**ABSTRACT**

A patient’s weight is important information because it is often used to calculate the appropriate medication dose. When medication errors arise due to inaccurate or unknown patient weights, the dose of a prescribed medication could be significantly different from what is appropriate. Nearly 480 event reports submitted to the Pennsylvania Patient Safety Authority specifically mentioned medication errors that resulted from breakdowns during the process of obtaining, documenting, and/or communicating patient weights. Analysis reveals that 67.2% of the events reached the patient. The unit mentioned most frequently in reports was the emergency department. All the frequently mentioned medications can be dosed based on a patient’s weight (i.e., weight-based dosing), and 5 of the top 10 medications are high-alert medications. Breakdowns described in reports most frequently involved failures to obtain accurate patient weight measurements. Once a value was obtained, errors arose from misuse of that value. Examples include problems when patients arrive at a hospital and are not weighed, leading to estimates of patient weights; assumptions that documented weights are current and/or accurate; and documentation breakdowns (e.g., the patient is weighed in pounds, but the weight is erroneously documented as kilograms). Strategies to address these problems include providing all units with the necessary equipment to weigh patients, weighing every patient during triage or admission to facilities, and weighing patients and documenting patient weights only in kilograms. (Pa Patient Saf Advis 2009 Mar;6[1]:10-5.)

Patient information helps practitioners select appropriate medications, doses, and routes of administration. One vital piece of patient-specific information, the patient weight, is especially important because it is often used to calculate the appropriate dose of a medication (e.g., mg/kg, mcg/kg, mg/m²). A prescribed medication dose can differ significantly from the appropriate dose as a result of missing or inaccurate patient weights. Oncology, elderly, and pediatric/neonatal patients are at greater risk for adverse drug events because they may be more vulnerable to the effects of an error and their weight may change frequently over a short period of time. Formulas such as the Cockcroft-Gault and the Harris-Benedict formulas rely on knowledge of an accurate patient weight. Both height and weight are needed to use nomograms to determine body surface area and body mass index.

**A Look at the Numbers**

There is little information in the literature that specifically mentions medication errors that result from missing or inaccurate patient weights. One prospective, cohort study of 1,120 patients in two academic institutions revealed that 3.7% of the institutions’ medication errors were due to missing or wrong weights.

Clinical analysts reviewed 479 event reports submitted to the Pennsylvania Patient Safety Authority from June 2004 through the end of November 2008 that specifically mentioned medication errors resulting from breakdowns in the process of obtaining, documenting, and/or communicating patient weights. Further breakdown of these events by harm score, which is adapted from the National Coordinating Council for Medication Error Reporting and Prevention harm index, shows that 67.2% (322) of the events reached the patient (harm index = C to I) and 1.3% (6) of the events resulted in harm significant enough to require additional treatment.

Of the 479 reports, 448 (93.5%) represent the five most common medication error event types, with the most commonly reported event type being wrong dose/over dosage (43.4%) and wrong dose/under dosage (21.3%) (see Table 1).

Table 2 lists events by the top five units in which the event occurred, representing 54% of all reports. The top three units associated with these errors include the emergency department (ED) (20.7%), pharmacy (12.1%), and medical/surgical units (10.9%). A national survey of EDs shows that more than 50% of all patients admitted to a hospital came through the ED. When looking at all the patients in the ED, 12% are admitted to hospitals and 1.3% are admitted directly to an intensive care unit (ICU) setting. Therefore, medication errors that occur because of wrong patient weight may perpetuate throughout a patient’s stay in a healthcare facility, if it is assumed that the weight originally obtained and documented by the ED is accurate.

