Title

Targeting insulin stacking to address overnight hypoglycaemia in hospitalised patients with diabetes

Journal

BMJ Open Quality, 14(1)

ISSN

2050-1315

Authors

Moolchandani, Priyanka
Patel, Satya
Larsen, Tyler
et al.

Publication Date

2025-03-01

DOI

10.1136/bmjoq-2024-003178

Peer reviewed

BMJ Open Quality

Targeting insulin stacking to address overnight hypoglycaemia in hospitalised patients with diabetes

Priyanka Moolchandani ,[1,2] Satya Patel,[1,2] Tyler Larsen,[1,2] Christopher Moriates,[1,2] Jane Weinreb,[1,3] Estelle Everett[1,3]

To cite: Moolchandani P, Patel S, Larsen T, *et al*. Targeting insulin stacking to address overnight hypoglycaemia in hospitalised patients with diabetes. *BMJ Open Quality* 2025;**14**:e003178. doi:10.1136/bmjoq-2024-003178

Received 22 October 2024
Accepted 2 March 2025

[1]Medicine, University of California Los Angeles, Los Angeles, California, USA
[2]Medicine, VA Greater Los Angeles Healthcare System, Los Angeles, California, USA
[3]Endocrinology, VA Greater Los Angeles Healthcare System, Los Angeles, California, USA

Correspondence to
Dr Priyanka Moolchandani; pmoolchandani@mednet.ucla.edu

ABSTRACT

Inpatient hypoglycaemia is a significant concern in patients with diabetes due to its association with increased mortality. At the Veterans Affairs Greater Los Angeles Healthcare System, we developed a project to reduce overnight hypoglycaemia in hospitalised patients with diabetes by addressing insulin stacking, defined as insulin dosed within 4 hours of each other. By delaying the timing of bedtime correctional insulin administration in the electronic health record, we achieved a 28% reduction in the proportion of patients experiencing insulin stacking after one year. This led to significant decreases in overnight hypoglycaemia.

INTRODUCTION

Diabetes is one of the most common diagnoses among hospitalised patients in the USA, affecting one in four inpatients.[1] Hypoglycaemia in these patients is a major concern as it leads to worse clinical outcomes including increased mortality.[2] Consequently, the American Diabetes Association's Standards of Care recommends a glycaemic target of 140–180 mg/dL in most hospitalised patients but will allow for blood glucose values as low as 110 mg/dL in those who are able to achieve this without hypoglycaemia.[3] Most hypoglycaemic events occurring in the hospitalised patients are iatrogenic; consequently, careful attention is needed to eliminate these serious and avoidable events.[4 5]

In the Veterans Affairs Greater Los Angeles Healthcare System, frequent overnight hypoglycaemia was anecdotally noted. Overnight hypoglycaemia is particularly concerning as it can go without detection as sleeping patients may not awaken to communicate their symptoms. Further investigation revealed that insulin stacking of the dinner nutritional insulin and bedtime correctional insulin, which was often being administered at intervals less than 4 hours, may be a potential driver of these low blood sugars. Insulin stacking results in hypoglycaemia because multiple doses of insulin are administered within a short period, often before the effects of previous doses have fully manifested.[6] There is no standard time definition for insulin stacking, but this study used less than 4 hours based on the known insulin pharmacokinetics.

The aim of this project was to decrease the percentage of low blood sugars experienced overnight by hospitalised Veterans with diabetes mellitus by at least 25% (outcome measure) from April 2022 to June 2023 by decreasing the rates of insulin stacking (process measure).

