



## Update on Medication Errors Associated with Incorrect Patient Weights

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### ABSTRACT

Healthcare practitioners require a current, accurate patient weight because weight is often used to determine an appropriate medication dose. When errors occur during the process of obtaining, documenting, and communicating and using a patient's weight, the dose of a medication can be dangerously incorrect. Analysts reviewed event reports relating to patient weight submitted to the Pennsylvania Patient Safety Authority through the Pennsylvania Patient Safety Reporting System from December 2008 through November 2015. Of the 1,291 event reports related to patient weights, the majority of errors reached the patient (74.8%,  $n = 966$ ) and the most common factors involved were documented weight too high (23.8%,  $n = 307$ ), confusion between pounds and kilograms (23.2%,  $n = 300$ ), and documented weight too low (14.9%,  $n = 192$ ). Important risk-reduction strategies include obtaining a current, accurate weight instead of relying on a historical, stated, or estimated weight; and obtaining, documenting, and communicating patient weights in metric units only (i.e., grams or kilograms). (*Pa Patient Saf Advis* 2016 Jun;13[2]:50-57.)

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### INTRODUCTION

Healthcare practitioner access to key patient information is an essential element of the medication use process.<sup>1</sup> Key patient information used to guide appropriate medication therapy includes age, weight, height, allergies, diagnoses, laboratory values, and vital signs.<sup>1</sup> A 1995 study indicated that inadequate availability of patient information during medication prescribing, dispensing, and administration was associated with nearly one-fifth (18%) of identified errors.<sup>2</sup>

Determining the appropriate dose of many medications requires an accurate patient weight. Numerous medications are dosed on units of weight (e.g., mg/kg, mcg/kg/min). Other medications are dosed by body surface area (BSA; e.g., mg/m<sup>2</sup>), which incorporates a patient's weight. Additionally, various medications require dosage adjustments based on renal function, using creatinine clearance (CrCl) as determined by a formula (e.g., the Cockcroft-Gault formula) that requires an accurate patient weight.<sup>3</sup> A missing or inaccurate patient weight can cause a prescribed medication dose to be significantly different from the appropriate dose and negatively impact patient outcome.<sup>3,5</sup>

A previous review of events reported to the Pennsylvania Patient Safety Authority through its Pennsylvania Patient Safety Reporting System (PA-PSRS) identified a variety of problems related to obtaining and documenting accurate patient weights.<sup>6</sup> A 2014 ECRI Institute report on weight-based medication dosing errors reported to the ECRI Patient Safety Organization (PSO) from September 2012 through August 2013 indicates that organizations continue to struggle with obtaining and documenting accurate patient weights.<sup>7</sup> It appears that medication errors related to the process of obtaining and documenting patient weight continue in spite of recommendations from multiple organizations designed to reduce errors associated with patient weight.<sup>8-13</sup> As such, analysis was performed on weight-related events reported to the Authority since its 2009 analysis.

### METHODS

Analysts reviewing events reported to the Authority through PA-PSRS can classify reports using a monitor code for future query opportunities. Analysts searched the PA-PSRS database for reports of medication errors tagged as weight-related, and "Other" event type reports that were weight related, submitted to the Authority from December 2008 through November 2015. These queries yielded 1,167 and 154 reports, respectively, for a sum of 1,321 reports.

The medication name, patient care area, event type, event description, and harm score, adapted from the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) harm index,<sup>14</sup> were provided by the reporting facility. When a medication name data field was left blank or incomplete but the name was provided in the event description, an analyst adjusted the medication name field. Reports were evaluated to first verify that the event was related to patient weight and then determine what factors were associated with the event. Reports were categorized into type of error (e.g., confusion between pound [lb] and kilogram [kg], incorrect estimated weight) based on analysis of the event description. Analysts could assign multiple types of error for each report, based on the event description. Analysts identified reports involving high-alert medications, based on the *ISMP List of High-Alert Medications in Acute Care Settings*.<sup>15</sup> Roughly 3% ( $n = 30$ ) of the reports were excluded from final analysis because they had been submitted more than once ( $n = 7$ ) or the event was not related to patient weight ( $n = 23$ ). Consequently, 1,291 event reports were included in the final analysis.

