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Development of an Insulin-Prescribing Chart for Paediatric Diabetes

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Abstract

Aim
Our aim was to design a new insulin prescribing tool in compliance with the Irish Medicines Safety Network recommendations.

Methods
In 2015, we undertook a review of the existing paediatric subcutaneous insulin-prescribing sheet introduced to Cork University Hospital in 2013. This involved a retrospective analysis of 15 consecutive in-patient insulin prescribing charts and a questionnaire distributed to health professionals. Following this a new insulin prescribing chart was designed and implemented in 2016 and a re-audit was performed in 2017.

Results
The 2017 re-audit demonstrated that the new insulin chart was viewed as easier (95% of previous users n=18) and safer (n=16) to use. There was less confusion (2017: 28%, n=11/39 vs 2015: 50%, n=17/34 2015) and the ALERT system helped staff standardise hypo/hyperglycaemia management (71%, n=28).

Conclusion
The new paediatric insulin prescribing chart has improved safety and ease of prescribing insulin. The colour coded quasi graph and ALERT system has made it easier to appreciate capillary blood glucose trends and manage them safely.

Introduction

Type 1 Diabetes Mellitus (T1DM) is a common condition seen with a relatively high national incidence in the paediatric population in Ireland- 28.8 cases/100,000/year[1]. Intensive insulin therapy has been shown to achieve optimum glycaemic control and reduce the risk of future complications [2-4]. Due to its narrow therapeutic index insulin has been identified as one of the top ten high-risk medicines worldwide[5]. Inadvertent over dosing can result in severe hypoglycaemia, which adds to morbidity associated with T1DM[6-8]. Insulin is one of the ten classes of drugs most frequently reported to be associated with medication related issues[9]. It has also consistently appeared in the top five

drugs associated with medication errors in the US Pharmacopeia (USP) medication error-reporting scheme MEDMARX[10].

The National Diabetes Inpatient Audit UK, 2015, described insulin related prescription errors in 22% of inpatients with diabetes[11]. A study undertaken in an acute Irish teaching hospital found that of the 8 medication classes, which accounted for 75.8% of medication errors that caused harm from 2005-2009, two classes caused significantly more harm: insulin and opiates[12]. Between 2003-2009 six deaths and twelve incidents resulting in severe harm were reported to the National Reporting and Learning System in the UK[13]. Furthermore, incorrect or inappropriate insulin prescribing leads to suboptimal glycaemic control. Smith et al., found that hyperglycemia and hypoglycemia in medical and surgical inpatients were mostly related to inadequate prescribing, monitoring, and communication practices[14].

In order to eliminate these largely preventable errors, in 2010 the Irish Medicines Safety Network (IMSN) issued a document titled 'Best Practice Guidelines for the Safe Use of Insulin in Irish Hospitals'[15]. This suggests a number of methods to reduce errors which were subsequently introduced into our department such as the development of an education programme on the practical aspects of insulin prescribing and administration and that hospitals should consider designing a drug chart solely for insulin prescribing and administration[15]. Nursing staff receive training regularly throughout the year by the diabetes nurse specialists while the NCHDs receive training every 6 months by a consultant paediatric endocrinologist and the paediatric diabetes nurse specialists.

A number of centers worldwide have explored the benefits of a dedicated insulin-prescribing chart for the purpose of improving glycaemic control and reducing prescribing errors[13-16]. Queensland public hospitals in Australia introduced a standardised statewide insulin prescribing record: one for intravenous and one for subcutaneous insulin prescriptions which resulted in an improvement in insulin prescribing, documentation of administration and blood glucose management[16]. A Canadian tertiary-care teaching hospital found that the implementation of a standardised, preprinted insulin order set facilitated best practices for insulin therapy, improved patient safety and was highly supported by treating practitioners[17]. A further study in New South Wales found that introduction of an adult subcutaneous insulin-prescribing chart had positive impacts on glycaemic management for patients on subcutaneous insulin therapy during admission[18].

Methods

At Cork University Hospital, a dedicated subcutaneous insulin-prescribing sheet was introduced within the Department in 2013 as a pilot project. The pilot period was completed within a year and the initial insulin prescribing chart was in regular use by January 2014 (Appendix 2). This included essential management information for example, capillary blood glucose (CBG) recording, carbohydrate intake at mealtimes, insulin:carbohydrate ratios and basal/bolus insulin prescriptions all on the one sheet. The initial Insulin:carbohydrate ratio (ICR) and insulin sensitivity factor (ISF) is calculated by the consultant paediatric endocrinologist.