A review of the medications commonly reported reveals two key attributes. First, all the medications

### Table 1. Top Five Medication Error Event Types Associated with Wrong Weights (n = 448)

<table>
<thead>
<tr>
<th>EVENT TYPE</th>
<th>TOTAL</th>
<th>% OF TOTAL REPORTS (N=479)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wrong dose/overdosage</td>
<td>208</td>
<td>43.4%</td>
</tr>
<tr>
<td>Wrong dose/underdosage</td>
<td>102</td>
<td>21.3%</td>
</tr>
<tr>
<td>Wrong rate (intravenous)</td>
<td>47</td>
<td>9.8%</td>
</tr>
<tr>
<td>Extra dose</td>
<td>12</td>
<td>2.5%</td>
</tr>
<tr>
<td>Other</td>
<td>79</td>
<td>16.5%</td>
</tr>
</tbody>
</table>
(see Table 3) can be dosed based on a patient’s weight (i.e., weight-based dosing). Second, 5 of the top 10 medications involved, representing 236 (49%) of all reports, are high-alert medications. High-alert medications are drugs that bear a heightened risk of causing significant patient harm when they are used in error.6

Further Analysis

The second step in the analysis process included a review of each report’s description of the event to determine what specifically went wrong in these reports. The types of errors observed in the data are discussed in Table 4.

Two general themes appeared in this analysis: (1) breakdowns in obtaining an accurate, up-to-date patient weight, and (2) errors that arise from misusing the value.

Obtaining Patient Weights

A variety of problems can occur when healthcare practitioners attempt to obtain a patient’s weight. One such problem occurs at the beginning of the patient encounter. There are times when patients arriving at hospitals may not be weighed; for example, if a patient is admitted for an emergency, is not ambulant, or is unable to communicate his or her weight. Care units may also not be provided with appropriate scales to weigh patients. These situations lead to healthcare practitioners estimating patient’s weights. According to published studies, estimating weights is inexact.7-10 Additional examples include the following studies.

In one prospective clinical study in a mixed medical and surgical ICU, 14 patients had their height and weight estimated by 20 members of the medical and nursing staff, and the estimates were compared to the patients’ actual weight. The study results showed that staff members’ estimation of weight was poor, with 47% of estimates at least 10% different and 19% of the estimates were at least 20% different from the measured weights.11

Another prospective study of adult patients presenting to an urban ED assessed the accuracy of estimations of patients’ weight by the patients themselves, physicians, and nurses in the ED. The authors found that weight was estimated within 10% of actual weight by 90.6% of the patients, 50.4% of the physicians, and 49.6% of the nurses. The authors concluded that when a patient is unable to be weighed, the patient’s own weight estimate should be used.12

In a third prospective, descriptive study of trauma patients, healthcare practitioners (physicians, trauma residents, and trauma bay nurses) estimated patients’ weights. Patients were then asked to report a value for their own height and weight estimates. Overall, practitioners were 53% correct in estimating patient weights. Patients were more frequently accurate (92%) about their own weight.13

Practitioners in Pennsylvania facilities are no different than their colleagues in other states, as reports

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| Table 2. Units Commonly Involved in Medication Errors Involving Wrong Weights (n = 259) |
|-------------------------------------|---------------------|-----------------|
| **DEPARTMENT** | **TOTAL** | **% OF TOTAL REPORTS (N = 479)** |
| Emergency department | 99 | 20.7% |
| Pharmacy | 58 | 12.1% |
| Medical/surgical unit | 52 | 10.9% |
| Telemetry | 27 | 5.6% |
| Pediatric unit | 23 | 4.8% |

| Table 3. Top 10 Medications Involved in Wrong-Weight Medication Error Reports (n = 304) |
|-----------------------------------------------|-----------------|
| **MEDICATION** | **TOTAL** |
| Heparin sodium* | 110 |
| Enoxaparin (Lovenox®)* | 84 |
| Acetaminophen (Tylenol®) | 20 |
| Dobutamine* | 17 |
| Dopamine* | 17 |
| Gentamicin sulfate | 17 |
| Vancomycin | 14 |
| Ibuprofen (Motrin®) | 9 |
| Nesiritide (Natrecor®) | 8 |
| Propofol (Diprivan®)* | 8 |