## RESULTS

Based on harm score, almost three-fourths (74.8%, n = 966) of events reached the patient (harm score = C through I) and 0.9% (n = 11) resulted in patient harm (harm score E through I; see Figure 1). Almost one-third (30.7%, n = 396) of events required patient monitoring or intervention to preclude harm (harm score D). A majority (8 of 11) of the events with patient harm involved high-alert medications.

Emergency departments (EDs; 29.4%, n = 379) were the most frequently involved care area. When totaled, a variety of intensive care units (ICUs) comprised 15.9% (n = 205) of care areas involved. Figure 2 shows the most commonly reported specific patient-care areas, encompassing 65% (n = 839) of events.

More than one-quarter of events involved pediatric patients (age younger than 18 years; 26.3%, n = 340) and 38% (n = 490) of events involved elderly patients (65 years of age or older). However, only 1 of the 11 harm events (9.1%) involved a pediatric patient.

Figure 3 shows the medications most commonly reported to be involved in the events. The top 10 medications were involved in 63.7% (n = 823) of event reports. Two anticoagulants, heparin (29.7%, n = 383) and enoxaparin (8.6%, n = 111), were involved in almost two-fifths (38.3%, n = 494) of events. In the entire dataset, more than half (59.3%, n = 765) of the events involved a high-alert medication. The specific medication involved could not be determined in nearly 10% (9.6%, n = 124) of reports.

When evaluating event types as reported by facilities, the five most common event types accounted for 94.4% (n = 1,219) of the events (see Table). Wrong dose/over dosage events represented the most commonly reported event type, comprising 42.2% (n = 545) of all reports.

Figure 1. Harm Scores for Events Involving Incorrect Patient Weights, as reported to the Pennsylvania Patient Safety Authority, December 2008 through November 2015 (N = 1,291)

