# Medication Errors with the Dosing of Insulin: Problems across the Continuum


## ABSTRACT

*Controlling blood sugars with insulin is essential in the management of hyperglycemia in both diabetic and nondiabetic patients. However, studies have shown that the use of insulin has been associated with more medication errors than any other type or class of drug. From January 2008 to June 6, 2009, Pennsylvania healthcare facilities submitted 2,685 event reports to the Authority that mentioned medication errors involving the use of insulin products. The most common types of medication error associated with insulin were drug omission (24.7%) followed by wrong-drug errors (13.9%). More than 52% of the reported events led to situations in which a patient may have or actually received the wrong dose or no dose of insulin (e.g., dose omissions, wrong dose/overdosage, wrong dose/underdosage, extra dose, wrong rate errors), which could lead to difficulties in glycemic control. Strategies to address these problems include limiting the variety of insulin products on the organization's formularies, developing standardized protocols and a standard format for prescribing insulin, avoiding the use of abbreviations or other shortcuts when communicating orders for insulin, and requiring an independent double check of all doses before dispensing and administering intravenous insulin. (Pa Patient Saf Advis 2010 Mar;7[1]:9-17.)*


## Introduction

An estimated 23.6 million Americans (nearly 8% of the U.S. population) have diabetes mellitus. In 2007, approximately 17.9 million people have been diagnosed with the disease, and 5.7 million remain undiagnosed.[1] Among adults diagnosed with type 1 or type 2 diabetes, 14% take insulin only, 13% take both insulin and oral medication, 57% take oral medication only, and 16% do not take either insulin or oral medication.[2]

Glycemic control is fundamental to the management of diabetes. Insulin is used to control blood sugars in both diabetic and nondiabetic patients. For example, it is used to manage hyperglycemia in intensive care unit (ICU) patients, a common finding caused by insulin resistance in the liver and muscle tissue. Some have considered insulin resistance to be an adaptive response, providing glucose for the brain, red blood cells, and wound healing.[3]

Due to a number of conflicting published studies, there has been an increased effort to determine the benefit of tightly controlled blood glucose levels, both in diabetic and nondiabetic patients. For example, in a large, single-center study of postoperative surgical patients, an initial investigation by van den Berghe et al. suggested that controlling blood glucose levels by intensive insulin therapy decreased mortality and morbidity in critically ill surgical patients.[4] The study design employed a continuous infusion of insulin to maintain blood glucose between 80 mg/dL and 110 mg/dL. Patients receiving intensive insulin therapy were found to be less likely to require prolonged mechanical ventilation and intensive care. Also, rigorous insulin treatment reduced the number of deaths from multiple-organ failure with sepsis, regardless of whether there was a history of diabetes or hyperglycemia.

The NICE-SUGAR study evaluated whether there was a difference in mortality between subjects randomly assigned to either intensive glucose control (target blood glucose range of 81 mg/dL to 108 mg/dL) or conventional glucose control (target of 180 mg/dL or less).[5] The study showed that the odds of dying with intensive control were 1.14 times *greater* than with conventional control. In addition, severe hypoglycemia (blood glucose level of 40 mg/dL) occurred in 6.8% of the intensive-control group and 0.5% in the conventional-control group. The NICE-SUGAR study also demonstrated that there was no significant difference between the two treatment groups in the median number of days in the ICU or hospital or in the median number of days of mechanical ventilation or renal-replacement therapy.

In a meta-analysis of randomized controlled trials of tight glucose control versus usual care in critically ill adults, the authors found no significant difference in hospital mortality or new need for dialysis. Although tight glucose control was associated with a significant reduction in septicemia overall, subgroup analysis suggested this benefit was limited to surgical ICU patients. Conversely, they found clear evidence that hypoglycemia *increased* roughly fivefold, regardless of the ICU setting, and was more common with patients receiving very, rather than moderately, tight glucose control.[6]

For many years, literature has shown that the use of insulin has been associated with more medication errors than any other type or class of drug. Cohen et al. reported in 1998 that 11% of harmful medication errors result from insulin misadministration.[7] The U.S. Pharmacopeia MEDMARX 2008 data report showed that insulin was the leading product involved in harmful medication errors (i.e., National Coordinating Council for Medication Error Reporting and Prevention [NCC MERP] harm index[8] E to I), representing 16.2% of all harmful medication error reports.[9] In 2004, the Pennsylvania Patient Safety Authority established that 25% of all medications errors reported involve high-alert medications, and 16.3% involved insulin products.[10] This article presents analysis of events involving insulin products reported to the Authority during an approximately 17-month period and describes the most common types of errors

involving the use of insulin, as well as those events that could contribute to uncontrolled blood sugars.

