◇Patient Safety Authority
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Challenges with Measurement and Transcription of Patient Height:

An Analysis of Patient Safety Events in Pennsylvania Related to Inaccurate Patient Height

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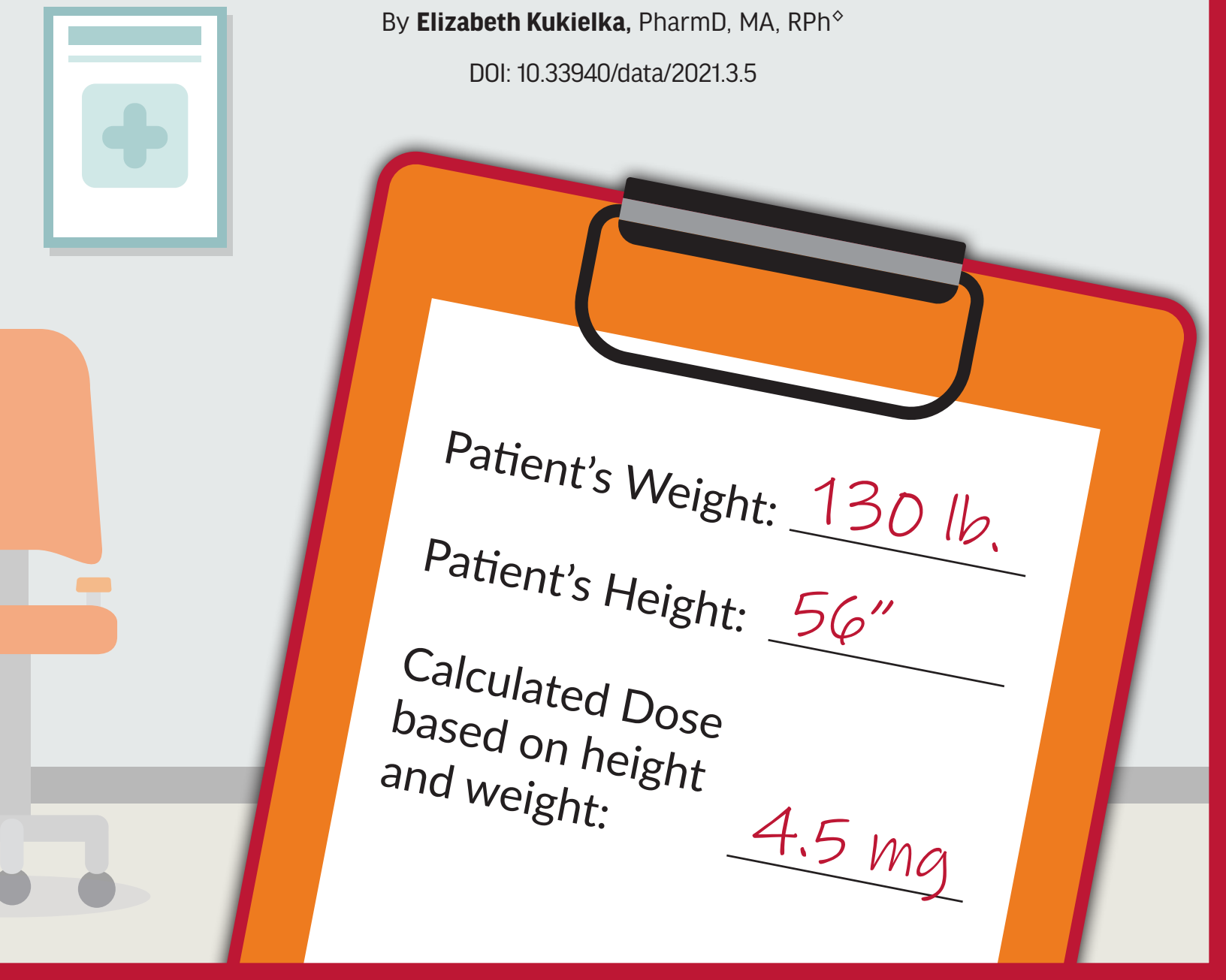