In January 2015 a review was undertaken to establish the compliance with and effectiveness of the existing insulin-prescribing chart as had been in regular use since January 2014 (Appendix 2). This study had two parts (1.) A retrospective analysis of 15 paediatric inpatient subcutaneous insulin prescribing sheets chosen from 15 sequential admissions of newly diagnosed patients from January-May 2015. and (2.) a questionnaire regarding the design and usability of the insulin-prescribing chart distributed to thirty-four healthcare professionals chosen randomly from a selection of relevant groups working within the Department of Paediatrics and Child Health (including paediatric nursing staff, clinical nurse managers, diabetes nurse specialists, general and sub-specialist Consultant Paediatricians and doctors in training) during this time period. The objective was to use the data gathered from users and patient records to design an improved version of the insulin-prescribing sheet (Figures 1a-1b) in line with recommended standards for hospital-based insulin prescribing. Ethical approval was granted prior to commencing the review.

Figure 1a: Front and back pages of new specific insulin prescribing chart

DATE	INSULIN NAME	DEVICE	TIME/MEAL	DOSE	ROUTE	MCRN	SIGNATURE	GIVEN BY	CHECKED BY
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					
				UNITS					

DETAILS OF PERSON **PRESCRIBING** INSULIN			
PRESCRIBER NAME	MCRN	SIGNATURE	INITIALS

The number of entries varied for each variable e.g. the patients allergy and weight were only entered on the insulin prescribing sheet once so N=15 for these variables. However, there were 270 insulin doses prescribed and subsequently administered within these 15 insulin prescribing charts so the prescribers signature, MCRP and nursing checks N=270 (Table 1)

Table 1. Comparative results of the Insulin Chart reviews from the 2015 and 2017 audits

Variable	Audit 2015	Audit 2017
The allergy box is completed (Obligatory)	67% (10/15)	60% (9/15)
The patient weight is noted on the chart	87% (13/15)	93.3% (14/15)
Patient details are stated on the chart (Obligatory)	100% (15/15)	100% (15/15)
The word 'units' has not been omitted when writing insulin dose	77% (215/280)	1% (4/300)
Insulin has been prescribed in the main kardex	-	26.6% (4/15)
The box been ticked to state insulin is prescribed in the main kardex	-	6.6% (1/15)
The insulin device is noted (Obligatory)	-	2.66% (8/300)
The Insulin type/name is documented (Obligatory)	-	99.6% (299/300)
The prescriber's signature is documented (Obligatory)	100% (270/270)	99.6% (299/300)
The prescriber's MCRN is documented (Obligatory)	-	100% (300/300)
The prescriber has noted their details in the appropriate space in the back of the chart	-	6.66% (1/15)
Nursing staff have signed for administration of insulin (Obligatory)	97% (263/270)	97% (291/300)
Nursing details have been documented in the back of the chart	-	100% (15/15)
The nursing 'checked by' box is ticked (Obligatory)	87% (234/270)	n/a
The insulin correction factor is omitted or incorrect	-	93.3% (14/15)
Insulin-carbohydrate ratios are omitted or incorrectly filled	79% (145/183)	73% (182/250)
Ketones have been checked if CBG >14	64% (62/97)	68% (72/106)
CBG has been rechecked post hypoglycemic episode	-	77% (77/100)
CBG recorded In correct bracket range (Obligatory)	-	91.1% (517/560)
Carbohydrates consumed per meal are documented	-	85% (254/299)
The date is documented (Obligatory)	-	95.8% (69/72)
The basal Insulin type is documented (Obligatory)	69%	90.2% (65/70)
The short acting insulin dose is documented (Obligatory)	-	81.2%
The 'Given by' section is signed (Obligatory)	97% (263/270)	97% (291/300)
The 'checked by' section is signed (Obligatory)	87% (234/270)	97% (291/300)
The time/meal at which insulin is to be given is noted (Obligatory)	-	98.3% (295/300)
The insulin dose and type is recorded in appropriate section on inner sheet of prescribing chart (Obligatory)	-	81.2% (191/235)

Note: - means that the variable was not recorded in the original 2015 audit cycle
Obligatory means that the variable must be recorded for the insulin to be administered on the ward
Our definition of the insulin-carbohydrate ratio having been omitted is that the ratio was omitted for that dose e.g. a lunchtime dose ratio of 1:5 was omitted but the nursing staff were still able to administer the insulin by basing it off the lunchtime dose administered the previous day. Our definition of an incorrectly filled insulin: carbohydrate ratio is if an insulin dose was administered based off of the previous day's regimen as the current day's prescription was incorrectly documented e.g. an individual number 1 or 5 without the second digit to complete the ratio.
'The short acting insulin dose is documented' refers to the number of times the short acting insulin dose was documented relative to the number of times it was given.

