An evaluation of the timing between key insulin administration-related processes: the reasons why these processes happen when they do, and how to improve their timing

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Abstract

We investigated the incidence of timing problems with insulin-related processes in a subacute inpatient unit in Melbourne and found that nursing staff often conduct blood glucose level (BGL) testing longer than 30 minutes before insulin administration (between 22% and 41%). Nurses are better at administering rapid-acting insulin doses within the recommended time before food intake (94%) than conventional insulin analogue doses (43%). BGL testing is carried out too early due to established ward practices and busy mornings, as well as poor guidance from an outdated policy. The timing of conventional insulin analogue administration is by nature more complex than that of rapid-acting analogues. Current timing places inpatients at risk of harm from hypoglycaemia. The high level of care demand in our subacute unit contributed to timing problems, and this is likely to be a problem in other units. Process redesign, policy revision and staff education could be used to reduce the risk of hypoglycaemia in this subacute inpatient unit.

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What is known about the topic?

Careful timing of insulin-related processes (testing, administration of insulin and meals) is essential to avoid hypoglycaemia in insulin-dependent patients.

What does this study add?

Less than half of the patients in one subacute unit were administered longer-acting insulin analogue doses within the recommended interval before food intake. Rapid-acting insulin doses were administered in a more timely manner. Recommended intervals between testing and insulin administration were poor for both types of insulin. Workflow problems contributed to delays.

What are the implications?

Insulin-dependent diabetic patients in subacute inpatient units may be at significant risk of hypoglycaemia, and careful attention to workflows is needed to reduce this risk.

The problem of insulin administration processes at Broadmeadows Health Service

BROADMEADOWS HEALTH SERVICE (BHS) is one of the four campuses of the Northern Metropolitan Health Service in Melbourne, Victoria. Broadmeadows Health Service is an Integrated Care Centre which provides subacute inpatient palliative care, rehabilitation, and geriatric evaluation and management (GEM) services, among others, to the population in Melbourne's north-western suburbs from the Hume-Moreland Local Government Area. BHS Rehabilitation and GEM Units provide subacute inpatient services to a mainly older patient population with high level care needs and complex health and social needs. Up to 30% of BHS inpatients have diabetes, and up to 10% of inpatients may be administered insulin during their hospital stay.

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Process mapping of insulin administration in 2002 highlighted differences in practice across inpatient units relating to capillary blood glucose level (BGL) monitoring and insulin administration. The timing of BGL measurements was also inconsistent with best practice diabetes management guidelines. A limited-scope audit in June 2003 suggested that improper timing of pre-meal insulin was a problem in the BHS inpatient units, placing inpatients at risk of experiencing hypoglycaemia.

Factors affecting insulin administration processes

The workload challenges faced by nurses in the subacute setting are different to those experienced in acute care. These challenges include the high level care needs of mainly elderly patients with complex health and social needs, the difference in the nursing ratio and skill mix in comparison to the acute setting, and the number of tasks that need to be completed first thing in the morning to ensure the patients can attend allied health and other appointments.

Despite the increased complexity of subacute patients' care needs, the expectation to reduce length of stay (LOS) and maintain a high bed-occupancy rate has remained. The Rehabilitation Unit decreased its LOS within the last year and the acuity of patients has increased, increasing the workload for nurses and allied health despite staffing increases. Subacute units have a higher proportion of Division 2 nurses than acute units. In Victoria, while there are moves to change this, Division 2 nurses are not allowed to administer medications and complete some other patient care tasks, which shifts significant workload to the Division 1 nurses.

Currently, one morning medication round of 10 patients may take 2 hours to complete. This is due to the average patient being administered 9 to 11 medications per round and the complex medication administration systems on two inpatient units. Because the medication rounds take so long to complete, the nurses find that during the last hour of the medication round they are often interrupted, as patients demand more assistance and allied health and medical staff start their shifts.

As a result we undertook a project in April 2003, funded by the Australian Council for Safety and Quality as part of the Medication Safety Innovations Awards Program, to reduce the potential for patient harm by improving insulin administration procedures. The original project scope was confined to the GEM Unit, with the possibility of roll out of evaluation and process change to the Rehabilitation Unit.

Operational definitions

For the purposes of this project, insulin administration processes were divided into three key components: capillary blood glucose level monitoring (BGL testing), insulin administration, and meal ingestion.

