle 4. Similarly, after first 2 weeks of a new medical team, glycaemic control was at 60% in PDSA cycle 9 but then increased again to 75% in PDSA cycle 10 mainly due to persistence of interventions with the same team.

Balancing measure

Frequent alerts to residents and nurses about compliance to protocol and glycaemic control of patients led to increased work load.

LESSONS AND LIMITATIONS

Lessons: following are the important lessons learnt from this project:

1. Development of a standardised inpatient antidiabetic regimen based on weight, diabetes control (baseline

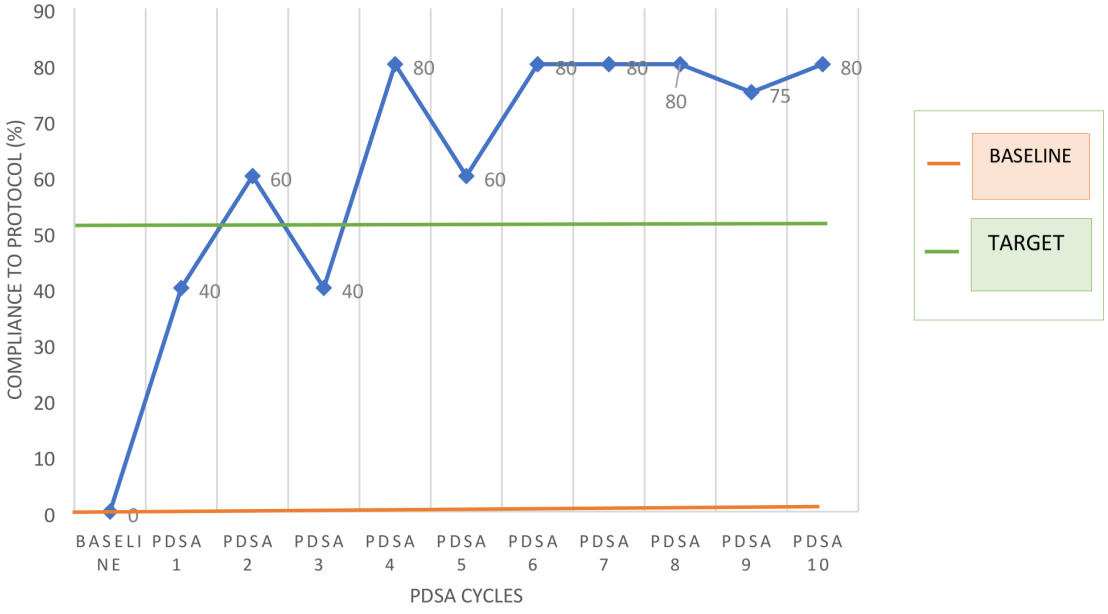

Figure 2 Compliance to protocol (%). PDSA, Plan–Do–Study–Act.

BMJ Open Qual: first published as 10.1136/bmjoq-2020-000982 on 13 August 2020. Downloaded from http://bmjopenquality.bmj.com/ on April 17, 2024 by guest. Protected by copyright.