## A Look at the Numbers

Pennsylvania healthcare facilities submitted 2,685 event reports to the Authority from January 2008 to June 6, 2009, that mentioned medication errors involving the use of insulin products. Categorization by harm score, which is adapted from the NCC MERP harm index,[8] shows that 78.7% (n = 2,113) of the events reached the patient (harm index = C to I) and 1.8% (n = 49) of the events resulted in patient harm (harm index = E to I). The care areas most often cited in these reports include medical/surgical units (22.3%, n = 599), pharmacy (8.7%, n = 234), and telemetry (7.1%, n = 191). Roughly 53% (n = 1,434) of the events involved elderly patients (ages 65 years and older), while 1.7% (n = 46) involved pediatric patients (ages younger than 17 years).

The predominant medication error event types associated with insulin (see Table) were drug omission (24.7%, n = 662) followed by wrong drug (13.9%, n = 374) and wrong dose/overdosage (13%, n = 348). More than 52% (n = 1,409) of the reported events led to situations in which a patient may have or actually did receive the wrong dose or no dose of insulin (e.g., dose omissions, wrong dose/overdosage, wrong dose/underdosage [5.1%, n = 137], extra dose [8.5%, n = 227], wrong rate [1.3%, n = 36]), which could lead to fluctuations in glycemic control.

## Wrong-Drug Errors Associated with Insulin Products

There are numerous case reports in the literature that discuss the issue of wrong-drug medication errors with insulin products due to similarities in the brand and generic names, as well as similarity in labeling and packaging.[11-14] The Authority has noted mix-ups between names occurring in Pennsylvania facilities (e.g., Humalog® and Humalog 75/25, Humalog and Humulin® R, Humalog 75/25 and Humulin 70/30, Novolog® and Humalog, Novolog 70/30 and Novolin® 70/30).[15]

**Table. Predominant Medication Error Event Types Associated with the Use of Insulin (N = 2,057, 76.6%), January 2008 to June 6, 2009**

| EVENT TYPE | NUMBER | % OF TOTAL REPORTS (N = 2,685)* |
|---|---|---|
| Dose omission | 662 | 24.7% |
| Wrong drug | 374 | 13.9% |
| Wrong dose/overdosage | 348 | 13% |
| Other (specify) | 309 | 11.5% |
| Extra dose | 227 | 8.5% |
| Wrong dose/underdosage | 137 | 5.1% |

* Sum of percentages exceeds 76.6% due to rounding.

During review of the wrong-drug medication errors, analysts found that facilities did not enter the actual name of the insulin products consistently into the reports. In fact, 70% (n = 262) of the submitted reports did not list a specific insulin product (e.g.,"insulin," "regular insulin," "NPH insulin," "insulin 70/30") or listed names of products that do not exist (e.g., "Humalog 70/30," "Humalog R," "Humulin 75/25"). This imprecise data collection limits individual facilities and the Authority from accurately determining the most common pairs of insulin products involved in wrong-drug errors. In addition, many of these reports did not specifically state why the error occurred or what went wrong that led to the patient receiving the wrong insulin product. Therefore, it was not possible to determine the most common types of wrong-drug errors that occurred (e.g., wrong drugs that may have been written by prescribers, selected during order entry, mislabeled in the pharmacy, wrongly pulled from stock). Analysts were able to determine the following:

- Seventy-five (20%) reports of wrong-drug insulin errors specifically mention that the breakdown occurred when retrieving the medication, for example, from stock or an automated dispensing cabinet (ADC). Specifically, 28 reports (37.3% of stock errors) mentioned the use of overrides to obtain the insulin product from an ADC.
- Sixty-nine (18.4%) of wrong-drug insulin errors involved mix-ups between a rapid acting insulin (e.g., Novolog, Humalog) and regular insulin (e.g., Novolin R, Humulin R, regular insulin).
- Sixty-five (17.4%) reports of the wrong-drug events specifically identified that the error occurred during the prescribing node. Most of these reports involved the clarification of nonspecific (e.g., a specific insulin product was not indicated) orders, such as the following:

  *The physician wrote an order for "Novolin 18 units bid." The order was not clarified when taken off, and regular insulin was given for two doses. When the physician came in the following day, the order was clarified, and he ordered Novolin N insulin. The patient was given two doses of Novolin R.*

Intravenous (IV) administration of insulin has some advantages over subcutaneous administration, namely (1) more rapid onset of effect in controlling hyperglycemia, (2) more overall ability to achieve glycemic control, and (3) improved nonglycemic patient outcomes.[16] During IV insulin infusion to control hyperglycemic crises, hypoglycemia, if it occurs, is short-lived; however, repeated administration of subcutaneous insulin may result in "stacking" the insulin's effect, causing protracted hypoglycemia.[16]