* High-alert medications

| Table 4. Types of Errors Involving Wrong Weight (n = 479) |
|---------------------------------|-----------------|
| **CATEGORIES** | **TOTAL** | **% OF TOTAL REPORTS** |
| Confusion between pounds versus kilograms | 129 | 26.9% |
| Documented weight was too high | 83 | 17.3% |
| Documented weight was too low | 48 | 10% |
| No weight was available or used | 45 | 9.4% |
| Incorrect estimated weight | 17 | 3.5% |
| Mix-up between ideal versus actual weight | 11 | 2.3% |
| Calculation error | 6 | 1.3% |
| Mix-up between height/temperature versus weight | 4 | 0.8% |
| Others | 10 | 2.1% |
| Unknown* | 126 | 26.3% |

* There was not enough information mentioned in the report to determine what went wrong.
submitted to the Authority describe events in which practitioners have inaccurately estimated patient’s weights.

The patient’s heparin infusion was started based on a patient weight of 80 lb. The actual weight of the patient was 162 lb. The patient was never weighed prior to starting the weight-based heparin nomogram.

A patient presented to the ED after having taken an overdose of Tylenol PM. The patient’s initial acetaminophen level (about 100) and an acetylcysteine (Mucomyst®) infusion was ordered based on the established pharmacy protocol. The amount of medication infused is based on the patient’s weight. An initial weight was given to the pharmacist and the infusion prepared. When the patient reached the floor and was actually weighed, [his or her] weight was found to be 23 kg less than originally stated. The pharmacist was notified, and the infusion rate adjusted based on this knowledge.

A report was given to ICU nurse from the ED. The ED nurse said the patient’s weight was 189 kg. This weight was only documented in [the computer system] under the Diprivan® (propofol) medication calculation. Due to patient weight, a bariatric bed was ordered but not available upon transfer. The patient remained on the ED stretcher in the ICU until a bariatric bed arrived. Upon transfer to the bariatric bed, the patient’s weight was confirmed at 250 lb and not 419 lb. The patient was on propofol and heparin protocols per weight. Pharmacy was notified so that heparin protocol could be changed. The propofol was adjusted with the new weight. According to the ED, the patient’s weight was an estimate because the ED could not weigh the patient prior to administration of the medications. The ED communicated to the ICU the patient’s weight on previous admissions. The physician estimated the weight for the infusions. The patient was unable to be weighed due to [his or her] critical status to stand on scale in ED. The ED does not have the capability to weigh patients on a bed.

Patient’s initial weight was estimated at 114 kg, due to difficulty ambulating. Heparin protocol was started at that time. After the patient arrived to the floor, [personnel] were able to weigh [the patient, whose] weight was recorded as 91 kg. Heparin rate adjusted appropriately.

Another problem arises when practitioners assume a documented weight is up-to-date and/or accurate. For example, when patients are transferred from facility to facility or within a facility between units, practitioners often assume that the weight documented in the medical record is accurate and up-to-date. They then decide that there is no need to reweigh the patient. One such scenario was reported to the Authority.

A patient was admitted through the emergency room. The demographic sheet obtained from the nursing home, which was used to determine the patient’s weight, listed [the weight] at 253 lb. The patient’s actual weight was 162 lb. Heparin was administered via drip based on 253 lb. The error was corrected based on correct weight of patient.

Although there are studies that show that a patient’s own weight estimate can be more accurate than a healthcare practitioner’s, problems can occur when solely relying on a patient’s stated weight. One example reported to the Institute for Safe Medication Practices (ISMP) involved an ED patient with deep vein thrombosis who purposely understated her weight as 160 lb because she did not want her husband to know that she actually weighed 180 lb. A short time later, a pharmacist working in the unit asked the patient to step on a scale and an error was averted.