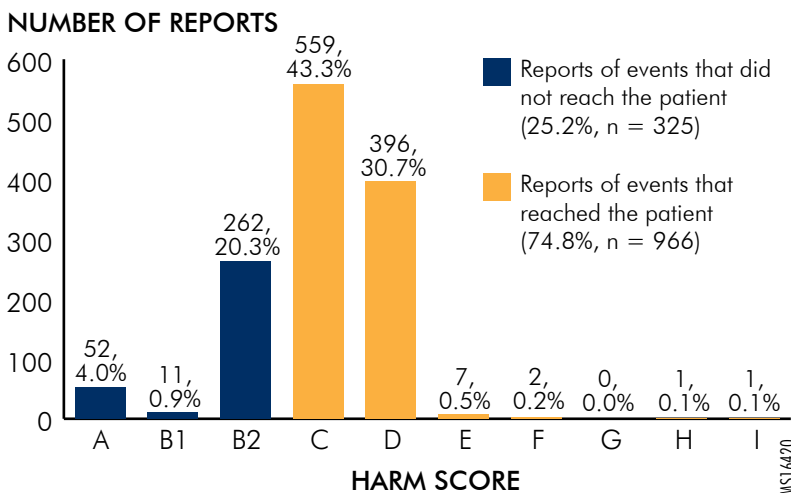
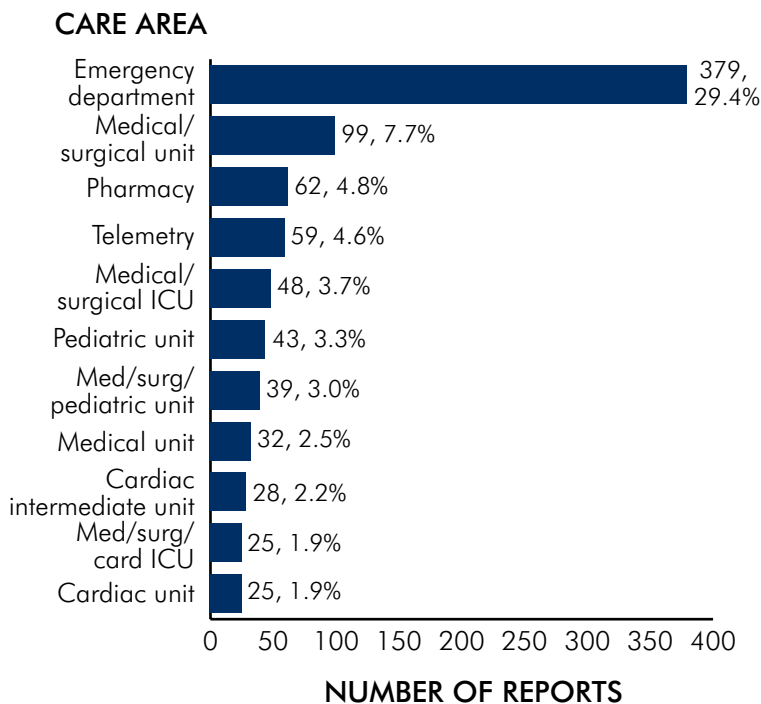
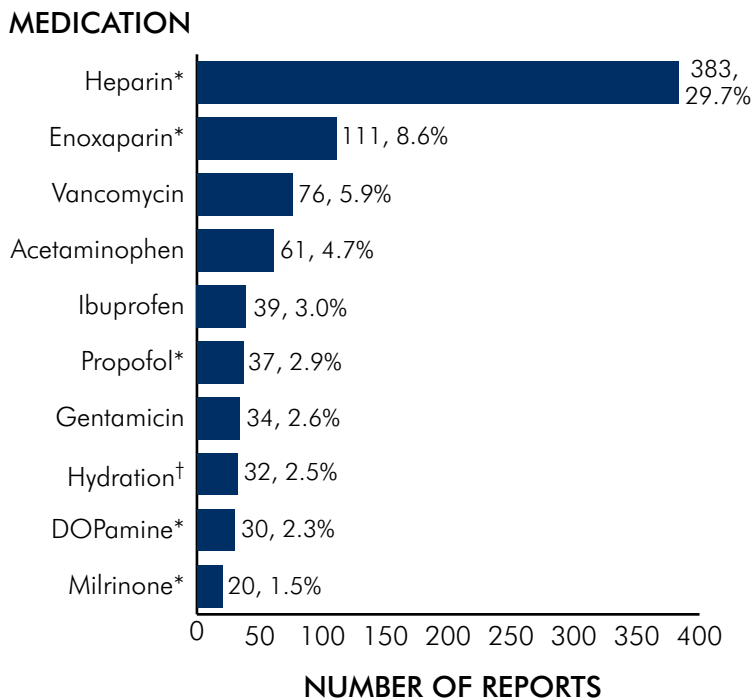


Figure 2. Care Areas Most Commonly Reported in Events Involving Incorrect Patient Weights, as reported to the Pennsylvania Patient Safety Authority, December 2008 through November 2015 (N = 1,291)



**Figure 3. Most Common Medications involved in Events related to Incorrect Patient Weights, as reported to the Pennsylvania Patient Safety Authority, December 2008 through November 2015 (N = 1,291)**



\* High-alert medication

† Represents intravenous replacement and maintenance fluids (e.g., lactated Ringer, normal saline, dextrose with saline solutions)

Table. Medication Error Event Types Associated with Events Involving Incorrect Patient Weights, as Reported to the Pennsylvania Patient Safety Authority, December 2008 through November 2015 (N = 1,291)

EVENT TYPE	NO. OF REPORTS	%*
Wrong dose/over dosage	545	42.2
Other	223	17.3
Wrong dose/under dosage	215	16.7
Wrong rate (intravenous)	182	14.1
Monitoring error	54	4.2
All other event types	72	5.6

\* Total is greater than 100% because of rounding

Analysis revealed several factors, or types of errors, associated with medication errors involving patient weight (see Figure 4). The three most commonly identified factors,

documented weight too high (23.8%, n = 307), confusion between pounds and kilograms (23.2%, n = 300), and documented weight too low (14.9%, n = 192)

were found in more than 60% (n = 799) of event reports. Analysts were unable to determine a contributing factor in 18.5% (n = 239) of events.