The stability of an IV insulin infusion is 24 hours and requires the production of insulin infusions by pharmacy when ordered. Unless this infusion is distinguished with highlighting or a prominent sticker, an insulin infusion will resemble other pharmacy-prepared infusions. Of the wrong-drug errors involving insulin reported to the Authority, infusion bags

containing insulin were mentioned in 9.4% (n = 35) of the cases. Nearly 88.6% (n = 31) of these reports reached the patient, and 11.4% (n = 4) resulted in patient harm. Patients accidentally received insulin instead of a noninsulin-containing infusion (e.g., antibiotics) in 60% (n = 21) of these wrong-drug, infusion-related reports. Examples are as follows:

> *An IV insulin bag was hung when replacing the patient's Versed® (midazolam) bag. Two bags of insulin were then hanging, one at rate of 8 (Versed rate) and one at 5 (insulin rate). A [mid-afternoon] accu-check showed that the [blood glucose] level decreased to 36. D50 was administered as per protocol, and the insulin drip was turned off. The wrong-bag error was found at [the next] change of shift.*

> *A patient was ordered IV Lasix® (furosemide), as well as IV insulin. The nurse meant to hang the IV Lasix but [before midnight] hung a bag of IV insulin instead. The patient already had an insulin infusion running. Approximately [four hours later], the patient was noted to be hypoglycemic. Both IV drips were turned off at that time, and the patient was given 50 ml of 50% dextrose. The RN [registered nurse] still believed that one of the IV drips was Lasix at this time. Four hours later, the oncoming RN was checking and verifying the patient's IV drips and discovered the error. The patient required several more doses of 50% dextrose throughout the morning to correct episodes of hypoglycemia.*

## Wrong-Dose Errors with Insulin

Analysis of events that resulted in patients receiving a type of wrong dose (e.g., wrong dose/overdosage, wrong dose/underdosage, extra dose) reveals a variety of breakdowns that occurred in the medication-use process, including problems with insulin coverage orders, ambiguous orders written by prescribers, transcription and order-entry errors, the obtainment and/or use of the incorrect blood glucose value of the patient, and the ways in which information about insulin products is displayed on pharmacy labels and medication administration records.

About 10.4% (n = 36) of the wrong dose/overdosage events reported to the Authority involved a tenfold overdose of insulin.

### Insulin Coverage Orders

The Diabetes Control and Complications Trial, a prospective, randomized controlled trial of intensive versus standard glycemic control involving inpatients with relatively recently diagnosed type 1 diabetes, showed that improved glycemic control is associated with significantly decreased rates of microvascular (retinopathy and nephropathy) as well as neuropathic complications.[17] This led to the recommendation that type 1 diabetes be treated by using multiple insulin injections (three to four injections per day of basal and prandial insulin) as well as by matching the dose of prandial insulin to carbohydrate intake, pre-meal blood glucose, and anticipated activity.

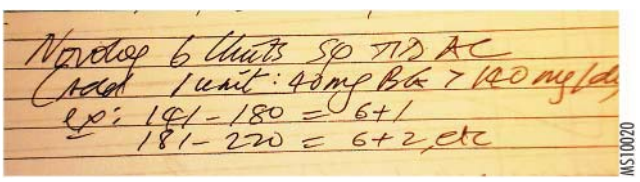
However, the use of multiple-dose injections of insulin throughout the day has added complexity to controlling a patient's blood glucose. For example, correction doses, sometimes referred to as "coverage" or erroneously as "sliding scales," are used to adjust glucose levels around mealtimes. Organizations often have multiple algorithms for corrections doses, such that a facility may have "low dose," "medium dose," and "high dose" algorithms that require the nursing staff to obtain and document each patient's blood glucose reading, determine the patient's ordered algorithm, and then select the proper dose based on the blood glucose reading.

The predominant theme mentioned in reports of wrong-dose events involves the dosing of insulin based on a range of blood glucose values with a corresponding coverage dose, determined by a patient's blood glucose reading. Of the wrong-dose errors submitted to the Authority (n = 712), 26% (n = 185) mention coverage or sliding scales. (Many events reported to the Authority used the phrase "sliding scale" in the narratives to denote the method used to determine the dose of insulin to administer to patients. While this term may be used in place of "correction dose" or "coverage," it should be noted that sliding-scale insulin regimens used *alone* are ineffective and potentially harmful. When using subcutaneous insulin injection therapy, scheduled or standing insulin regimens should be the standard of care.[18-21]) As mentioned previously, this recommended method of maintaining tight control of a patient's blood sugar, regardless if the patient is diabetic or not, adds complexity to the medication-use process for all healthcare practitioners.

One problem often seen with coverage orders is the clarity of handwritten orders from physicians, a particular problem when an organization does not have a standardized protocol or order form to order insulin, including the type of coverage (e.g., low, high). Adding to the complexity of these orders are the multiple values often used for multiple ranges of blood sugars. Problems have also occurred when shortcuts are taken when writing these types of orders for insulin. For example, orders have been written stating doses of insulin as "6+1" or "6+2" instead of writing out "7" or "8" (see Figure 1).