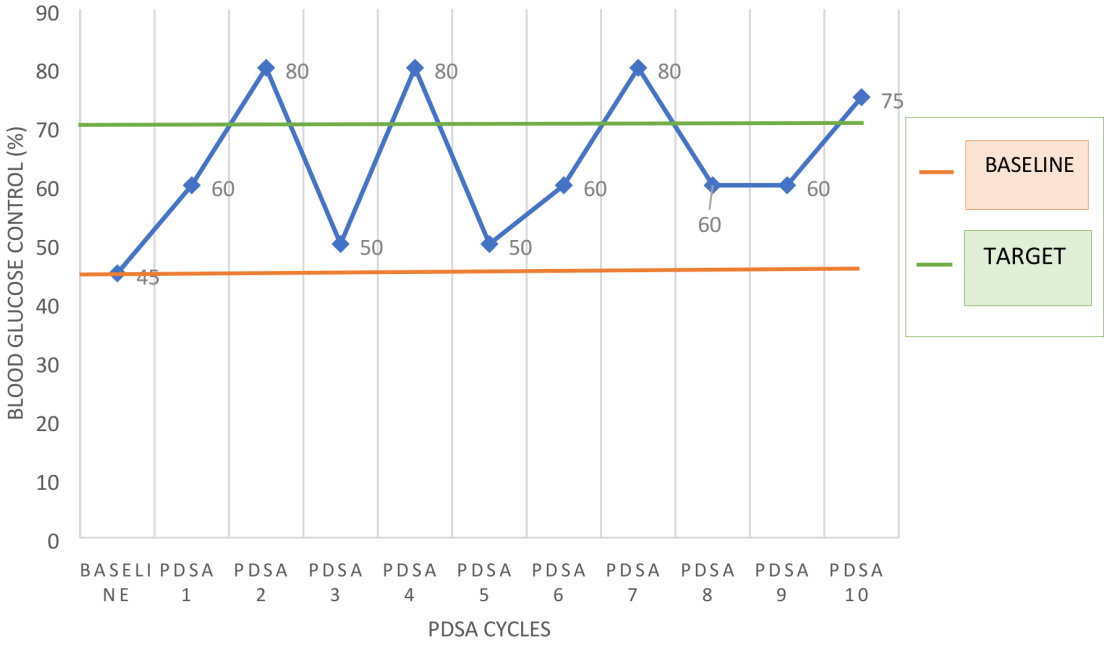

Figure 3 Control of blood sugar levels (%). PDSA, Plan–Do–Study–Act.

HbA1c) and renal function is the cornerstone of improving inpatient glycaemic control.
2. Educational sessions about goals and protocol of inpatient glycaemic control for healthcare professionals and medical residents lead to improvement in the prescription of fixed-dose insulin regimens hence improving glycaemic control.
3. Automatic reminders to physicians about standard protocol and glycaemic control of patients along with education of patients are some measures that led to an improvement in inpatient glycaemic control of patients with diabetes.

Limitations

1. One of the main limiting factors encountered in this QI project was the continuous rotation of medical residents and medical team supervising consultants that led to variation in results. However, with implementation of protocol throughout the medicine department and regular educational sessions for trainees, further and consistent improvement in glycaemic control is expected. Moreover, monitoring of glycaemic control of patients during hospitalisation by hospital QI department will contribute towards sustainability of results.
2. After the conduct of educational sessions for trainees (along with other interventions as mentioned above), an improvement in blood glucose levels of patients was observed. However, a formal preintervention and postintervention survey was not conducted which makes it difficult to measure the exact effect of this intervention alone and may need to be explored in future studies. Currently, we are in the process of developing an electronic module for inpatient diabetes management for physicians
3. We have not evaluated the effect of this QI project on length of stay and cost-effectiveness. Further work is required in this regard.

CONCLUSION

Our QI project emphasises different strategies that can help in improving inpatient glycaemic control. Availability of hospital-based inpatient hyperglycaemia management protocol is of utmost importance. Furthermore, teaching medical trainees about the approach to hyperglycaemia management in patients with diabetes is of significance as junior doctors are the ones taking care of such aspects of patient care. Our project aimed at improving glycaemic control to 70%. This target was achieved in 4 of the 10 PDSA cycles. But because of the consistent rotation of medical trainees as mentioned earlier, it was not straightforward to achieve the target in consecutive cycles. Maintenance of this improvement will require constant efforts to educate medical residents and development of a system to facilitate prescription of appropriate insulin regimens based on the protocol. Diabetes management protocols are often complex and therefore, call for a need for standard electronic or paper-based insulin order sets to improve compliance to protocols as shown in several studies.[18 19] Recommendations have been made to the quality management department and hospital administration, and measures are being taken in this regard.

Organisation information

Hamad Medical Corporation (HMC) is a tertiary care hospital and the primary healthcare provider in Qatar. It has a capacity of over 2000 beds and is accredited by Joint Commission International (JCI). Internal Medicine Training Program at HMC is accredited by 'Accreditation

BMJ Open Qual: first published as 10.1136/bmjoq-2020-000982 on 13 August 2020. Downloaded from http://bmjopenquality.bmj.com/ on April 17, 2024 by guest. Protected by copyright.

Council for Graduate Medical Education-International (ACGME-I)' which ensures the quality of training of its trainees.

Acknowledgements The authors would like to thank the following collaborators who played a significant role in data collection for the project: Khaldun Obeidat, Zubair Shahid, Awni Alshurafa, Muhammad U Saddique, Haajra Fatima, Rohit Sharma, Ammar Chapra, Hammad S Chaudhry, Sundus Sardar. They would also wish to thank Dr Ibrahim Abdulla A Mohd, Senior Consultant Endocrinology in Hamad Medical Corporation, Qatar who significantly contributed to the preparation of Inpatient Hyperglycaemia Management Protocol.