The following are examples of events in which the documented weight was too high.\*

*A premature infant was ordered 1mEq/kg of potassium chloride as a replacement dose for a K [potassium] value of 2.5. Patient's weight is 0.58 kg. The nurse incorrectly changed the dosing weight from 0.58 to 6 kg [increasing the documented weight by a factor of 10]. Within the same minute, she realized the error and changed the weight back [to the correct value]. Pharmacy dispensed the medication (14.4 mL or 6 mEq) based on the [incorrect weight value (approximately a 10-fold error)] and the medication was administered. A double check was completed prior to administration. During the administration, the patient developed bradycardia and was successfully resuscitated. Potassium chloride administration was stopped during resuscitation. Later in the day, pharmacy discovered that the dose sent was based on a 6 kg weight that was in their EMR [electronic medical record] system.*

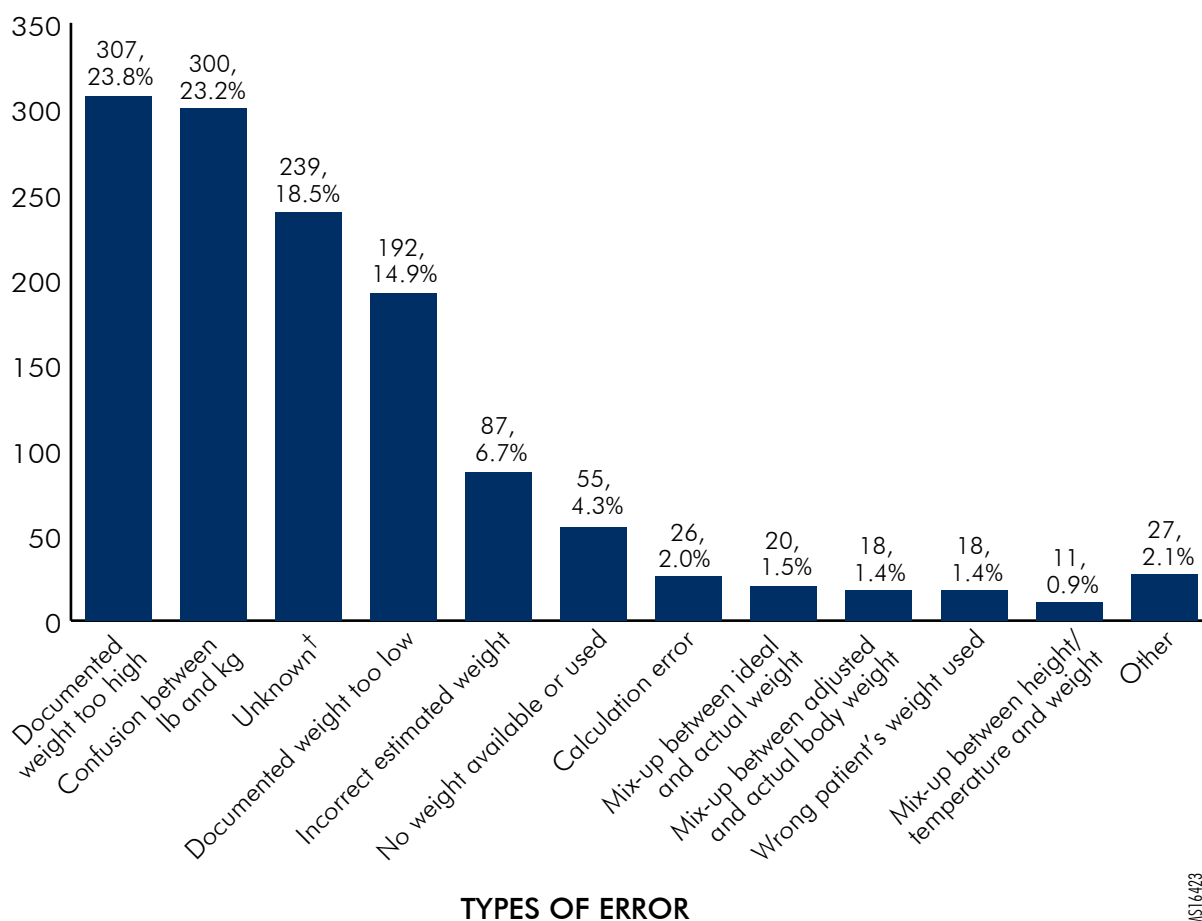
*A patient was dosed milrinone based on an incorrect weight of 400 kg. The patient's actual weight is 114 kg. The patient subsequently developed short runs of ventricular tachycardia and hypotension. He became symptomatic with complaints of fatigue and lightheadedness. The milrinone was stopped and the patient was treated with norepinephrine and stabilized.*

*A pediatric patient was written an order for fentaNYL 1 mcg/kg/dose.*

\* The details of the PA-PSRS event narratives in this article have been modified to preserve confidentiality.