Once these complex orders have been written, problems have occurred when transcribing the orders to medication administration records (MARs) or entering them into computerized order-entry systems. Errors also have occurred when selecting the blood glucose range, dose, or algorithm from a pharmacy label, a handwritten MAR, or a computer-generated

**Figure 1. Example of Ambiguous Insulin "Coverage" Order**

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MAR (see Figure 2). Pennsylvania facilities are experiencing these types of errors as evidenced by these events reported to the Authority:

*A patient was ordered insulin on sliding scale level 2, but the order was transcribed incorrectly on the MAR as sliding scale level 1. The patient received two doses at level 1 coverage instead of level 2. The error was found during the 24-hour MAR check.*

*A patient was changed from high-dose sliding scale coverage to moderate dose. Order was transcribed onto medication sheet as bedtime coverage, but original order was for no bedtime coverage. Patient received four units of insulin.*

## Ambiguous Orders Written by Prescribers

There has been much written about problems with handwritten orders for insulin, including the use of dangerous abbreviations or dose expressions and other shortcuts when communicating orders. How the use of the letter "U" to abbreviate "unit" has contributed to medication errors has been discussed for several decades.[22] Errors that have occurred when using "U" for unit have resulted when the "U" resembles the number "0" or "4." Reports to the Authority reveal similar examples of wrong doses due to the use of shortcuts when writing orders for insulin.

*Intern wrote order for 8 U of insulin, which was transcribed as 80 units of insulin.*

*Order written by the doctor as "ss insulin 10u tid Novolog." The order should have been clarified but was not and should have been written according to abbreviation policy. The order was transcribed as "Novolog 10 Units TID," but the order was intended to be "Sliding Scale Low TID."*

*The physician wrote "ss" for sliding scale, and the staff transcribed the order as "55 units." The error was caught prior to administration.*

*Order on chart is for Humalog 4 units, but it had said 5 units, and the 5 was crossed off, and the 4 was placed in front of the crossed-off 5. Therefore the order appeared to say 45 units and was placed in by pharmacy . . . and verified by the nurse as 45 units. The chart was reviewed due to the very high dose of Novolog to be given, and it was found that the 5 was crossed off. The pharmacy was called, and they corrected the dose.*

Although writing out the complete word "units" is the recommended alternative to using the abbreviation "U," be aware that tenfold overdoses may still occur when writing the word "unit(s)," particularly when there is inadequate white space between the dose number and the word (see Figure 3). Examples reported to the Authority include the following:

*A patient was admitted to the ED [emergency department] after [the patient's] morning insulin had been administered. The ED completed medication reconciliation documentation, including "insulin 7units." The resident referred to the written medication reconciliation document, perceiving the insulin dose to read "70units." Resident ordered Lantus 70 units bid, and the pharmacy verified the order. The patient was transferred, and the nurse administered the evening dose of Lantus 70 units as ordered, with appropriate double check. The patient later questioned dose, stating "I take 7 units."*

*A patient was ordered "20 units Lantus q 24hr." The pharmacist misread the order and transcribed the order onto the MAR as "Lantus 200 units." The nurse administered 200 units Lantus [that evening], and [two hours later], the patient's blood sugar was reported as 54. The nurse increased tube feedings, and subsequent accuchecks were read as "error."*

*The physician transcribed an incorrect insulin dose from the transfer orders. Physician wrote 70 units of insulin instead of 7 units of insulin. The physician misinterpreted the order due to the fact that the u (for units) was very close to the 7 on the transfer orders.*

**Figure 2. Example of "Coverage" Order Complicated Directions on a MAR**

| | |
|---|---|
| DOSE: | SEE SLIDING SCALE SUBQ AS NEEDED/PRN |
| COMMENTS: | DOSE PER SLIDING SCALE BELOW AND DOCUMENT ON DIABETES RECORD FORM. *HIGH DOSE* BS < 60 OR SYMPTOMATIC REFER TO ROUTINE HYPOGLYCEMIA ORDERS. OBTAIN STAT LAB GLUCOSE AND NOTIFY MD. 151-200= 6 UNITS, 201-250= 8 UNITS, 251-300= 10 UNITS, 301-350= 12 UNITS, 351-400= 14 UNITS, 401-500= 16 UNITS, >500 GIVE PRESENT REGIMEN DOSE FOR BS 401-500. OBTAIN STAT LAB BLOOD SUGAR AND CALL MD WITH RESULTS. |

MS10022

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## Transcribing and Order-Entry Errors