Literature review

Medication errors are an expensive problem in the Australian health care system, and they cause significant harm and disability burden. Insulin is a high alert medication that may account for 6% to 9% of all medication errors,[1] with potentially catastrophic consequences.

It has been identified that insulin-related errors may occur due to poor (or less than ideal) timing of administration in relation to meals;[2,3] disruption of the normal routine of self-administering patients;[4,5] poor glycaemic control; and diabetes care being secondary during admission for other primary diagnoses.[4] Nursing workload may also influence the care of diabetic patients and increase the potential for insulin-related error.[4]

In the case of insulin administration at BHS, some more general problems with medication administration may also contribute to insulin medication errors, including distractions during medication rounds; out-of-date clinical guidelines; inconsistent documentation processes; and a complex medication administration system for some units which increases the risk of error, especially dose omissions.

Reason for the project

The most significant studies relate to quantification of undetected hyperglycaemia,[2] process redesign by introducing standardised insulin sliding scales,[6] and care improvement by controlling meal delivery times.[2] Heatlie did a study in the acute setting on the effects of promotion of the use of a standardised insulin ordering form, nursing staff education and monitoring of the timing of BGL testing.[7] All studies were completed in the acute setting.

Little has been done to investigate the reasons for poor timing of insulin administration-related processes. No studies were found that investigated the quality of insulin administration processes in the subacute setting, or that evaluated compliance with guidelines for timing of the intervals between insulin administration and meal delivery.

Project methods

Objectives

The primary project objectives were to evaluate the timing of existing insulin administration-related processes, and to find the reasons for current timing of these processes. The secondary objective was to find a solution to the timing problems that would be successful at BHS.

Project design

The project was a descriptive evaluation with both qualitative and quantitative data. Process mapping was used to define process weaknesses in order to focus on the target of improvement.

Data were collected from two subacute inpatient units (Rehabilitation Unit and GEM Unit) at an integrated care centre in the northern metropolitan area of Melbourne.

The pre-intervention insulin dose audit was carried out in November and December of 2003. The insulin dose data were collected from Division 1 nursing staff who administered insulin to inpatients during November and December 2003. Group interviews were carried out during December 2003 and January 2004 to establish the reasons for current practice. Participants included Division 1 and 2 nursing staff, personal services attendants (PSAs), dietitians and diabetes nurse educators from the GEM Unit.

Before collecting these data, nurses had been instructed to record actual BGL test time and actual insulin administration time, as previous focus groups revealed that normal practice was to document the time the patient was charted to have a BGL test or to be administered insulin on the drug chart. The nurses were also instructed not to change what they would normally do, other than their documentation.

The project team comprised the project coordinator, the project diabetes nurse educator and three BHS diabetes nurse educators.

Data collection instruments

The Insulin Dose Recording Sheet was a one-page table with 6 columns (date, type of insulin, time of BGL test, time of insulin administered, meal arrival time and reason for dose delay). It was placed in the medication chart of all diabetic inpatients admitted to the Rehabilitation and GEM Units during November and December of 2003.

The Division 1 nurses were instructed in meetings, and by email, flyers and attachments to the Recording Sheet, to self-record the information. The front of the chart was also endorsed with a bright label reminding nursing staff to complete the record when each insulin dose was administered. No validity assessments were completed on this tool. Each dose record took one minute to complete.

Group interviews

Four group interviews were held to find out why processes occurred when they did. The project coordinator facilitated the meetings, which involved four to six nursing and PSA staff familiar with existing processes. The staff all worked on the GEM and Rehabilitation Units. The facilitator commenced each group interview with a list of questions about the timing of key processes and the reasons for those times. Common answers

and answer ranges were collated to provide qualitative data.

Sample design

Only inpatients admitted to the Rehabilitation and GEM Units at BHS and receiving insulin during their stay in November or December of 2003 were included in the evaluation. Exclusion criteria included: long-acting insulin analogue doses (eg, Protophane); doses with incomplete or illegible records on the Insulin Dose Recording Sheet; and Palliative Care Unit patients. Insulin doses not recorded by nursing staff were not included in the data.