METHODS

A multidisciplinary team of endocrinologists and hospitalists and the chief resident in quality and safety created a process map (figure 1) for insulin administration in patients with diabetes, defined as having an A1C value ≥6.5 any time between 1 year prior to their admission or up to 7 days after their admission. Based on our process map, we noted that the electronic health record (EHR) order for bedtime blood sugar check and insulin sliding scale administration was set to 21:00, while the dinner sugar check and sliding scale administration was set to 17:00. This is exactly 4 hours separation. Nurses are allotted +/- 1 hour- grace period to administer medications; consequently, in our pre-intervention data, 42% of patients in our hospital were receiving these insulin doses <4 hours apart. Thus, we worked with pharmacy, informatics and nursing to change the timing of the bedtime sliding scale insulin administration from 21:00 to 22:00 in the EHR, which created a forcing function, a strong action for driving change based on the Institute for Healthcare Improvement action hierarchy. This change went into effect in June 2022. This change was communicated to the nursing supervisors to disseminate to the rest of the nursing staff in the entire hospital.

To evaluate the short and long-term clinical impact of this intervention, we used

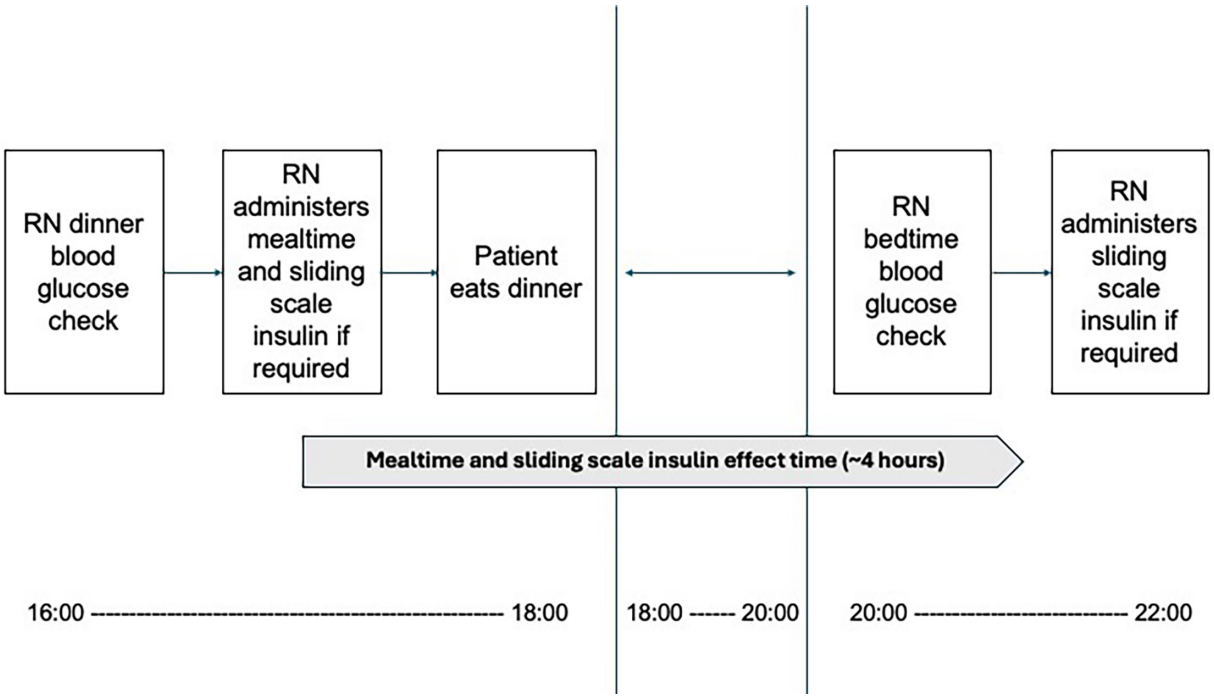

Figure 1 This process map details nurse (RN) workflow for insulin administration which demonstrates the possibility for insulin stacking based on the current state electronic health record insulin dosing schedule.

descriptive statistics and $\chi 2$ analysis to compare process and outcomes measures in the pre-intervention period (April to June 2022), to immediately postintervention (June to September 2022) and 1-year postintervention (April to June 2023). This study was found to be exempt by the local Institutional Review Board.