While a 20 lb difference in an adult may not cause a problem, larger discrepancies between a patient’s stated weight and a measured weight have been reported to ISMP (up to 100 pounds).14

Finally, the patient’s weight may not be communicated to appropriate healthcare practitioners. For example, the weight, especially an accurate weight, may not be provided to pharmacy, either on paper or electronically, to calculate or double check weight-based drug doses. In a survey performed by ISMP and the Pediatric Pharmacy Advocacy Group to determine what medication safety practices were in place for pediatric patients in both critical care and noncritical care units, only about half of all respondents reported that the patient’s weight is always entered into the computer before processing orders to allow the system to warn practitioners about drug doses that exceed safe limits.15

Errors with Documenting Weights

Most patients are weighed in pounds, both in their home and in the healthcare organization. But weighing and documenting patients’ weights in pounds introduces the need to then calculate the weight into kilograms, an error-prone process,16 for weight-based and other dosing. However, the greater problem is obtaining the weight in pounds then failing to convert and document that weight in kilograms, resulting in more than two-fold dosing errors. In fact, more than 25% of the 479 reports mention breakdowns that occurred when the patient’s weight, measured in pounds or kilograms, was erroneously documented as the patient’s weight in kilograms or pounds, respectively. Reports submitted to the Authority illustrate that this can occur with weights documented in a paper-based patient record or computerized order-entry systems, as well as weights entered into infusion pumps.

A patient’s weight was inaccurately reported to the pharmacy using pounds instead of kilograms. The dosage for daptomycin was incorrectly calculated, and the patient received three times the ordered dose.

Patient was ordered dobutamine to infuse at 3 mcg/kg/min. The physician ordered an increase in dobutamine to infuse at 5 mcg/kg/min or 8.9 mL/hr. The intravenous line (IV) was found infusing at 11.8 mL/hr when the nurse went to change rate.
Another nurse did not convert the patient’s weight from pounds to kilograms.

A patient’s weight was estimated at approximately 180 lb. The nurse did not convert the pounds into kilograms when drawing up the Lovenox® injection. The nurse administered 180 mg of Lovenox.

A patient in the ED was ordered “fosphenytoin IV stat” for breakthrough seizures. The resident entered the patient’s weight into the CPOE [computerized prescriber order entry] system in pounds instead of kilograms (44 lb versus 20 kg). The patient received an overdose of the medication that resulted in toxicity.

Upon checking IV pump settings, both the weight and kilograms were incorrectly programmed into pump. The infusion pump was set at 180 kg instead of 180 lb. Once the correct weight was programmed into the pump, the dose of dopamine was decreased, which decreased patient’s blood pressure, resulting in need to increase dopamine and increase monitoring.

Ideal versus Actual Body Weight

A third, less frequently reported error involving patient weights is the inappropriate use of either ideal body weight or actual body weight given the patient’s condition or specific medication. For certain types of patients, medications may be dosed on an ideal body weight instead of an actual body weight. For example, if a patient is dehydrated, his or her actual weight will be lower than his or her ideal body weight, and conversely, a patient who is obese will have an actual body weight that is greater than his or her ideal body weight. Examples reported to the Authority include the following:

Patient was started on a heparin infusion per protocol. A partial thromboplastin time (PTT) level came back from the lab at high panic [greater than] 249. According to protocol, the heparin infusion was stopped for three hours and another PTT drawn. When the second PTT results were reported, the infusion was recalculated and the original calculations were noted to have been made using ideal body weight, when actual body weight should have been used in this case (the actual body weight in this patient was less than ideal body weight). New drip calculations were done and verified with pharmacy, as well as another registered nurse on the unit.

The physician ordered “acyclovir 2 gm IV” based on patient’s actual weight of 98 kg. The standard dosing is for this medication is 10 to 15 mg/kg, based on the ideal body weight [emphasis added]. The patient’s ideal body weight was estimated at 70 kg. The pharmacy did not clarify the high dose order with the physician.

Document Weights

For weight documentation, consider the following:

- Review all locations that allow for the entry of patient weights, including printed order forms, computerized order-entry systems (both physician and pharmacy), and infusion pumps.
- Require an entry of weight in computer systems for pediatric patients (as well as weight-based medication) before processing orders. Establish a communication process that facilitates the timely transfer of accurate patient weights from nursing to the pharmacy.
- Build a hard stop for patient weight into CPOE and pharmacy order entry systems. At a minimum, configure the systems to alert staff if the field is empty. Until this is a required field, print a daily report of missing information for follow-up by pharmacy staff.
- Build and test maximum and subtherapeutic dose alerts in the order entry system (based on patient age and weight when applicable).
- When recording a patient’s weight, include the date. This can help other practitioners recognize older weights and prompt them to reweigh the patient.