An accurate patient height is necessary to calculate certain measurements (e.g., body surface area [BSA]) and lab values (e.g., creatinine clearance [CrCl]), which may be needed to assess renal, cardiac, and lung function and to calculate accurate medication doses. We queried the Pennsylvania Patient Safety Reporting System (PA-PSRS) and identified 679 event reports related to an inaccurate patient height. All events were classified by the reporting facility as incidents, meaning that the patient did not sustain an unanticipated injury or require the delivery of additional healthcare services. The most common care area group where an event occurred was outpatient/clinic (35.8%; 243 of 679). Events were categorized as being related to an error in transcription (72.5%; 492 of 679) or measurement (7.4%; 50 of 679), and the remainder were categorized as etiology of error unclear (20.2%; 137 of 679). The most common transcription errors were the use of the wrong unit of measurement, the transposition of another measurement with height, and typographical errors. Inaccurate patient heights most often led to errors in calculation of medication doses or laboratory values. The most common medication class involved in a dosing error was cancer chemotherapy. In order to ensure accuracy of patient height measurements, patients should be measured at the beginning of every healthcare encounter, units of measurement should be consistent from measurement to transcription into the electronic medical record, and estimated patient height should never be relied upon or recorded.

Keywords: *patient height, measurement, transcription, medication error, electronic medical record, patient safety, medication safety*

Introduction

Ideally, every patient should be measured at the beginning of every healthcare encounter*, whether at a routine check-up, an emergency department visit, or prior to a procedure or surgery, to ensure baseline anthropometric (e.g., weight and height) and vital (e.g., body temperature, heart rate, blood pressure, and respiratory rate) information is accurate and up to date. An accurate patient height in particular is necessary to calculate certain measurements (e.g., body mass index [BMI] and body surface area [BSA]) and lab values (e.g., creatinine clearance [CrCl]), which may be needed to assess renal function and to calculate accurate medication doses.[1,2] Inaccurate height measurements may negatively impact patient safety by causing treatment delays, medication dosing errors, and inaccurate assessments of nutritional status.[1,2]

During a recent analysis of patient safety events related to extreme patient height submitted to the Pennsylvania Patient Safety Reporting System (PA-PSRS)†, we observed event reports that detailed patient safety events involving an inaccurate patient height. Because the etiology of and outcomes associated with an inaccurate patient height are distinct from those associated with an extreme patient height, we undertook a separate analysis of patient safety events related to inaccurate patient heights submitted to PA-PSRS. The objective of this analysis was to gain a better understanding of factors that may contribute to an inaccurate patient height being recorded into a patient's medical record, the ways in which a wrong patient height may negatively impact patient care, and possible risk reduction strategies to decrease the potential for these events.

Methods

PA-PSRS has been collecting reports of patient safety events since May 2004, and as a result it is one of the largest databases of its kind in the world. Event reports include responses to both structured fields (e.g., event date, patient age, patient sex, care area, facility type) and free-text narrative fields (e.g., event detail, which allows the reporter to describe the details of the event in their own words). The information supplied in free-text narrative fields is at the discretion of the reporter, so the depth and detail of the information varies from one event report to the next.

On October 5, 2020, we queried the entire acute care dataset in PA-PSRS to identify event reports related to an inaccurate patient height with an event date on or before August 31, 2020. We employed the following search strategy:

- Event Detail, Event Comments, or Event Recommendation field contained one of the following keywords or phrases: "wrong height," "wrong pt height," "wrong patient height," "inaccurate height," "inaccurate pt height," "inaccurate patient height," "incorrect height," "incorrect pt height," or "incorrect patient height."
- Event Detail, Event Comments, or Event Recommendation field contained the keyword "height" and one of the following keywords: "switch," "swap," or "transcri."
- Event Detail, Event Comments, or Event Recommendation field contained the keyword "height," the root or abbreviation for centimeter (i.e., "cm" or "centim"), and the root or abbreviation for inches (i.e., "in" or "inch") or feet (i.e., "ft" or "feet").
- Event Type was specified as "medication error," and Event Detail, Event Comments, or Event Recommendation field contained the root or abbreviation for centimeter (i.e., "cm" or "centim") or the root or abbreviation for inches (i.e., "in" or "inch") or feet (i.e., "ft" or "feet").
- Event Subtype was specified as "other" and the associated free-text response field contained the keyword "height."

We reviewed each event report to ensure it involved an inaccurate patient height. We excluded any event report that was not related to an inaccurate patient height, such as those in which height was mentioned but the patient safety event was related to an inaccurate weight.

