

Insulin prescription and administration and blood glucose monitoring at Mater Dei Hospital

Carol Cardona Attard, Rachel Agius, Alison Psaila, Stephen Fava

Abstract

Background: Incorrect insulin prescription and administration has been associated with substantial medication-related patient harm and mortality. We aimed to assess whether blood glucose was being monitored according to our local hospital protocol and whether insulin was being prescribed accurately by doctors and administered safely by nurses. Moreover, we evaluated whether education to nurses and doctors resulted in less insulin prescription and administration errors.

Methods: Inpatients on insulin in Mater Dei Hospital's medical wards were recruited. Data was collected from patients' files on errors in insulin prescription and on the timing of blood glucose monitoring and insulin administration in relation to meals. The first audit was carried out in 2013. A re-audit was carried out in 2017 following education to doctors and nurses and a change in the treatment chart format. The z-test was used to compare the two audits.

Results: On re-auditing, a significant improvement was noted in the timing of blood glucose monitoring and insulin administration in relation to meals, in the legibility of the insulin doses, 'Units' were more written in full and supplementary Actrapid® was more frequently prescribed where indicated. However, inappropriate omission of fixed insulin doses occurred more often, while written instructions by doctors on when to administer fixed insulin, including supplementary Actrapid®, were still lacking. Moreover, there was no improvement in adherence to the supplementary Actrapid® algorithm by nurses.

Conclusion: Further education and an improved treatment chart including hypo- and hyperglycaemia trouble-shooting guidelines are required to further reduce insulin prescription and administration errors.

Key words

insulin; prescription errors; administration errors; blood glucose monitoring; education.

Introduction

Subcutaneous insulin is considered a high-alert inpatient medication by the Institute for Safe Medication Practices.¹ It has a narrow therapeutic index and thus requires accurate dose changes together with careful administration and regular monitoring.² In a review by *Cousins et al*, 16,600 incidents related to incorrect insulin prescription and administration were identified between November 2003 and November 2009. Twenty four

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percent of these incidents resulted in patient harm. These incidents mainly occurred following the administration of the wrong insulin type, dose, frequency or strength, as well as inappropriate omission or delayed dosage, leading to insulin being administered at an incorrect time in relation to food. Moreover, the abbreviation of 'Units' to 'U' or 'IU' may be read as 0 or 10, especially in cases of poor handwriting, which can result in the administration of 10 or 100 times higher insulin doses.³ Confusion between the different available insulins or administration of insulin meant for another patient can also result in dangerous blood glucose fluctuations.⁴ Thus, although insulin can be a life-saving medication, it can also be life-threatening when used incorrectly.⁵

Insulin was reported to be implicated in 33% of medication error related mortality. Much of these insulin prescription and administration errors can be the result of illegible handwriting, heavy workloads on doctors and nurses, impaired communication, unawareness of the importance and possible complications associated with the incorrect timing of insulin administration in relation to meals and of the need to keep blood glucose controlled, as well as the absence of back-up checking systems.⁵

According to our teaching hospital's clinical practice guideline relating to insulin administration, all diabetic patients on insulin admitted to hospital, should have their capillary blood glucose checked 30 minutes before each meal and at bedtime (10pm).⁶ This is because Actrapid®, which is the short-acting human insulin available at Mater Dei Hospital, should be administered 30 minutes prior to a meal or a carbohydrate containing snack.⁷ On the other hand, rapid-acting insulin analogues (such as Novorapid®) should be given immediately before or after a meal, but the dose may need to be adjusted according to the patient's capillary blood glucose level prior to the meal.⁸ Basal insulins such as Insulatard® or long-acting insulin analogues e.g. insulin Glargine, do not need to be administered in relation to meals.^{9,10} However, when Insulatard® is mixed with Actrapid® to form biphasic insulin or Mixtard®, administration should occur 30 minutes before a meal.¹¹

Our trust also has a supplementary Actrapid® algorithm available to nursing staff, which guides them in administering supplementary Actrapid® pre-meals and at bedtime when blood glucose monitoring (BGM) is greater than 8mmol/L. An

algorithm for supplementary Actrapid® is assigned according to the patient's total daily dose of insulin or alternatively according to the patient's body weight.⁶

The aim of this audit was to assess whether BGMs were being checked according to our local Mater Dei hospital protocol and whether insulin was being prescribed accurately by doctors and administered safely by nursing staff. Moreover, we evaluated the use of supplementary Actrapid®, and whether this was being given in accordance to our local guideline. Another objective of this audit was to document any inappropriate insulin omission as well as resultant complications secondary to improper insulin prescription or administration. The re-audit aimed to assess whether educational sessions to both doctors and nurses led to a reduction of such errors in insulin prescription and administration.