Communicate Drug Orders

The organization’s medication-use policies should include a provision that weight-based medications are not prescribed, dispensed, or administered (except in emergencies) unless weights are available to and considered by all practitioners.

In a study to evaluate preprinted order forms, a form was designed to guide prescribers through the process of handwriting a complete inpatient prescription by using forcing functions. To assess the effectiveness of this intervention, medication prescriptions were collected for two weeks before and after introduction
of the new forms and evaluated for compliance with medication prescription guidelines. The introduction of this form increased the inclusion of a patient weight from 57% to 98%.18 Therefore, for weight-based therapy, consider adding prompts on standard order forms to communicate the patient’s weight.19

Prescribers need to confirm that the patient’s weight is correct for weight-based dosages and write the weight on each order written.2 Where appropriate, prescribers should include the weight of the patient on the prescription or medication order. The age (and weight) of a patient can help dispensing healthcare professionals in their clinical double-check of the appropriate drug and dose.20 Prescribers should include the calculated dose and the dosing determination, such as the dose per weight (e.g., milligrams per kilogram) or body surface area, to facilitate an independent double-check of the calculation by a pharmacist, nurse, or both.

Notes


15. Institute for Safe Medication Practice. Hospital survey shows much more needs to be done to protect pediatric patients from medication errors. ISMP Med Saf Alert 2000 April 19;5(8):1-3.


(See Self-Assessment Questions on next page.)
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. Which medication was not involved in medication errors, reported to the Authority, associated with inaccurate patient weights?
   a. Dobutamine
   b. Acetaminophen
   c. Heparin
   d. Cefazolin

2. Which area was associated with the highest number of reports related to inaccurate patient weights?
   a. Pediatric unit
   b. Medical/surgical unit
   c. Emergency department (ED)
   d. Pharmacy

3. All of the following statements about patient weights are true EXCEPT:
   a. Patient weight is important because it is often used to calculate the appropriate dose of a medication.
   b. A prescribed medication dose can differ significantly from the intended dose as a result of missing or inaccurate patient weights.
   c. Oncology, elderly, and pediatric/neonatal patient populations are at an increased risk for adverse drug events because they are vulnerable to the effects of an error.
   d. Formulas such as the Cockcroft-Gault and the Harris-Benedict formulas rely on knowledge of an accurate patient age.

4. All of the following are risk reduction strategies to prevent errors due to inaccurate weights EXCEPT:
   a. Making kilograms the standard nomenclature for weight on prescriptions, medical records, and staff communications
   b. Obtaining and documenting the patient weight in pounds
   c. Confirming that the patient’s weight is correct for weight-based dosages and writing the weight on each order
   d. Making patient weights a required field (i.e., hard stop) in computerized prescriber order-entry and pharmacy order-entry systems

5. A patient was transferred from another facility to the ED and was admitted to the hospital with a diagnosis of deep vein embolism. A weight-based heparin infusion protocol was initiated in the patient care area.

   What would be the best approach to dosing this patient, based on his or her weight?
   a. Weigh the patient.
   b. Refer to the weight provided by the previous facility.
   c. Refer to the weight documented in the ED.
   d. Estimate the weight of the patient.
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THE PENNSYLVANIA PATIENT SAFETY AUTHORITY AND ITS CONTRACTORS

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The Institute for Safe Medication Practices (ISMP) is an independent, nonprofit organization dedicated solely to medication error prevention and safe medication use. ISMP provides recommendations for the safe use of medications to the healthcare community including healthcare professionals, government agencies, accrediting organizations, and consumers. ISMP’s efforts are built on a nonpunitive approach and systems-based solutions.