We performed a descriptive analysis to evaluate trends among information specified by the reporting facility, including patient age and sex, facility type, care area, harm score, and event type and subtype(s). Concerning the care area field, it should be noted that although PA-PSRS does specify that this should be the location where the event occurred, there are times when it is clear that the reporter has listed the location where the event was discovered. For example, a patient's height may be transcribed incorrectly during triage in the emergency department, but the error may not be discovered until the pharmacist verifies the

*A healthcare encounter is defined in this article as a meeting between a patient and a healthcare provider in order to evaluate the health status of a patient or to deliver healthcare services.

†PA-PSRS is a secure, web-based system through which Pennsylvania hospitals, ambulatory surgical facilities, abortion facilities, and birthing centers submit reports of patient safety–related incidents and serious events in accordance with mandatory reporting laws outlined in the Medical Care Availability and Reduction of Error (MCARE) Act (Act 13 of 2002).[3] All reports submitted through PA-PSRS are confidential and no information about individual facilities or providers is made public.

patient's medication orders, and the care area may be listed as the pharmacy. For this reason, we did not analyze any potential relationship between care area group and other factors.

We manually reviewed and coded each event report for the following (if specified):

- Whether the event was related to an error in measurement or an error in transcription.
- The result of an inaccurate height, such as a wrong dose of medication or an inaccurate calculated measurement, laboratory value, or test result.
- The specific medication, measurement, laboratory value, or test result affected.
- The medication class for each medication involved.

All coding, reviews, and analyses were performed by a patient safety analyst at the Patient Safety Authority (PSA).

Results

The query returned 820 event reports from the PA-PSRS database that occurred from the inception of the database in May 2004 through August 31, 2020. We excluded 141 event reports from the analysis because they were not related to an inaccurate patient height. The final dataset included the remaining 679 event reports submitted by 81 facilities.