Materials and Methods

The treatment charts of adult patients aged 18 years and over, who were admitted to any acute or general medical ward, were reviewed for possible inclusion in the audit. The inclusion criteria involved adult patients on any regular fixed doses of insulin. Patients who were on an intravenous insulin infusion were excluded. Each participant involved with data collection would review their allocated wards to include any newly admitted patients. The 1st audit was carried out over a 4-week period in 2013. The re-audit was carried out over a 12-week period in 2017 following educational sessions to both doctors and nurses.

The audit was carried out by all the authors of this manuscript together with the doctors mentioned in the acknowledgement section. A proforma was drawn up by one of the authors and this was then reviewed and endorsed by the supervising consultant. In addition to this, all doctors involved with data collection were asked to attend a briefing on the proforma to ensure conformity in the data collection process. The briefing was carried out by the most senior author participating in the audit. Educational sessions were given by the corresponding authors together with a diabetes specialist nurse after the results of the first audit were issued. These were one hourly one-time sessions, where all doctors and nurses working at Mater Dei hospital were invited to attend via emails from the respective associations. A new treatment

chart, with space available to write any important instructions for any prescribed drug, had also been issued prior to the re-audit. The same proforma was used for both audits.

The proforma consisted of six parts: the first section included demographic data of each patient recruited, including age, sex, type of diabetes and reason for admission. The second part was concerned with treatment, specifically the type of insulin the patient was on. In the third section details of insulin and supplementary Actrapid® prescription, including a correctly filled algorithm available in the patients' files, was audited. Correct insulin prescription involved writing insulin and dose correctly and legibly, 'Units' in full and clear instructions on when to administer insulin in relation to meals. This was in turn followed up by auditing whether BGM and insulin administration, including supplementary Actrapid®, was carried out in relation to meals according to the local protocol. Any inappropriate insulin omission was recorded. Insulin omission was taken as inappropriate if omitted following correction of hypoglycaemic episode¹² or if not given despite the patient having a BGM >4mmol/L and not nil by mouth in both cases. The last section included details about any complications, mainly hypoglycaemia (BGM <4mmol/L)¹² or hyperglycaemia (BGM persistently >10mmol/L),¹³

that might have arisen from errors of insulin prescription and administration.

The results were tabulated using an Excel® spreadsheet and expressed as absolute numbers and percentage values with the help of Microsoft Excel®. When comparing the results between the two audits the z-test was used. The International Business Machines Corporation Statistical Package for the Social Sciences programme was utilized for this purpose. A *p*-value of <0.05 was used to define statistical significance.

Permission from all consultants who were directly responsible for the management of these patients was obtained as well as approval from the data protection officer in order to access the patients' files. Ethics approval was not sought as at no point did any of the participants have any form of contact with the recruited patients.