Data analysis

The insulin type data collected from the Insulin Dose Recording Sheet were grouped into three categories: rapid-acting, conventional and long-acting insulin analogues. The drugs falling into the category of rapid-acting analogues included Novomix 30® and Humalog®. The drugs included in the conventional insulin category were premixes including Mixtard 30/70, Mixtard 20/80, and Actrapid/Protaphane mixes. Long-acting insulin analogues were excluded for the purposes of this project. Rehabilitation and GEM unit data were pooled for analysis.

Raw data were manipulated by calculating the time elapsed in minutes between BGL measurement and administration of insulin doses, and between administration time and meal delivery time, for those receiving both rapid-acting insulin analogues and conventional insulin analogues. Means and standard deviations were calculated for the elapsed time between BGL testing and insulin dose, and time between insulin administration and meal delivery, and the proportion within recommended limits were calculated (Box 1 and Box 2)

Proportions of insulin doses falling within acceptable time limits in relation to BGL testing and meal delivery were calculated based upon pharmaceutical company guidelines for rapid-acting and conventional insulin analogues. For the purpose of this study, the time limit between BGL testing and insulin administration was set as between 0 and 30 minutes, ensuring the BGL result reflects the patients' glycaemia status as close as possible to the time of insulin administration. The acceptable time range between rapid-acting insulin administration and meal delivery was chosen to be –5 to 15 minutes, based on drug profiles from pharmaceutical guidelines of rapid-acting insulin analogues. The acceptable time range between conventional analogue administration and meal delivery was set as between 10 and 30 minutes, again to reflect the pharmaceutical guidelines for conventional insulin analogues.

The Student *t* test was used to test for a significant difference between rapid-acting and conventional analogues with regard to the timing between BGL measurement and insulin administration, and between insulin administration and meal delivery in the different analogues. Group interview data were analysed by extracting common themes and the range of staff beliefs and perceptions.

1 Time elapsed between BGL test and insulin administration, and insulin administration and meal, for rapid-acting and conventional insulin analogue doses in the BHS inpatient population

Rapid-acting	*n*	Mean+/–SD	Proportion between limits
Time between BGL and insulin	32	62+/–39 mins	0.22
Time between insulin and meal	32	–2+/–4 mins	0.94
Conventional			
Time between BGL and insulin	163	49+/–40 mins	0.41
Time between insulin and meal	145	22+/–19mins	0.43

Results

Timing results are as shown in Box 1 and the differences in results between the two insulin types are shown in Box 2.

Most of the time nursing staff at BHS did not BGL test within an acceptable amount of time before insulin administration, for both rapid-acting and conventional insulin analogues. BGL testing was undertaken within 30 minutes before administration of rapid-acting insulin analogues in 22% of doses. In 41% of doses of conventional insulin analogues, nurses BGL tested within the 30 minutes before insulin administration.

There was no significant difference between the two analogues (rapid-acting versus conventional) with respect to the average time elapsed between BGL testing and insulin administration. It is unlikely that the type of insulin to be administered affects the time of BGL testing.

A higher proportion of rapid-acting insulin doses fell within the acceptable timing range in relation to meal delivery (94%) in comparison to conventional insulin analogue administration (43%) ($P < 0.001$). This means that nurses comply with relevant guidelines more often with rapid-acting analogues than with conventional insulins.

Discussion

Barriers to ideal practice and implications

This evaluation has shown that nurses at BHS inpatient units performed BGL tests outside the time range recommended in diabetes management guidelines. The reasons for this include: habit; the bustle of the early morning nursing period due to medication rounds, showers and breakfast; and disruption caused by other activities during medication rounds. The existing hospital policy specified BGL testing times that were unsuitable for current processes and ideal timing. Group interviews confirmed that many know they should take the BGL measurement just before insulin administration, yet feel that their other tasks prevent them from doing so.

Rapid-acting analogues do not require a time gap between insulin administration and meals. In the case of patients who may not eat, or who eat little, the nurses can inject after the meal to ensure the patient does not experience an episode of hypoglycaemia.

In terms of timing, conventional insulin analogues provide nurses with a more complex administration process. The nurses administer the insulin at the commencement of the morning medication round to ensure patients requiring insulin receive it before breakfast, as conventional analogue absorption is impaired if administered after a meal.

Timing of pre-meal insulin was affected by the care demands of inpatients with high level and complex health and social needs. This meant there was significant potential for patient harm due to improper timing of capillary BGL monitoring, insulin administration and meal ingestion on the inpatient units.