The results of the initial audit cycle were used to redesign the insulin prescribing chart which came into use in 2016.

A repeat of the audit cycle was carried out in 2017 with a second retrospective analysis of 15 consecutive in-patient charts from September-November 2017 and a similar questionnaire distributed to 39 healthcare professionals in September 2017.

Results

Of note, no serious adverse events related to insulin prescribing had been recorded since introduction of the first insulin-prescribing chart in 2013.

Analysis of the former insulin-prescribing chart demonstrated issues with proper completion and documentation (Table 1). 79% of the insulin: carbohydrate ratios were left blank and in 76% of entries, the word units were either not documented or documented as 'iu' or 'u.'

Analysis of questionnaires identified issues with the design and usability of the former insulin-prescribing chart (Table 2). While most respondents perceived this chart to be safer than previous, some design changes were suggested. The first usability problems are related to the information layout of the sheets in which it leads to confusion (50%) and there is a need for additional space for carbohydrate counting (38.3%). The 2013 chart blood glucose recording did not clearly illustrate abnormal blood glucose levels (47.1%). Inclusion of an action system outlining guidelines for treatment of hypo and hyperglycemia and more columns for recording of CBG levels and the prescribing of insulin corrections were suggested. Using a graph to portray CBG readings was also suggested, so readings that are out of range can be more readily identified.

Table 2: Comparison of results from staff questionnaires

Note: 82% of Staff members did not participate in 2015 Audit		
	Audit 2015	**Audit 2017**
Adequate writing space is provided	61.7%	61.5%
It is clearly visible when CBG levels are out of normal range	52.9%	87%
There is a need to provide additional dose calculation space	64.7%	53.8%
The prescribing chart is user friendly	82.3%	82%
Confusion arose when completing the chart	50%	28%
It is easy to understand the basic functionality of chart	97%	94.8%
The prescribing chart is self explanatory	-	46%
There was adequate training or information on how to use the insulin prescribing sheet	88.2%	28.2%
It is easier to appreciate CBG trends due to the colour coded quasi graph	-	89.7%
CBG levels are referred to when prescribing (Doctors) or administering (Nursing staff) insulin	88.2%	87%
The use of the pre-printed 'units' reduces use the writing of words 'units' or abbreviated 'iu'	-	87%
The ALERT system is useful to standardise hypo/hyper glycaemia treatment	-	71%
The non-administration of insulin codes (Reasons for non-administration of the prescribed insulin dose) should be included in the prescribing chart	94.1%	53.8%
The font used in the insulin prescribing chart is appropriate	88.2%	89.7%

Following approval by the Quality Office of Cork University Hospital, the new insulin-prescribing record for the administration of subcutaneous insulin to paediatric patients was launched in December 2016 and is now used in regular clinical practice within the Department.

Analysis of the new insulin prescribing chart in 2017 demonstrated an improvement in prescribing and documentation (Table 1). A significant issue identified was that the short acting insulin dose was only documented 81.2% of the time relative to the number of times it was given. The main reasons for such events were failure to prescribe the morning dose the night before with the on call staff unable to come while managing other patients. Similar events occurred at busy peak times for patient care e.g. weekend doses. A diabetes nurse specialist at our center has gained certification as a nurse prescriber to prevent such events going forwards. Similarly, analysis of questionnaires completed by 39 health care professionals demonstrated many improvements (Table 2). It was now more clearly visible when CBG levels are out of range (87% 2017 vs 52.9% 2015) and there was less confusion when completing the chart (28% 2017 vs 50% 2015). The introduction of the colour coded Quasi graph made it easier to appreciate CBG trends (89.7%). The ALERT system helped NCHDs and nurses standardize hypo/hyperglycaemia treatment (71%). Table 3 shows the current insulin sheet was safer and easier to use than the previous itineration with the majority of staff satisfied with its use and design overall.

Table 3: Overall Quality of Insulin Sheet: Table 3 shows the current insulin sheet was safer and easier to use than the previous itineration with the majority of staff satisfied with its use and design overall.