Results

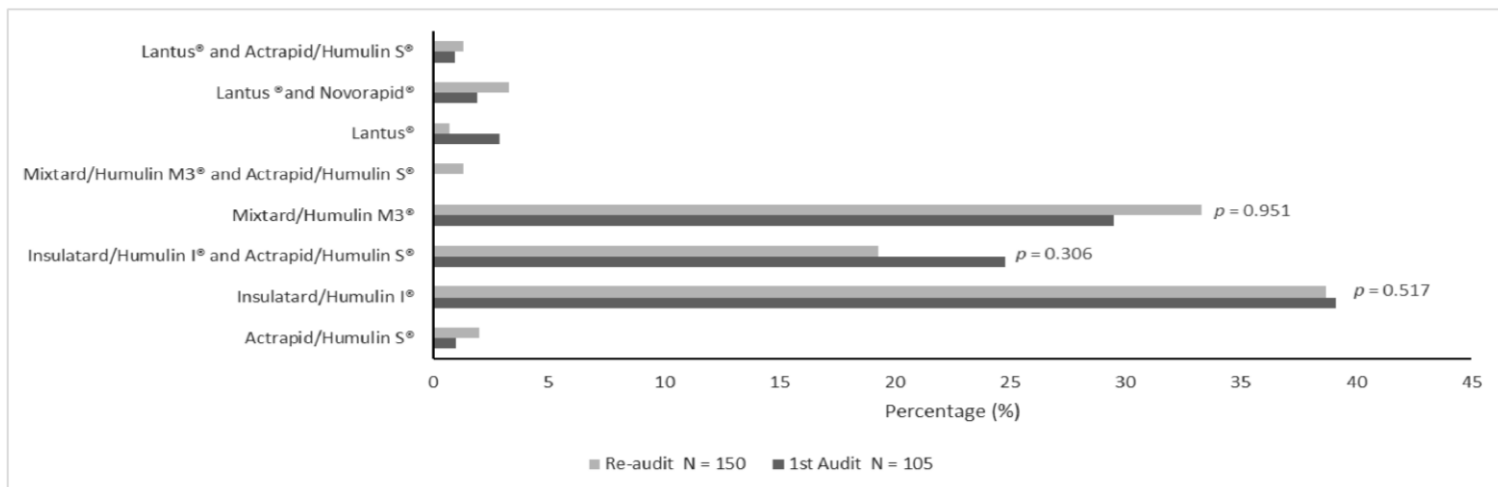
One hundred and five insulin-treated patients with diabetes admitted to 19 medical wards at Mater Dei Hospital were recruited during the original audit, while 150 patients were recruited during re-audit. Demographic data and treatment with different insulin regimes for both audit samples are shown in table 1 and figure 1 respectively.

Table 1: Demographic characteristics and frequency of patients in 1st audit and re-audit

Demographic characteristics	1st Audit (N = 105)	Re-audit (N = 150)	P^a
Age, mean ± SD	69 ± 13.7	71.8 ± 12.5	0.15
Gender			0.869
No. female	55	77	
% female	52.4	51.3	
Type of Diabetes Mellitus			0.146
No. T1DM	10	7	
% T1DM	9.5	4.7	
No. T2DM	95	143	
% T2DM	90.5	95.3	

^a z-test

SD- standard deviation; No- Number; %- percentage; T1DM- type 1 diabetes; T2DM- type 2 diabetes.

Figure 1: Different insulin regimes in 1st audit and re-audit

Insulin prescription errors

A satisfactory result in writing the insulin name correctly and legibly was present in both audits, while an improvement in dose legibility was noted in the re-audit (see table 2). A significant improvement in writing 'Units' in full rather than abbreviated 'U' was recorded compared to the original audit (23.8% in 2013 to 41.3% in 2017, $p=0.002$). Moreover, supplementary Actrapid® was prescribed more often (74.8% in 2013 to 85.5% in 2017, $p=0.002$). However, no improvement in the prescription of insulin or supplementary Actrapid® in relation to meals was observed despite education and the launch of a new treatment chart in 2016.

BGM and insulin administration

BGM was carried out in all patients except for one patient in the re-audit. Capillary blood glucose was monitored at the correct time in relation to meals in 39% of patients during the initial audit (Table 3). This improved to 61.3% in the re-audit ($p<0.001$).

Time of administration of insulin was charted in 97.3% in the re-audit, which is a significant increase from 55.2% noted in the original audit ($p<0.001$). Correct insulin administration in relation to meals was observed to be more in

accordance with the local guideline in the re-audit compared to the original audit (71.2% vs 31.0% respectively, $p<0.001$). A poor compliance to our local protocol with regards to the administration of supplementary Actrapid® (where prescribed) in relation to meals and when BGM was more than 8mmol/L was noted in both audits. However, when given, a significant improvement in the documentation of the timing and the dose administered was observed in the re-audit ($p<0.001$). Moreover, it was more often signed for compared to the first audit (Table 3).