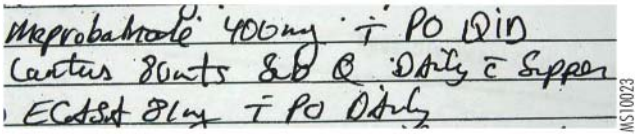
Among the wrong-dose insulin errors, 13.8% (n = 98) of the events involved breakdowns that occurred when transcribing orders, such as when entering orders into an MAR or a computerized order-entry system. Examples reported to the Authority include the following:

*A patient was ordered "human regular insulin 150 units subcutaneously qam prn," with the reason stating that the patient was on the medication at home. The order was entered as a nonformulary drug request. I questioned the order and discovered that the patient has a sliding scale regimen [as follows:] if blood sugar is 150 to 200: give 2 units; blood sugar 201 to 250: 4 units; blood sugar 251 to 300: 6 units; blood sugar 301 to 350: 8 units; blood sugar 351 to 400: 10 units; and blood sugar 401 to 500: 12 units. The first blood sugar parameter was incorrectly entered by the [physician] as the insulin dose.*

*A physician wrote an order for a patient to receive four units of regular insulin if the patient's early morning blood sugar was equal to or greater than 250. Blood sugar was checked, and it was 179, so patient should not have received any insulin. The original order was transcribed incorrectly in that clerk wrote four units of Humalog 75/25 instead of regular insulin. Not only did patient receive insulin when he shouldn't, but he received the wrong insulin. The transcription on the medication Kardex had not been cosigned by two nursing staff as is our policy.*

*Medication verification sheet documented a wrong dose of 70/30 insulin as per patient's spouse bringing*

**Figure 3. Order Written for 8 Units of Lantus Insulin Misread as 80 Units**

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*in recent hospital discharge instructions sheet of medications as proof. The patient was ordered 10 units of 70/30 insulin, but the order was transcribed as 40 units.*

## Obtaining and/or Using the Correct Blood Glucose Value of the Patient

In addition to the 30 events reported as "Monitoring errors/Clinical lab values," 12.9% (n = 92) of the wrong-dose events involved breakdowns with obtaining and/or communicating patients' blood glucose values. Specific problems reported to the Authority included reporting an incorrect value, confusing the patient's weight for his or her blood glucose level, and communicating the wrong patient's value, as well as simply documenting the wrong result. Both licensed professionals and support staff have been involved in these breakdowns.

*The patient's blood sugar was written on the board as 148. The patient was given two units of regular insulin [that evening]. When the history in the glucometer was checked, the patient's actual reading was 450. An additional 10 units of regular insulin was given at [one and a half hours later].*

*The nurse asked the nursing assistant for the patient's Accucheck results. The nurse was told that the blood glucose was 377. The patient was covered with 10 units of Humalog per sliding scale guidelines. When the nursing assistant wrote the Accuchecks on the bulletin board, the blood glucose of 97 was written for that patient.*

*The nurse used the wrong number for the coverage, using the patient's weight of 341 pounds, when the BG was 81. The nurse's aide gave her the wrong number.*

*A nurse extern came out of patient's room at the time accuchecks are performed. The nurse extern stated "211," and RN repeated "211, right?" The nurse extern was referring to the patient's daily weight, which is supposed to be performed at 7:30 a.m. The nurse covered the patient with four units of regular insulin when five minutes later nurse extern informed the RN that the patient's blood glucose level was 130.*

In a similar example reported by the Institute for Safe Medication Practices (ISMP), a nurse picked up a piece of scrap paper that listed several patients with a number next to each name.[23] All of the numbers were well above 200. Assuming the numbers were blood glucose results, she administered insulin to each patient using a sliding scale protocol. Afterward, she realized that the numbers were actually patient room numbers.

## Displays on Insulin Products on Pharmacy Labels and MARs

Most pharmacy-generated labels, both in acute care and outpatient settings, display the name and strength (i.e., concentration) of the drug on the same line. For Humalog, many labels read "Humalog 100 units/mL" on the first line, with the intended dose for the patient appearing on the line below the drug name and concentration (see Figures 4 and 5). Similarly, pharmacy-provided, computer-generated MARs and other forms of drug information display dosage strength or concentration information the same way as the label. Display of drug and dosing information in this way has led practitioners to misinterpret the drug's strength or concentration (100 units/mL) as the patient's dose. Although this issue was only apparent in 14 events reported to the Authority, it is of great concern because of the potentially large difference between the intended dose and the administered dose.