Figure 4. Types of Error Involving Incorrect Patient Weights, as identified in Reports Submitted to the Pennsylvania Patient Safety Authority, December 2008 through November 2015 (N = 1,291)\*

### NUMBER OF REPORTS



MS16423

\* Analysts could classify a given report under multiple error types. Percentages are based on total number of reports.

† The report did not have enough information to determine the error type.

Patient's weight entered incorrectly in electronic health record as 67 kg. The patient weighs 5.6 kg. Dose was ordered by anesthesia as 67 mcg instead of 5.6 mcg. FentaNYL given in OR [operating room] (dose not recorded). The surgeon reported child had bronchospasms and desaturations during OR case. Pharmacy saw this order in PACU [postanesthesia care unit] and halted immediately.

The following are examples of events in which there was confusion between pounds and kilograms.

The physician placed the patient's weight into the record but placed the pounds in as kilograms (i.e., 160 pounds was input as 160 kg). Pharmacy mixed the [alteplase] dose according to the weight. The nurses verified the dose off the incorrect weight and administered the bolus of

9 mg as calculated by pharmacy and started the drip of 81 mg over 1 hour. Approximately 50 minutes into the infusion of the drip, it was noted that the weight was incorrect and the bolus was stopped. The patient was given approximately 72 mg of the drip. According to pharmacy, the patient should have been dosed with a bolus of 6.5 mg and a drip of 58.9 mg. The patient received an overdose of



approximately 15.6 mg. The patient subsequently hemorrhaged and required intubation and chest tube insertion for hemothorax.

Patient triaged in ED via EMS [emergency medical services] following witnessed generalized seizure at home. Patient has history of seizures and has been treated with phenobarbital 30 mg PO BID [orally, twice a day] at home. Patient's weight obtained in triage and recorded in EMR as 55.7 kg, however patient's actual weight is 55.7 lb (25.3 kg). The initial PHENobarbital level was less than 2.1 [mcg/mL, normal therapeutic range: 15 to 40 mcg/mL], therefore a loading dose of 20 mg/kg was prescribed to be administered over 30 minutes. Actual dose administered was 1,100 mg but based on correct weight the dose should have been 505 mg. After the loading dose infusion, patient became lethargic and difficult to arouse and anesthesiology and neurology were consulted. A repeat phenobarbital level was over 50 [mcg/mL]. The patient was intubated, ventilated, and transferred to tertiary care facility.

The following are examples of reports in which the documented weight was too low.

*The patient weighs 108 kg and was on a heparin drip with dose at 18 units/kg/hr. The IV [intravenous] pump was programmed with weight of 1.08 kg. The patient's aPTT level was subtherapeutic.*

*Patient's weight on acute care floor today of 39.8 kg, triple checked and compared to ED weight of 21.7 kg. The discrepancy was reported to the senior resident. Patient's mom states patient was weighed on a bed in the ED and that she (mom) commented that the weight of 21.7 kg didn't seem accurate in the ED, but the 21.7 kg was still documented. Patient's pain medications were based on home*

*dosing regimen, but patient was also on cefTRIAxone and azithromycin and doses were adjusted for the correct weight. Patient has had negative blood cultures to date and antibiotics were increased as preventive measure.*

*Patient weighed 62 kg in ED. A heparin drip was initiated in ED using this weight. Patient was received to floor with heparin drip infusing. Patient was weighed via bed scale, which was zeroed out prior to use. Patient weighed at 72.2 kg (10 kg difference). Patient was receiving wrong dose because of wrong weight. The nurse weighed patient on bathroom style scale twice in ED. Both times, she obtained same weight of 62 kg and dosed heparin accordingly. Later the nurse learned of discrepancy in weight from floor nurse, so she weighed herself and found scale [ED bathroom style scale] to be off by 10 kg. The scale was placed out of service until battery changed.*