Insulin Omission and Complications

Insulin was inappropriately omitted more often in the re-audit (3.8% to 10%, $p = 0.044$). No documented reason for insulin omission was present in all cases during the first audit and in 46.7% of cases in the re-audit. Inappropriate omission after treated hypoglycaemia or in the presence of normal but lowish BGM (between 4 and 5mmol/L) was present in 53.3% of cases in the second audit.

A greater number of complications secondary to errors in insulin prescription/administration were recorded in the re-audit (3.8% 2013 compared to 38.6% in 2017, $p<0.001$). Observed complications are shown in figure 2.

Table 2: Absolute numbers and percentage values of insulin prescription errors in the 1st audit and in the re-audit

<i>Insulin prescription errors</i>		<i>1st Audit</i>		<i>Re-audit</i>		<i>P^a</i>
		<i>N</i>	<i>No (%)</i>	<i>N</i>	<i>No (%)</i>	
Written correctly		105	100 (95.2%)	150	134 (89.3%)	0.071
Insulin name legible		105	96 (91.4%)	150	138 (92.0%)	0.871
Doses legible		105	86 (81.9%)	150	138 (92.0%)	0.021
‘Units’ Written in full		105	25 (23.8%)	150	62 (41.3%)	0.002
When ‘Units’ not written in full	‘U’ written like a zero	80	2 (2.5%)	88	4 (4.6%)	0.469
	‘Units’ not written at all	80	5 (6.3%)	88	11 (12.5%)	0.160
Insulin prescribed in relation to meals		105	10 (9.5%)	150	11 (7.3%)	0.539
Supplementary Actrapid® prescribed*		103	77 (74.8%)	145	124 (85.5%)	0.038
Supplementary Actrapid® prescribed in relation to meals (when prescribed)		77	9 (11.7%)	124	9 (7.3%)	0.307
Supplementary Actrapid® algorithm present in file*		103	59 (57.3%)	145	99 (68.3%)	0.077
Correctly filled supplementary Actrapid® algorithm (if present in file)		59	38 (64.4%)	99	69 (69.7%)	0.495

^a z-test

* Patients on Novorapid® excluded

No – absolute numbers

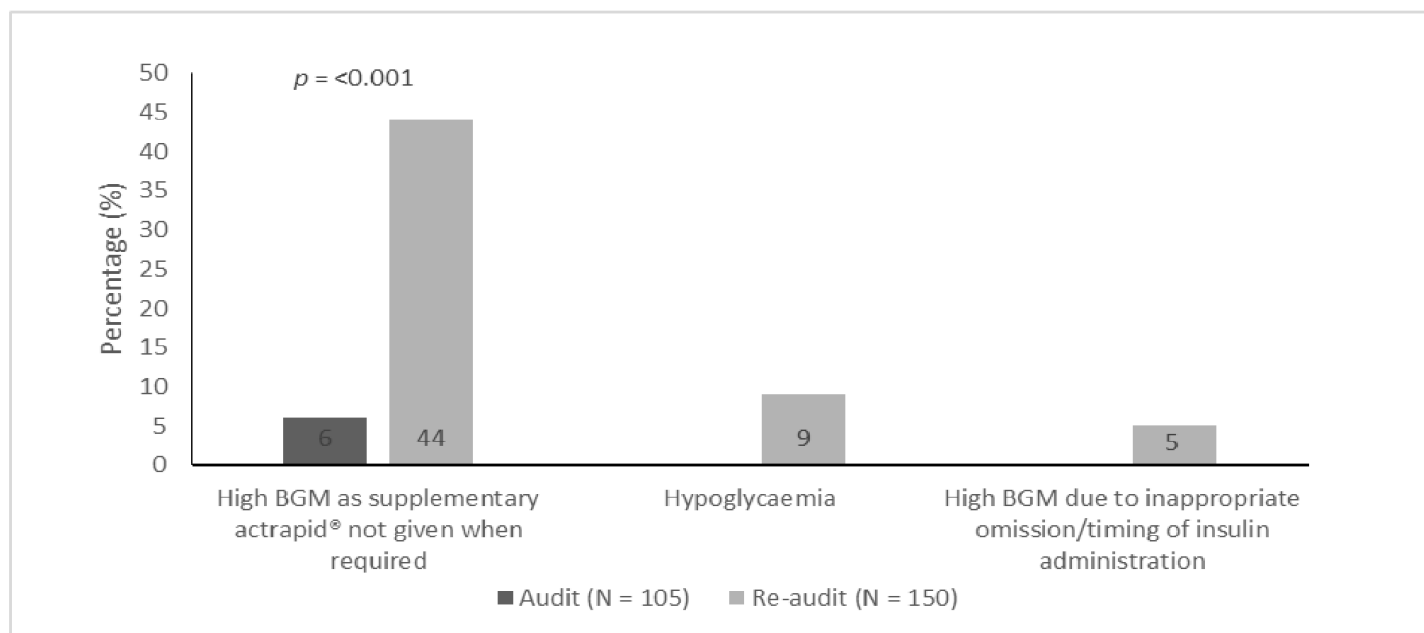
Table 3: BGM and administration of insulin in 1st audit and re-audit