*Patient was on Lantus insulin at the nursing home. When physician was reviewing the medication orders from the nursing home, the Lantus order read "Lantus 100 units/ml vial inject 15 units sub q at bedtime." The physician misinterpreted this order to mean Lantus 100 units sub q at bedtime and ordered it as such. The patient's blood sugar was 85 [that evening], so this dose was not given, and it was subsequently decreased to 80 units. The patient did receive the 80 units the next day, and the blood sugar dropped to 52 two days later. The Lantus dose was decreased again to 40 units on the following day and was administered at bedtime. [The follow morning,] the patient arrested, and patient's blood sugar was 12.*

*The printed medication list from a previous facility indicated "Lantus 100 units/ml 15 units once a day subcutaneously at 8pm." The nurse reconciling the patient's medications misread the order as 100 units. The medications were reviewed with the physician and obtained telephone order for "Lantus 100 units SQ at hs." The nurse administering medications gave as ordered.*

*The patient's medication reconciliation form indicates that the patient takes 100 units of Lantus in addition to Januvia® and metformin. When I saw these medications ordered for [the evening dose], I questioned the patient on the amount of Lantus he takes at home. He said "15 cc." I explained that insulin comes in units. I brought him a syringe and asked how high he fills it, and he pointed to 15 units. I asked how much he had last night, and he said the nurse brought in a large syringe full of insulin. The nurse gave 100 units of Lantus last night according to the computer screen. The patient only takes 14 units at dinnertime.*

## U-500 Insulin

Most insulin products are supplied from the manufacturer in a 100 unit/mL concentration. The insulin is then administered using an insulin syringe specially designed for use with this concentration of insulin. When a patient needs a dose of 40 units, a caregiver draws the insulin to the designated 40-unit marking

on the insulin syringe. However, there is a more concentrated form of insulin that comes as a 500 unit/mL concentration.

The use of U-500 insulin has been increasing due to factors including an escalating obesity epidemic, increasing insulin resistance, growing use of insulin pumps, and rising usage of high doses for tight glucose control.[24] *However, there are no insulin syringes designed to measure doses of U-500 insulin*; therefore, healthcare practitioners are forced to prescribe, dispense, and administer U-500 insulin using insulin syringes designed for 100 units/mL insulin or other syringes marked in mL. For example, a patient using U-500 insulin with a U-100 syringe might state his dose as "40 units" because he is reading 40 units on the U-100 syringe he used to administer the insulin. However, he is actually administering 200 units of insulin because of the higher concentration. This increases the risk that a fivefold dosing error will occur when the patient communicates his dose to a healthcare practitioner. The Authority's database includes the following examples:

> *A patient was admitted on routine regular insulin, and sliding scale was ordered at admission. [On Monday, the] physician ordered that the patient may use home insulin. The pharmacist modified the insulin orders with additional signature of the patient's own medications. The order in the computer system used 100 units/mL, and the patient's actual med was Humulin R U-500 (a concentration of 500 units/mL). The regimen ordered was Humulin R 85 units before lunch, 70 units before breakfast, 95 units before supper, and 35 units [at bedtime]. Doses [Monday evening through Tuesday bedtime] may have been given using ordered volume in computer (based on 100 unit/mL) using the patient's own 500 unit/mL concentration; therefore, possibly five times the desired amount was given. The glucose reading [6 a.m. Wednesday morning] was 39 (25 mL D50W given), and repeat readings at 8:30 a.m. and 8:35 a.m. were 23 and 26 respectively (another 50 mL D50W given). The patient returned to normal blood glucose of 85 at 9:30 a.m. Wednesday after D50W administration and eating breakfast.*
>
> *U-500 insulin was prescribed as units (from a U-100 syringe) instead of volume. The patient subsequently received 1/5 of his insulin dose, and his blood sugars became excessively high.*

A case reported by ISMP involves an endocrinologist who wrote an order for 25 units of U-500 insulin to be given in the morning.[25] Nurses correctly calculated that the volume needed for a 25-unit dose of the 500 units/mL concentration was only 0.05 mL. A call was made to the physician to ask about changing to U-100 insulin for more accurate measurement. The doctor said that he actually wanted his patient to receive 125 units. He simply thought it would be easier for the nurses if he prescribed 25 units knowing that the "25 units" marking on a U-100 insulin syringe scale would actually measure 125 units when U-500 insulin was used. In another case, a physician changed a patient's insulin to U-500 and prescribed 5 units at noon and 8 units at dinnertime. As in the first case, the doctor meant for the nurses to use a U-100 syringe when preparing and administering the U-500 insulin. Thus, he intended the patient to receive 25 units at noon and 40 units at supper.[25]

Problems also arise with the vials on nursing units. One case involved a vial of U-500 insulin that was left in a nursing unit refrigerator after the patient for whom it was prescribed went home.[26] While looking for regular insulin in the refrigerator, a nurse saw the familiar brand name, Humulin R (regular insulin) but did not notice the U-500 concentration. She drew the prescribed dose into a U-100 insulin syringe and administered it. Luckily, another nurse saw the vial that was used and noticed that the U-500 insulin was given in error—a fivefold overdose.