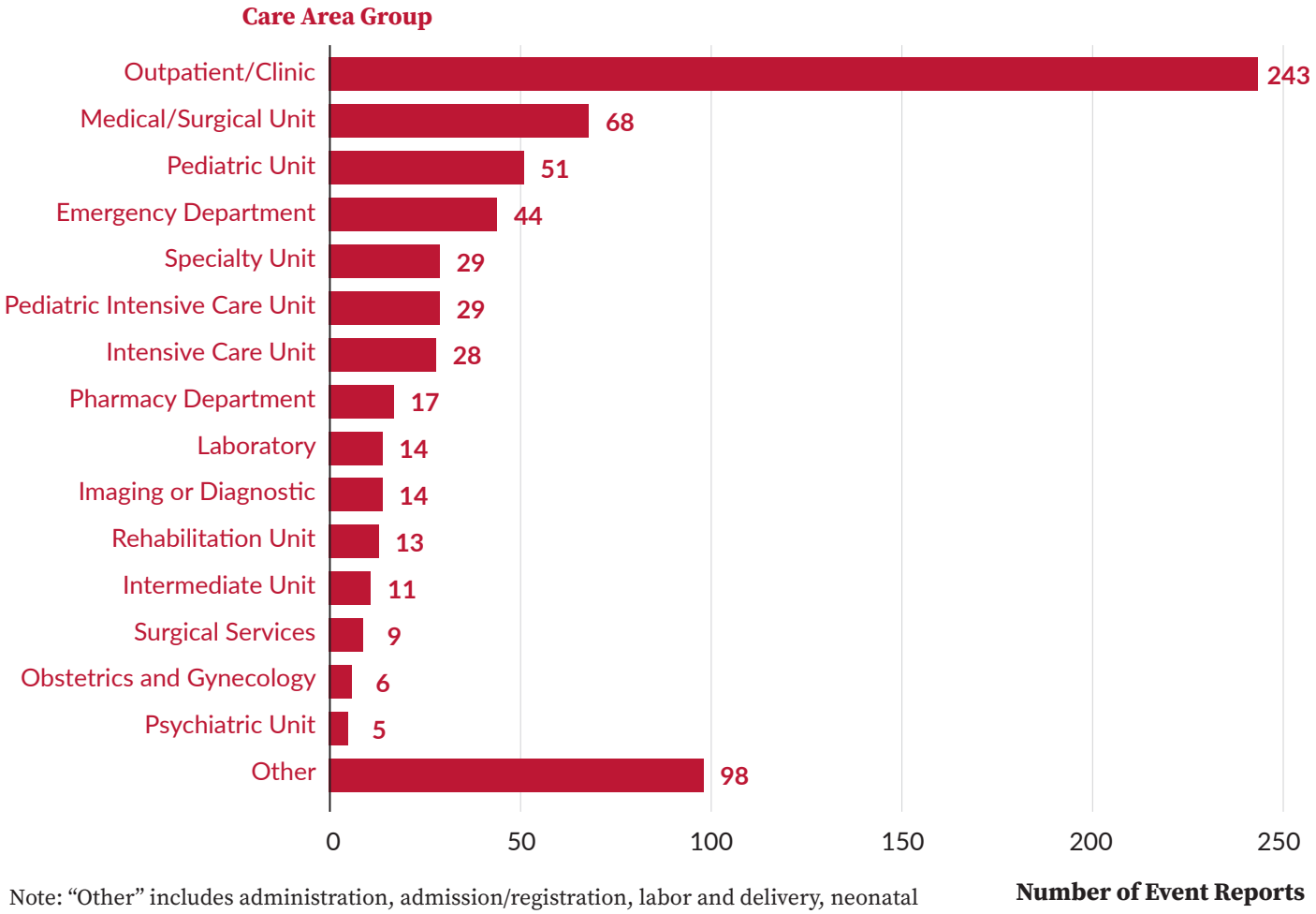
Descriptive Analysis

Event reports more often involved female patients (54.6%; 371 of 679) than male patients (45.4%; 308 of 679). Event reports also indicated that patients ranged in age from 1 day to 99 years, with a median patient age of 46 years (25th percentile=12 years; 75th percentile=65 years).

Most event reports were submitted by an acute care hospital (87.0%; 591 of 679) or a children's hospital (12.5%; 85 of 679), and the remaining event reports were submitted by a long-term acute care facility (n=2) and an ambulatory surgery facility (n=1). Of note, approximately two-fifths of event reports were submitted by a single facility with event dates in 2019 and 2020, and we have highlighted any place where this might have affected the data throughout the results. While at times the PSA publishes articles highlighting the safety culture or improvement work of a facility, this was out of scope for this study, so we have refrained from any additional discussion related to the reporting culture at this facility.

The most common care area groups were outpatient/clinic (35.8%; 243 of 679), medical/surgical unit (10.0%; 68 of 679), pediatric unit

Figure 1. Frequency of Event Reports Involving an Inaccurate Patient Height by Care Area Group, N=679



Note: "Other" includes administration, admission/registration, labor and delivery, neonatal intensive care unit, nursery, outpatient observation, radiation oncology, and respiratory.

(7.5%; 51 of 679), and emergency department (6.5%; 44 of 679); care area groups for all event reports are summarized in **Figure 1**. About 70% of event reports from an outpatient/clinic were submitted by the single facility identified as the largest reporter.