Contributors AAK conceived the idea of this quality Improvement project, designed and conducted the project. He was the leading resident (trainee) of the project. Furthermore, he was the primary author of the manuscript, conducted literature review, responsible for submitting the manuscript and is responsible for overall content. AS played his role in literature review and revision of the manuscript. Furthermore, he played significant role in performing PDSA cycles and analysis of results of QI project. SR helped in literature review. She was also involved in performing PDSA cycles and analysis of results of QI project. DHSHAM critically reviewed the manuscript and supervised the QI project. MZ, as senior consultant, was the primary leader of the project. He supervised the QI project design, conduct and implementation of PDSA cycles. He was of significant importance in assessing the outcomes of PDSA cycles and planning interventions and is responsible for overall content. In addition, he supervised writing and revision of this manuscript and critically reviewed it.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

REFERENCES

1 Diabetes. Available: https://www.who.int/news-room/fact-sheets/detail/diabetes [Accessed 10 Nov 2019].
2 Leite SA, Locatelli SB, Niece SP, *et al*. Impact of hyperglycemia on morbidity and mortality, length of hospitalization and rates of re-hospitalization in a general Hospital setting in Brazil. *Diabetol Metab Syndr* 2010;2:49.
3 Yan C-L, Huang Y-B, Chen C-Y, *et al*. Hyperglycemia is associated with poor outcomes in surgical critically ill patients receiving parenteral nutrition. *Acta Anaesthesiol Taiwan* 2013;51:67–72.
4 Krinsley JS. Association between hyperglycemia and increased hospital mortality in a heterogeneous population of critically ill patients. *Mayo Clin Proc* 2003;78:1471–8.
5 The Model for Improvement : Quality Improvement – East London NHS Foundation Trust. Available: https://qi.elft.nhs.uk/resource/the-model-for-improvement/ [Accessed 31 May 2020].
6 Corsino L, Dhatariya K, Umpierrez G. Management of Diabetes and Hyperglycemia in Hospitalized Patients. In: Feingold KR, Anawalt B, Boyce A, *et al*, eds. *Endotext*. South Dartmouth (MA): MDText.com, 2000. http://www.ncbi.nlm.nih.gov/books/NBK279093/
7 Kilpatrick CR, Elliott MB, Pratt E, *et al*. Prevention of inpatient hypoglycemia with a real-time informatics alert. *J Hosp Med* 2014;9:621–6.
8 Cryer PE. Death during intensive glycemic therapy of diabetes: mechanisms and implications. *Am J Med* 2011;124:993–6.
9 Ostling S, Wyckoff J, Ciarkowski SL, *et al*. The relationship between diabetes mellitus and 30-day readmission rates. *Clin Diabetes Endocrinol* 2017;3:3.
10 , Finfer S, Chittock DR, *et al*, NICE-SUGAR Study Investigators. Intensive versus conventional glucose control in critically ill patients. *N Engl J Med* 2009;360:1283–97.
11 American Diabetes Association. 15. Diabetes Care in the Hospital: *Standards of Medical Care in Diabetes-2019*. *Diabetes Care* 2019;42:S173–81.
12 Joint British diabetes societies (JBDS) for inpatient care group. Available: https://abcd.care/joint-british-diabetes-societies-jbds-inpatient-care-group [Accessed 11 Dec 2019].
13 Helmle KE, Dechant AL, Edwards AL. Implementation of a multidisciplinary educational strategy promoting Basal-Bolus insulin therapy improves glycemic control and reduces length of stay for inpatients with diabetes. *Clin Diabetes* 2019;37:82–5.
14 Sriphrapradang C, Mongkolrattanakul P, Tanasanitkul H, *et al*. Improving inpatient glycemic control by diabetes education program in internal medicine residents. *Diabetes Metab Syndr* 2019;13:2647–52.
15 Franco T, Aaronson B, Williams B, *et al*. Use of a real-time, algorithm-driven, publicly displayed, automated signal to improve insulin prescribing practices. *Diabetes Res Clin Pract* 2019;157:107833.
16 Connor T. System of profound knowledge, 2020. Available: https://medium.com/10x-curiosity/system-of-profound-knowledge-ce8cd368ca62 [Accessed 2 Jun 2020].
17 Deming's 14 Points: Total Quality Management Principles. Available: https://asq.org/quality-resources/total-quality-management/deming-points [Accessed 2 Jun 2020].
18 Valgardson JD, Merino M, Redgrave J, *et al*. Effectiveness of inpatient insulin order sets using human insulins in noncritically ill patients in a rural hospital. *Endocr Pract* 2015;21:794–806.
19 Kravchenko MI, Tate JM, Clerc PG, *et al*. Impact of structured insulin order sets on inpatient hypoglycemia and glycemic control. *Endocr Pract* 2020;26:523–8.

BMJ Open Qual: first published as 10.1136/bmjoq-2020-000982 on 13 August 2020. Downloaded from http://bmjopenquality.bmj.com/ on April 17, 2024 by guest. Protected by copyright.