**Figure 4. Section of an MAR Listing Insulin Name with Concentration of 100 Units/mL on the Same Line**

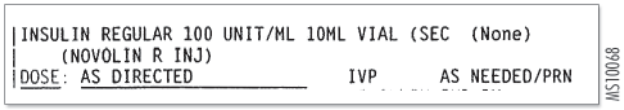


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**Figure 5. Outpatient/Community Pharmacy Label Listing Insulin and Concentration of 100 Units/mL on the Same Line**

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## Risk Reduction Strategies

Organizations should strive to identify system-based causes of errors with the use of both insulin vials and insulin pen devices and implement effective types of error reduction strategies. Error reduction strategies such as constraints and standardization, which are more powerful because they focus on systems, will be more effective than education alone, which relies on individual performance and will likely be ineffective when used alone.

### Constraints

Organizations should use strategies that lessen the chance of harm with the use of insulin. For example, an organization could attempt to reduce or limit the variety of insulin products on its formulary.[27] In addition, organizations could remove patient-specific insulin vials, including U-500 insulin, from patient care areas upon patient discharge.

### Standardization

Many strategies that could prevent harm with the use of insulin could be addressed by simplifying and

standardizing the many processes surrounding its use. They include the following:

- Standardize and simplify orders for insulin. [28]
  - — Develop standardized protocols and a standard format for prescribing insulin, preferably using preprinted order forms or electronic order sets that list specific products, ingredients, and component ratios.[29]
  - — Include generic names for insulin products on protocols, computer screens, MARs, and labels, when possible, to reduce confusion between brand names.[29]
  - — Establish a standardized algorithm within the organization for the dosing of insulin when providing coverage with meals.
  - — Avoid the use of abbreviations or other shortcuts when communicating orders for insulin. Use the complete word "units" when expressing doses and concentrations of insulin.[28] Do not use the abbreviation "U." In addition, do not use "SSRI" as an abbreviation for sliding-scale regular insulin, because it has been misinterpreted as selective serotonin-reuptake inhibitor.[29]
  - — Use a single, standard concentration for adult IV insulin infusions. If a nonstandard insulin concentration is needed, list the concentration and the patient's dose in units and volume.[29]
  - — Establish a plan for treating hypoglycemia for each patient. Track all episodes of hypoglycemia in the hospital.[30]
- Safely store and dispense insulin.[28]
  - — Do not keep insulin vials on top of medication carts or counters or under pharmacy compounding hoods, as insulin could be confused with heparin, which also is measured in units. Put all insulin back in the appropriate storage area immediately after use.[28]
  - — Separate insulin products from one another in refrigerators (i.e., avoid storing multiple types of insulin together in a single bin). Consider using visual clues, such as affixing a photo to the bin of the vial that should be stored there, to help ensure that the correct vial is returned to the correct bin.

## Differentiate

Employ strategies to distinguish or make insulin products different in appearance, such as the following:

- Have pharmacy prepare and dispense prefilled syringes for once daily doses of long-acting insulin (e.g., insulin glargine).[28]
- Emphasize the word "mixture" or "mix," along with the name of the insulin product mixtures, for drug selection screens.[29]
- Use tall man lettering in order-entry screens, medication administration records (MAR) and pharmacy labeling (e.g. NovoLOG, NovoLIN, HumaLOG, HumaLIN).
- Apply bold labels on atypical insulin concentrations.[27]

## Redundancies

For example, require an independent double check of all doses before dispensing and administering IV insulin. Build the double check into daily work processes so it can be accomplished without disruption.[28]

## Education and Information

Education and information strategies include the following:

- Provide staff with ongoing education about insulin products and methods of delivery.[28]
- Prepare a chart that lists all insulin products used in your facility. Include generic and brand names; concentration; onset, peak, and duration of action; acceptable routes of administration; time of administration in relationship to meals; appropriate drug delivery devices; and special precautions (e.g., measuring the proper dose, mixing instructions, more frequent patient glucose monitoring). Pictures of the boxes in which insulin is packaged also would be helpful. Post the charts in areas where insulin is prescribed, dispensed, and administered.[28]
- Check MARs and pharmacy labels to identify truncated information about insulin products and take steps to clarify important drug information as needed.[31] Work with vendors to modify the appearance of MAR/eMAR and pharmacy labeling entries so that the wording is congruent with how medications will be administered (e.g., 10 units) rather than how they are supplied (e.g., 100 units/mL)[28]

## Monitoring of Adverse Events

Historically, measurement efforts have focused on practitioner reporting of medication errors, which, at best, uncovers just a fraction of the errors, most of them harmless.[32] Consider measures other than practitioner reporting of medication errors to evaluate your organization's safe use of insulin, including the following examples:

- Assess core processes associated with insulin use by using process measures.
- Obtain outcome measures by evaluating patient records using a list of triggers is the most effective means of collecting data on adverse drug events.

(Visit the Authority's Web site at http://patientsafetyauthority.org/EducationalTools/PatientSafetyTools/Pages/home.aspx to view or download a sample tool that can be used to identify and monitor actual or potential problems with the use of insulin.)