Another significant factor identified in event reports was the incorrect estimation of patient weight (6.7%, n = 87; see Figure 4). Healthcare practitioners most frequently performed incorrect estimation of patient weight, but incorrect weight estimates were also provided by patients, family members, and guardians. Besides the event reports clearly associated with incorrect estimated weights, many of the events related to too high or too low documented weights were likely related to the practice of estimating weights. Fifty-four percent (n = 47 of 87) of the incorrect estimated weight events provided enough information to calculate a percent difference between estimated and actual weight. Of these 47 events, the estimated weight was wrong by more than 10% in 80.9% (n = 38 of 47) events. The percent of error ranged from 6% to 75%; in one such case, this represented a 58 kg (32.8%) underestimation of the patient's weight. Examples of these reports follow.

*The admission weight entered in the chart was 63 kg, which is listed as an "estimated weight." When a heparin drip was ordered for the patient, the order automatically pulled in the admission weight. This was not the patient's actual weight. On subsequent days when the patient was actually weighed, her weight was found to be significantly lower at 58 kg. Since heparin is dosed by weight, the patient was receiving a higher dose of heparin than she required. I noticed this error after the patient's a PTT was supratherapeutic on two consecutive days. This error could have been avoided if the patient was actually weighed on admission.*

*An [adult patient] was admitted with nausea, vomiting, chest pain, anxiousness, and DKA [diabetic ketoacidosis] (BG [blood glucose] 484 mg/dL). In the ED, an insulin bolus of 10 units (regular) and infusion at 10 units/hr was ordered. The patient only had an estimated weight in the ED of 85 kg. An actual weight performed once patient arrived to ICU a few hours later was 66 kg. The patient's BGs dropped precipitously to 146 mg/dL and the insulin infusion was turned off. The patient needed the insulin infusion placed back on later that morning, due to an increased anion gap. The initial error in weight may have contributed to a rate that caused the precipitous [drop] that led to infusion stopped prematurely.*

Examples of less frequently identified factors (see Figure 4) or multiple factors identified in one event report follow.

*Received patient from ED with norepinephrine and DOBUTamine infusing through peripheral lines at too high of an hourly rate. The weight had been entered as 240 kg on the pump. When receiving report from ED, the nurse had stated the*

estimated weight of the patient was 240 lb. The patient has red tracking from peripheral IV site where DOBUTamine was infusing.

Patient's weight was accidentally entered into dose field by pharmacist. Patient received 72 units/kg/hr of heparin instead of 12 units/kg/hr, which exceeded the maximum rate. Patient received more than 5,000 units of heparin over an hour instead of the ordered 1,000 units. For unknown reasons, the pharmacist overrode a dose alert warning. The nurse attempted to use the drug library to program the pump but received an alert and programmed the pump manually. CT [computed tomography] [scan] of head showed no evidence of acute intracranial pathology.

Clinical oncology specialist noticed weight was significantly different between flow sheet and medication order. The specialist used kg weight to dose chemotherapy order and did not notice conversion was incorrect by 10 kg. The weight difference was not noticed by anyone prior to patient receiving chemotherapy. The patient received one dose of chemotherapy and was scheduled for next cycle on a later date. Upon further investigation, it was noted that weight was recorded in pounds with an incorrectly calculated kilogram weight next to it.

The patient was given acyclovir based on her real body weight. Per the infectious disease team, the acyclovir should have been prescribed based on the patient's ideal body weight. The patient developed renal failure as a result of the incorrect doses.

A heparin drip was ordered at 18 units/kg/hour. [Pharmacy dosing weight was 82 kg which = 1,476 units/hr = 14.8 mL/hr. Patient's actual weight was 68 kg = 1,224 units/hr = 12.2 mL/hr. Shortly after the order was verified, the nurse called the pharmacy with a new weight. The

pharmacist updated the weight that populates into [the pharmacy information system] with the patient's new and accurate weight. The new weights in [electronic health record] do not populate to [pharmacy information system], thus any dosing based on weight may be incorrect.