RESULTS

Our intervention reduced the proportion of patient experiencing insulin stacking by 23% in the quarter immediately postintervention and 28% in the quarter a year postintervention (table 1). This resulted in a reduction in blood sugars below target (110 mg/dL) at both time points. True hypoglycaemia (blood glucose<70 mg/mL) was rare but reduced by 50% at a year post-intervention (table 1). Blood sugars in the range of 70–99 mg/dL,

Table 1 Clinical impact of change in nightly blood glucose (BG) check and insulin administration

	1 April 2022 to 21 June 2022	22 June 2022 to 22 September 2022	1 April 2023 to 21 June 2023
	Pre-intervention	Immediately postintervention	1 year postintervention
	n=2148	n=2214	n=2293
Process measures			
Mean time of bedtime BG check	20:53	21:09	21:10
Mean time of bedtime insulin sliding scale administration	21:08	21:31	21:35
Mean time of last dinner insulin administration	17:02	17:01	17:03
Patients receiving insulin <4 hours apart	42.60%	32.88% (**p<0.001**)	30.48% (**p<0.001**)
Patients receiving insulin >4 hours apart	57.40%	67.12% (**p<0.001**)	69.52% (**p<0.001**)
Outcome measures			
Below target (less than 110 mg/dL)	4.28%	3.03% (p=0.027)	2.70 (**p=0.004**)
Overnight BG between 70 and 99 mg/dL	2.7%	1.99% (p=0.119)	1.22% (**p<0.001**)
Overnight hypoglycaemia BG <70 mg/dL	0.56%	0.54% (p=0.0941)	0.26% (p=0.120)

P value presents a significant difference between current period and pre-intervention period.

which can often predict future hypoglycaemia, reduced by 26% and 54%, respectively.[7]

CONCLUSION

We demonstrated that careful evaluation of long-standing health system practices can reveal problematic processes, which once intervened on can result in clinically meaningful impact. The change in the timing of insulin orders did not eliminate all insulin stacking. This has informed our next steps to collaborate with frontline nursing staff to better understand how dosing insulin greater than 4 hours apart may impact their workflows. Widespread nursing education regarding the intervention is important because the order in the EHR might change, but their workflow may not. This will guide additional strategies to reduce iatrogenic low blood sugars in the hospital related to insulin stacking.

Contributors PM contributed to the design, results interpretation, initial draft of the manuscript and subsequent revisions. SP contributed to the study design and revision of the manuscript. TL contributed to the revision of the manuscript. CM contributed to the revision of the manuscript. JW contributed to the design and revision of the manuscript. EE (guarantor) contributed to the study conceptualisation and design, performed the data analysis and result interpretation, and contributed to the first draft of the manuscript and subsequent revisions.

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 consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer-reviewed.

ORCID iD

Priyanka Moolchandani http://orcid.org/0000-0001-6469-9197

REFERENCES

1 American Diabetes Association Professional Practice Committee. Diabetes Care in the Hospital: Standards of Medical Care in Diabetes. *Diabetes Care* 2024;S295–306.
2 Rubens M, Ramamoorthy V, Saxena A, *et al*. Recent Trends in Diabetes-Associated Hospitalizations in the United States. *J Clin Med* 2022;11:6636.
3 Brutsaert E, Carey M, Zonszein J. The clinical impact of inpatient hypoglycemia. *J Diabetes Complications* 2014;28:565–72.
4 Amori RE, Pittas AG, Siegel RD, *et al*. Inpatient medical errors involving glucose-lowering medications and their impact on patients: review of 2,598 incidents from a voluntary electronic error-reporting database. *Endocr Pract* 2008;14:535–42.
5 Alrwisan A, Ross J, Williams D. Medication incidents reported to an online incident reporting system. *Eur J Clin Pharmacol* 2011;67:527–32.
6 Hirsch IB. Insulin analogues. *N Engl J Med* 2005;352:174–83.
7 Mathioudakis N, Everett E, Golden SH. PREVENTION AND MANAGEMENT OF INSULIN-ASSOCIATED HYPOGLYCEMIA IN HOSPITALIZED PATIENTS. *Endocr Pract* 2016;22:959–69.