## U-500 Insulin Strategies

Strategies unique to the use of U-500 insulin include the following:

- Ensure consistent use of a tuberculin syringe with U-500 insulin, with total doses expressed in terms of both units and volume (e.g., 200 units [0.4 mL]).[33]
- Establish a practice to have pharmacy draw up and dispense the ordered dose of U-500 insulin with a second individual (e.g., nurse, technician) performing an independent check of the vial, syringe, and contents.[25]

## Beside Blood Glucose Monitoring

Organizations must determine the safest way to receive, document, communicate, and verify glucose meter readings. Sample strategies include the following:

- Nurses need to know patient's blood glucose level before administering insulin. A flow sheet for recording each dose of medication and corresponding lab values allows nurses to review previously administered doses and track the patient's overall response to therapy.[34]
- Require nursing assistants to write the patient's blood sugar on the MAR so the nurse can give the correct amount of insulin.[23]
- Discourage verbal communication of blood glucose results.

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## Self-Assessment Questions

The following questions about this article may be useful for internal education and assessment. You may use the following examples or come up with your own.

1. What is the most common type of reported medication error associated with the use of insulin?
   a. Wrong drug
   b. Wrong dose/overdosage
   c. Dose omission
   d. Extra dose
   e. Wrong dose/underdosage
2. Breakdowns or errors that lead to reported wrong-dose medication errors associated with insulin include all of the following EXCEPT:
   a. Use of insulin coverage orders
   b. Ambiguous orders written by prescribers
   c. Inaccuracies when obtaining and/or using a patient's blood glucose value
   d. Errors when transcribing and entering orders into a computer system
   e. Use of a standardized protocol or order form to order insulin
3. Which of the following statements about the reported wrong-drugs errors associated with insulin products is INACCURATE?
   a. A majority of the submitted wrong-drug reports did not list a specific insulin product or listed names of products that do not exist.
   b. Wrong-drug insulin errors included breakdowns that occurred when retrieving the medication from stock or an automated dispensing cabinet.
   c. Most of the submitted reports that occurred during the prescribing phase involved the clarification of non-specific orders (i.e., a specific insulin product was not indicated).
   d. The most common type of wrong-drug errors involving insulin occurred when insulin vials were mislabeled in the pharmacy.
   e. Most of the wrong-drug errors involving infusion bags containing insulin reached the patient.
4. All of the following strategies can be used to prevent errors with the use of insulin EXCEPT:
   a. Limiting the variety of insulin products on an organization's formulary
   b. Establishing a standardized algorithm for dosing insulin when providing coverage with meals
   c. Using multiple, patient-specific concentrations for adult IV insulin infusions
   d. Having pharmacy prepare and dispense prefilled syringes for once-daily doses of long-acting insulin
   e. Requiring an independent double check of all doses of insulin before dispensing and administering IV insulin infusions
5. Which of the following statements about concentration and U-500 insulin is INACCURATE?
   a. The use of U-500 insulin has been increasing due to factors including an escalating obesity epidemic, increasing insulin resistance, growing use of insulin pumps, and rising usage of high doses for tight glucose control.
   b. Prescribe U-500 insulin in units based on a U-100 syringe.
   c. There are no insulin syringes designed to measure doses of U-500 insulin.
   d. Use tuberculin syringes when administering U-500 insulin, with total doses expressed in terms of both units and volume (e.g., 150 units [0.3 mL]).
   e. Establish a practice to have pharmacy draw up and dispense ordered doses of U-500 insulin.
6. A physician wrote an order for a patient to "decrease Lantus insulin to 8 u qd," but the order was transcribed as 80 units. The medication was administered as transcribed, and the patient's blood sugars were documented as 40 mg/dl.

   Predict which of the following strategies would NOT help prevent this event from reoccurring.
   a. Develop a standard format for prescribing insulin, preferably using preprinted order forms or electronic order sets that list specific products, ingredients, and component ratios.
   b. Avoid the use of abbreviations or other shortcuts when communicating orders for insulin.
   c. Use tall man lettering in order-entry screens, medication administration records, and pharmacy labeling.
   d. Require an independent double check of all doses before dispensing and administering IV insulin.
   e. None of the above.

# PENNSYLVANIA PATIENT SAFETY ADVISORY

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An Independent Agency of the Commonwealth of Pennsylvania

The Pennsylvania Patient Safety Authority is an independent state agency created by Act 13 of 2002, the Medical Care Availability and Reduction of Error ("Mcare") Act. Consistent with Act 13, ECRI Institute, as contractor for the Authority, is issuing this publication to advise medical facilities of immediate changes that can be instituted to reduce Serious Events and Incidents. For more information about the Pennsylvania Patient Safety Authority, see the Authority's Web site at http://www.patientsafetyauthority.org.

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