## DISCUSSION

Similar to the previously published Advisory article<sup>6</sup> and ECRI Institute report,<sup>7</sup> data analysis revealed general themes related to errors involving patient weight. These themes revolve around (1) obtaining a current, accurate patient weight; (2) documenting and communicating the weight value; and (3) properly using the weight value. Event reports exposed the complexity and error-prone nature of obtaining, documenting, communicating, and using patient weights.

Numerous difficulties in obtaining a current, accurate patient weight exist.<sup>6</sup> For example, many critically ill patients are not weighed in EDs and ICUs because of the urgency of their clinical status.<sup>5,16,17</sup> Healthcare facilities may not possess the equipment necessary (e.g., standing scales, pediatric scales, wheelchairs scales, bed scales) to facilitate the accurate collection of patient weights.<sup>16,17</sup> Even if present, the equipment may not be functional or reliable.<sup>18</sup> These barriers may lead clinicians to forego weighing a patient and decide to use a previously documented weight or estimate a patient's weight.<sup>5,16,17,19</sup> Abundant literature exists highlighting the inaccuracies of clinicians and patients/caregivers estimating patient weights and its association with medication errors, adverse events, and clinical ineffectiveness.<sup>5,6,11,16</sup> Our analysis revealed ample evidence that Pennsylvania healthcare practitioners experience and encounter many of these same barriers to obtaining a current, accurate patient weight.

Once clinicians overcome the barriers associated with obtaining a current,

accurate patient weight, they face obstacles related to documenting and communicating the weight to other members of the healthcare team. Clinicians must take the obtained weight value and accurately transfer this information to the medical record, either paper based or electronic, and to an infusion pump or other systems requiring this information. This is a process ripe for error as demonstrated by many events (23.2%, n = 300) involving confusion between pounds and kilograms. A clinician may obtain a weight measured in pounds and forget to convert to kilograms, or obtain a weight in kilograms but document it incorrectly as pounds. Additionally, clinicians may transcribe the weight into the medical record or infusion pump incorrectly, by transposing numbers or using the wrong patient's weight.

Similar to the issue described by Hilmer and colleagues,<sup>3</sup> certain event reports pointed to problems related to the patient weight being documented in multiple locations within the medical record. This may lead to the documentation of multiple different values in the medical record, causing confusion among clinicians about which value is current and correct. Also, depending on the location in the record where the weight is documented, some clinicians (e.g., pharmacists) may not be able access or view the weight value. This problem is exacerbated by the numerous clinical systems into which a weight should or must be documented. For example, patient weight may be required in the medical record, computerized prescriber order entry (CPOE) system, pharmacy information system, infusion pump, and other systems as appropriate. These systems may not be integrated or automatically share patient weight information, resulting in the possibility of multiple different weight values being documented across systems.

Although many medications dosed by weight use a patient's actual weight, in some situations it is more appropriate to

use a patient's ideal body weight (IBW), adjusted body weight (ABW), or another determined weight value to serve as the "dosing weight."<sup>20,21</sup> Patients can receive inappropriate dosages of medications when the actual body weight is used as the dosing weight instead of the more appropriate IBW or ABW, or vice versa. In nearly 3% (n = 38) of event reports, these mix-ups were identified as a factor contributing to the event.

Perhaps more significant is the risk of perpetuating the use of an inaccurately obtained or documented patient weight throughout the episode of care.<sup>19,22,23</sup> Fuller and colleagues found that nearly 80% of patients given vancomycin (a medication that should be dosed by weight) in the ED and subsequently admitted to the hospital received an unchanged, inappropriate dose.<sup>19</sup> Although the benefits of electronic health records (EHRs) are numerous, Bokser describes the dangers associated with EHRs and the perpetuation of bad data and subsequent erroneous decision support.<sup>22</sup>

### Limitations

In-depth analysis by the Authority of medication errors involving patient weight occurring in Pennsylvania facilities is limited by the information reported through PA-PSRS, including the error description and reasons why the event occurred. Additional patient weight events and associated causes may have been reported but not identified by the query and analysis. Additionally, unique organizational reporting cultures and patterns, along with different interpretations of what occurrences are reportable may lead to reporting variations.