<i>BGM and insulin administration</i>	<i>1st Audit</i>		<i>Re-audit</i>		<i>P^a</i>
	<i>N</i>	<i>No (%)</i>	<i>N</i>	<i>No (%)</i>	
BGM monitoring	105	105 (100%)	150	149 (99.3%)	0.316
Correct time of BGM monitoring	105	41 (39.1%)	150	92 (61.3%)	<0.001
Less frequent BGM monitoring than recommended	64	5 (7.8%)	58	7 (12.1%)	0.434
More frequent BGM monitoring than recommended	64	18 (28.1%)	58	39 (67.2%)	<0.001
Administration of regular insulin signed on treatment chart	105	100 (95.2%)	150	142 (94.7%)	0.837
Time of administration of fixed dose charted	105	58 (55.2%)	150	146 (97.3%)	<0.001
Correct administration of insulin in relation to meals	58	18 (31.0%)	146	104 (71.2%)	<0.001
Supplementary Actrapid® administered as per algorithm*	97	26 (26.8%)	103	30 (29.1%)	0.714
Administered supplementary Actrapid® signed and dose given documented*	97	54 (55.7%)	84	73 (86.9%)	<0.001
Time of administered supplementary Actrapid® documented*	97	52 (53.6%)	84	75 (89.3%)	<0.001

^a z-test

No – absolute numbers; BGM- blood glucose monitoring

*Where supplementary Actrapid® was prescribed and/or given; patients on Novorapid® excluded.

Figure 2: Type and frequency of complications secondary to errors in insulin prescription/administration

BGM- blood glucose monitoring

Discussion

Educational sessions to doctors were effective in improving some aspects of insulin prescription, as prescribed insulin doses were more legible, insulin 'Units' were more frequently written in full, while supplementary Actrapid® was prescribed more often in patients not taking short-acting insulin analogues. Although, no improvement was noted with regards to writing insulin names correctly and legibly, this was done appropriately in the majority of cases. Educational sessions to nurses also led to a significant improvement in the timing of BGM and insulin administration in relation to meals and in the documentation of the time of any administered insulin.

Although more complications were documented in the re-audit, it is possible that blood glucose charts were scrutinized more closely in the re-audit, as data collection was carried out mainly by diabetologists/diabetes trainees, while in the first audit data collection was primarily carried out by foundation doctors and basic specialist trainees. The majority of complications occurred secondary to non-adherence with our local supplementary Actrapid® algorithm, resulting in persistently high BGM as supplementary Actrapid® was not always given when blood glucose was more than 8mmol/L pre-meals and at bedtime.