Overall Quality of the Insulin Sheet:				
Is administering and recording the subcutaneous insulin order easier with the current subcutaneous insulin sheet than alternatives used in the past?	Yes 46.1%	No 2.56%	Did not use previous insulin sheet 48.7%	
Have there been any unintended consequences from using the prescribing sheet that you personally are aware of? e.g. missed doses of insulin, routine insulin not being prescribed etc.	Yes 10.2%	No 58.9%	Unsure 28.2%	Spoiled 2.56%
Please rate the safety of the new insulin prescribing sheet compared to previous sheet.	Safer 41.0%	Less Safe 2.56%	Did not use previous insulin sheet 56.4%	
Please rate your level of satisfaction with the insulin prescribing sheet	Satisfied 76.9%	Not Satisfied 10.2%	Unsure 10.2%	Spoiled 2.56%
Is there a clear communication between multidisciplinary users using the sheet on ward rounds?	Yes 66.6%	No 15.3%	Unsure 15.3%	Spoiled 2.56%
Would you make any design changes based on your experience using the prescribing sheet?	Yes 46.1%	No 23.0%	Unsure 28.2%	Spoiled 2.56%
Implementation of insulin to carbohydrate counting leads to more accurate dosing of insulin needed by the patient	Yes 61.5%	No 2.56%	Unsure 33.3%	Spoiled 2.56%

Discussion

Our findings demonstrated the need for an updated insulin-prescribing chart within the Department following the introduction of the initial dedicated insulin prescribing chart in 2013. Prior to 2013, all insulin prescriptions were prescribed in the main drug Kardex akin to prescribing analgesia or an antibiotic. The IMSN suggest that an insulin prescribing chart should incorporate the following safety features: the word ‘units’ pre-printed wherever a dose of insulin has to be prescribed to avoid the use of abbreviated ‘u’ or ‘iu’. Using U as an abbreviation for units can lead to 10 times overdosing as if U is mistaken as 0 and IU can lead to I being mistaken for 1 e.g. when 6IU is prescribed, 61units could be given instead of 6. A reference list of the insulin most commonly prescribed in hospitals, classified by the different formulations of insulin and the provision of space for double signatures on the drug chart to prompt staff to seek a second person to check insulin doses prior to administration.

The Australian Commission on Safety and Quality in Healthcare analysed a number of insulin prescribing charts and offered numerous potential design solutions including the use of a quasi-graph design as a method for recording CBG levels (Figure 1b.) as it gave a visual representation of the trend in CBG readings while also allowing numerical values to be recorded and the use of a colour coded track and trigger system for the detection of abnormal CBG levels[19].

The newly designed Paediatric Subcutaneous Insulin Prescribing and Capillary Blood Glucose Record (Figures 1a-1b), has a number of additional features. (1.) The front cover includes a check box tool to ensure insulin has also been prescribed on the main drug kardex. (2.) The word 'units' has been clearly printed in each prescribing space, reducing the risk that the prescriber will include an abbreviated 'u' or 'iu' instead. (3.) Each chart has space for recording five days of information, with each day clearly separated (4.) Recording of CBG is done on a colour-coded quasi-graph, which gives a visual picture of the variation of CBG levels throughout the day and will clearly demonstrate if recorded CBG levels are within target range. (5.) As recommended by staff, additional spaces for CBG recording have been included, along with prompts to ensure a two-hour post prandial CBG is checked after every meal. (6.) The most commonly used long and short acting insulin have been listed and should be circled by the prescriber in addition to writing the insulin prescription in the spaces provided at the front and back of the chart. (7.) A colour coded alert system, with a corresponding action plan has also been included in the new insulin-prescribing chart. (8.) Often doctors in training are called to prescribe insulin or review CBG levels that are out of range. Those with limited experience in the management of diabetes may be unsure of how to manage abnormal CBG levels. For this reason, a management plan for hypoglycaemia and hyperglyceaemia has been included. This ensures a standardized approach to the management of diabetes in all inpatients, which should result in better glycaemic control and consistency in the patient education process[20].

This insulin-prescribing chart is a step towards eliminating preventable errors associated with the prescribing and administration of insulin. Due to the frequency of medication errors and potentially fatal consequences of the administration of incorrect insulin doses, it is vital that we have safe and effective prescribing and administration records.

The biggest barrier to safe insulin prescribing from the 2017 re-audit is the persistence in confusion (28%) in completing the chart as only 28% of staff felt that they had received adequate training with using the insulin prescribing chart. This reflects a lack of training so a first step is to provide dedicated staff education sessions on the insulin prescribing chart.

Limitations to the above study include the small sample sizes and that some respondents who responded to the questionnaire in 2017 had not used the previous 2015 insulin prescribing sheet- mainly new NCHDs who invariably rotate through sites.

Achieving the safest, most effective insulin chart will be a dynamic process. Therefore, further audits of this chart will be required to again evaluate compliance and usability and make the necessary improvements ideally to further eliminate preventable insulin prescribing errors. This will involve further redesigning of the insulin prescribing chart and further staff education sessions. Ultimately we aim to produce a paediatric diabetes insulin prescribing sheet to include in-patients on insulin pump therapy and MDI which can be rolled out nationally.

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Declaration of Conflicts of Interest:
The authors have no conflicts of interest to declare.

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