### RISK REDUCTION STRATEGIES

The events included in this analysis, observations from the Institute for Safe Medication Practices, and recommendations in the literature offer strategies that healthcare facilities may consider to

reduce risk of errors in the medication-use process involving patient weight. Strategies related to patient weight that healthcare facilities can apply to the medication-use process include the following:

- Ensure all patient care areas have the necessary equipment to easily obtain an accurate patient weight, including weights for infants and children, as appropriate. Examples of possible equipment include floor scales, stretchers and beds with built-in scales, and standing, chair, and wheelchair scales.<sup>4,6,9,12,22,23</sup>
- To facilitate accurate weight measurements, use and maintain (e.g., test, calibrate) scales in accordance with applicable manufacturer recommendations.<sup>18,24</sup>
- Weigh each patient as soon as possible on admission and during each outpatient or ED encounter, excluding encounters in which medications are not prescribed (e.g., laboratory visit). Avoid the use of an estimated, historical, or stated weight.<sup>6,7,10-13</sup>
- Measure patient weight in metric units only (i.e., grams or kilograms). Use scales that measure in metric units only, or lock scales to measure only in metric units.<sup>7,10,12,13,22,23</sup>
- Document and communicate patient weight in metric units only. Ensure computer information system screens, infusion pumps, and other medication device screens, printouts, and preprinted order forms prompt users to record patient weight in metric units only.<sup>7,10,12,13,22,23</sup>
- Develop organizational expectations that obtaining the patient's actual weight is part of the mandatory nursing assessment and reweighing of the patient occurs as warranted, based on patient's clinical condition. Consider requiring reassessment of a patient's weight when initiating or changing the dose of weight-based medications, clinical situations

in which weight fluctuations are expected, or situations in which a weight variation may impact the course of care.<sup>6,12,23,24</sup>

- Document patient weight in a prominent location within the medical record readily viewable by all healthcare practitioners.<sup>8,9,12</sup>
- Develop organizational medication-use policies that state weight-based medications will not be prescribed, dispensed, or administered unless an accurate weight is available (except in emergencies).<sup>6</sup>
- Implement "hard stops" or automated clinical decision support at the time of data entry to alert clinicians when the weight parameter is missing (for weight-based medications) or when the entered patient weight value is not consistent with an expected value.<sup>6,7,22,23</sup>
- Develop organizational policies that clearly define specific criteria for when medications will be dosed by other than actual body weight (e.g., IBW, ABW) and delineate where and how this "dosing weight" will be communicated to clinicians to prevent confusion and error.<sup>17</sup>
- Maximize available device integration to enable automatic, accurate, and transparent transmission of patient weight data directly from scales to EHRs, pharmacy information systems, and medical devices.<sup>22</sup>

### CONCLUSION

Healthcare practitioners need current, accurate patient information, including patient weight, to properly guide medication therapy. Analysis of 1,291 reports submitted to the Authority from December 2008 through November 2015 revealed multiple factors contributing to medication errors related to obtaining, documenting, communicating, and using patient weight. Results were consistent with those presented in 2009,<sup>6</sup> indicating

that Pennsylvania facilities continue to struggle with the complexity of the issue.

Risk-reduction strategies presented in this analysis may help organizations minimize

the occurrence of medication errors involving patient weight.

## NOTES

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# PENNSYLVANIA PATIENT SAFETY ADVISORY

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## THE PENNSYLVANIA PATIENT SAFETY AUTHORITY AND ITS CONTRACTORS

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 website at <http://www.patientsafetyauthority.org>.



ECRI Institute, a nonprofit organization, dedicates itself to bringing the discipline of applied scientific research in healthcare to uncover the best approaches to improving patient care. As pioneers in this science for nearly 50 years, ECRI Institute marries experience and independence with the objectivity of evidence-based research. More than 5,000 healthcare organizations worldwide rely on ECRI Institute's expertise in patient safety improvement, risk and quality management, and healthcare processes, devices, procedures and drug technology.



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.



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