Unfortunately, no improvement was observed in the prescription of insulin including supplementary Actrapid® at the correct time in relation to meals despite the introduction of a new treatment chart, which included extra space dedicated for the documentation of any important instructions regarding the prescribed drug. This could be due to the heavy work-load doctors have to endure during duty hours. In order to ensure accurate prescription of insulin, including clear instructions of when to administer insulin and supplementary Actrapid® in relation to meals, we propose the drafting of a prescription chart devoted for insulin therapy, incorporating a blood glucose and ketone monitoring chart. The appropriate time when to check blood glucose in relation to meals will be written clearly on the treatment chart and will provide a space to prescribe hypoglycaemia medications. The treatment chart will also include a space to provide clear instructions with regards to the timing of insulin administration. Such treatment chart, including hypo- and hyperglycaemia troubleshooting guidelines, was found to significantly improve compliance with evidence-based practice, insulin administration timing, hypoglycaemia control and provided a means to educate non-specialist staff.¹⁴

Inappropriate omission of fixed insulin doses was observed more often in the re-audit, with the majority of cases being due to a blood glucose of between 4-5mmol/L or hypoglycaemia. Further educational sessions to both nurses and doctors will be required to stress the importance of not omitting insulin in cases of hypoglycaemia. In such cases insulin doses should be reviewed, as insulin omission can result in rebound hyperglycaemia and diabetic ketoacidosis.¹²

Patients who are experienced and competent to manage their diabetes should be involved in decisions regarding their diabetes management.⁴ Giving such patients the choice to self-monitor and self-manage their own diabetes and insulin may result in reduction of errors involving insulin administration including type and dose as well as timing in relation to meals, all of which can lead to better glucose control and reduced hospital stays. Therefore, implementing a policy for diabetes self-management at Mater Dei hospital, while allowing flexibility for changing clinical situations, may further help with reduction of insulin prescription and administration errors and resultant patient harm. The diabetes specialist team should be immediately involved if further education on diabetes self-management is required or if blood glucose is uncontrolled.¹⁵

Another strategy which was found to be successful, is the implementation of a multifaceted multidisciplinary prevention team, which would monitor insulin prescription, dispensing and administration. This strategy also involved authentication of any short-acting insulin orders above 25 units and other insulins above 50 units by different individuals, together with continued staff education on product-labelling warnings and on the importance to adhere to protocols.¹⁶ In another study, the use of a diabetes specialist nurse prescriber, who reviewed prescription of insulin and oral hypoglycaemic agents (OHA), provided education to patients, medical and nursing staff when needed, continued to review insulin and OHA regimes and prescribed if medical staff were unavailable in emergency situations or if delay in prescribing will harm the patient, significantly reduced the number of insulin and OHA medication errors and reduced hospital stay.¹⁷ Both aforementioned strategies may therefore help to re-enforce adherence to current local supplementary Actrapid® algorithm, so that supplementary

Actrapid® can be administered when needed and at the correct time, thus avoiding both hypo- and hyperglycaemia. Computer-based clinical decision support systems might similarly help to further improve inpatient diabetes care.¹⁸

The results of our audit could have been constrained by three major limitations. Although we asked nursing staff in each ward the times when the main meals were distributed to patients, we could never know for sure whether the recruited patients ate their meals or had their food distributed at that exact time. Therefore, matching the documented time of any administered insulin with meal times might have been inaccurate. Moreover, any incorrect documentation of the time when blood glucose was monitored or when insulin was administered would have impacted our results. Lastly, there was no way of knowing for sure whether the correct type and dose of insulin was administered. Such limitations may be overcome by carrying out a prospective study, where insulin administration and its timing in relation to meals will be directly observed by the researcher.

In conclusion, although educational sessions led to some improvement in insulin prescription and administration, further work needs to be done to ensure patient safety in hospital and to avoid inadvertent patient harm secondary to errors in insulin prescription and administration.

Summary Box

What is known:

1. Insulin is a high-alert medication with a narrow therapeutic index.
2. Incorrect insulin prescription and administration can result in patient harm and medication error related mortality.
3. Errors in insulin prescription and administration can be the result of impaired communication, illegible handwriting, heavy work-loads and unawareness of the possible complications related to incorrect insulin prescription and administration.

New findings:

1. Education is effective in improving some aspects of insulin prescription and administration.
2. Lack of adherence to our local supplementary Actrapid® algorithm and inappropriate insulin omission resulted in capillary blood glucose readings to remain persistently high and in

rebound hyperglycaemia respectively.

- The introduction of a new treatment chart with space dedicated for documentation of any important instructions related to the prescribed drug did not improve insulin prescription in relation to meals.

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