Recommendations for process redesign for the GEM Unit

Opportunities to improve the timing of insulin administration-related processes on the GEM Unit are discussed below. The GEM Unit is the

2 Comparison of time between BGL test and insulin administration, and time between insulin administration and meal delivery, in rapid-acting and conventional insulin analogue groups.

	Rapid-acting	Conventional	*P* value
Time between BGL and insulin	62.03 +/– 38.58	49.14 +/– 40.15	0.093
Time between insulin and meal delivery	–2.19 +/– 4.16	22.32 +/– 18.95	< 0.001

focus for change, as the majority of patients administered insulin are GEM Unit inpatients.

Deliver breakfasts to the GEM Unit earlier

Gilman recommends controlling meal delivery times as one of the most effective ways of controlling insulin administration timing problems.[2] Although breakfasts normally arrive from the kitchens on time, delivering them to patients (in the dining room and at bedsides) can take 15 to 20 minutes.

The other barrier to optimal meal delivery times is the sequential distribution of meals across the hospital. The order of progression is Rehabilitation, GEM then the Palliative Care Unit. The GEM unit typically has the highest proportion of diabetic patients, and if GEM was the first unit to receive breakfast, the timing of meal delivery in relation to (conventional analogue) insulin administration would be ideal. However, the Rehabilitation Unit patients have to attend to their morning showering and dressing activities of daily living so they can attend their therapy appointments on time, so later delivery could be a problem for that unit.

Deliver insulin-dependent patients' breakfasts first

Delivering insulin-dependent patients' breakfasts first would require changes to the patient meal print outs and the introduction of a unit summary list highlighting special dietary or other requirements, including insulin dependence. The use of colour coding could assist staff with rapid recognition of the names and locations of relevant patients.

Administer conventional insulin analogues 20 minutes later

Currently, morning administration rounds are commenced with the administration of injections including insulin, then nursing staff work systematically around the ward to administer oral medications. They do this to avoid back tracking which can lead to dose omissions. In order to achieve ideal timing of insulin administration, it should be carried out 20 minutes later. Administration of conventional insulin analogues 20 minutes later could be achieved in one of two ways: by starting the medication round later, or administering insulin 20 minutes after the start of the medication round, to better coincide with breakfast deliveries.

The simplest way would be to commence the medication round 20 minutes later, and to continue to commence medication administration with insulin injections. However, this process change would have large impacts on workflow. The morning medication round now starts immediately after completion of morning handover, typically at 07:20, so that the bulk of doses can be administered before medical rounds and allied health appointments. More importantly, most morning doses are ordered for 08:00, so commencing the round later would result in many delayed doses.

Although many nurses are aware that conventional analogues should be given ideally between 15 to 30 minutes before eating, they are concerned about forgetting insulin injections altogether if they were left until later in the medication round.

Review the policies, procedures and guidelines for nurses

Part of the process mapping involved checking whether existing in-house guidelines were consistent with best practice. BHS has a Diabetes Mellitus Management Policy and Procedure, but it had not been reviewed since March 2000. The prescribed early morning BGL testing time was not ideal in relation to insulin administration and meal delivery times. Thus BHS needs to review the Diabetes Mellitus Management Policy and Procedure, and ensure the times for testing are compatible with required insulin administration times.

Staff consultation and training on new policies and procedures

Process mapping highlighted that BGL testing times were vastly different between inpatient units, with some not in accordance with the current Diabetes Mellitus Management Policy and Procedure. This suggests that staff either did not know the policy and procedure existed; had not

read the policy and procedure; chose to ignore the recommended times; or experienced significant barriers to testing at those times. To overcome this problem, nursing staff and PSAs should be involved in the development of new policies and receive continuing education about them.

Conclusion

Process redesign would require a review of the BHS Diabetes Mellitus Management Policy and Procedure focusing on investigating and overcoming barriers to ideal timing of BGL testing and insulin dosage, as well consideration of a strategy to deliver breakfasts to insulin dependent patients first. This latter option appears to be the most easily achievable, safest and least disruptive change possible. The development of any new strategy or policy should entail nursing staff consultation and subsequent staff education.

A follow-up evaluation will include the effects of process redesign and staff training on the timing of insulin administration-related processes on both units. Roll out to the Rehabilitation Unit will depend on the effectiveness of the changes in improving the timing problems within the GEM Unit, and adjustments are likely to be needed.

Competing interests

None identified.

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