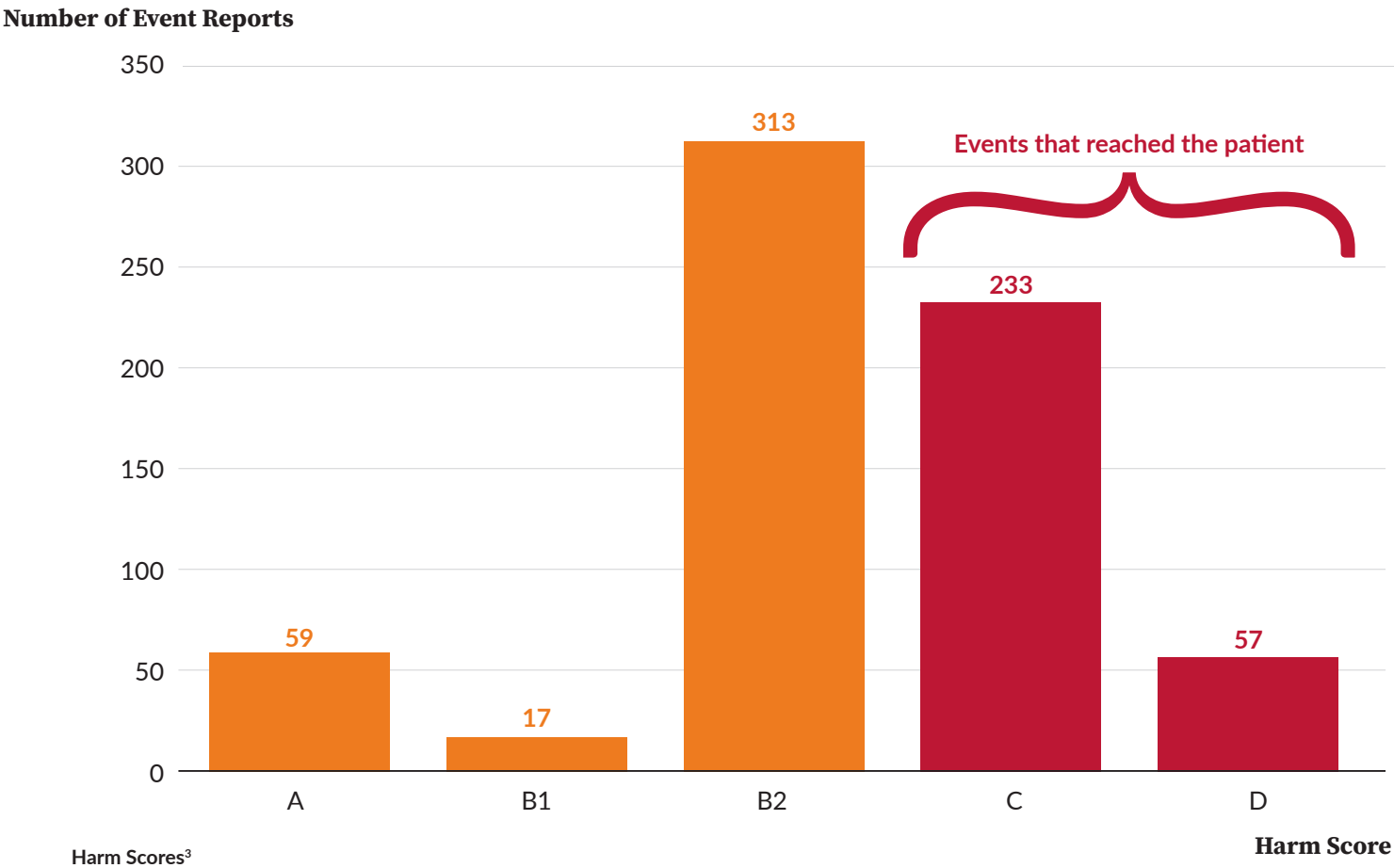
Event reports were most often classified by the reporting facility as an error related to a procedure, treatment, or test (52.1%; 354 of 679) or as a medication error (20.6%; 140 of 679); the remaining event reports were classified as a complication of a procedure, treatment, or test (1.3%; 9 of 679); equipment, supplies, or devices (0.6%; 4 of 679); or other/miscellaneous (25.3%; 172 of 679). The vast majority of event reports were classified under the event subtype "other (specify)" (81.4%; 553 of 679), which allowed the reporting facility to describe the event in their own terms. More than 80% of event reports classified as an error related to a procedure, treatment, or test were submitted by the single facility identified as the largest reporter.

All event reports were classified by the reporting facility as incidents, meaning that the patient did not sustain an unanticipated injury or require the delivery of additional healthcare services.[3] Harm scores for each event report are summarized in **Figure 2**; the most common harm scores were B2 (46.1%; 313 of 679), which is an event that did not reach the patient as a result of the intervention of a healthcare provider, and C (34.3%; 233 of 679), which is an event that reached the patient but did not cause harm or require increased monitoring to prevent harm.[3] About 60% of event reports assigned a harm score of B2 were submitted by the single facility identified as the largest reporter.

Qualitative Analysis

We analyzed each event report to determine the type of error that had occurred, with particular attention to free-text fields (i.e., Event Detail, Event Comments, Event Recommendation, and Event Subtype - Other), and these are summarized in **Figure 3**. Event reports that specified that the patient's height had been transcribed, recorded, entered, or documented incorrectly (or other similar language) were categorized as transcription errors (72.5%; 492 of 679). Event reports that specified that the patient had been

Figure 2. Frequency of Event Reports Involving an Inaccurate Patient Height by Harm Score, N=679



Harm Scores[3]

A – Circumstances that could cause adverse events (e.g., look-alike medications, confusing equipment, etc.)

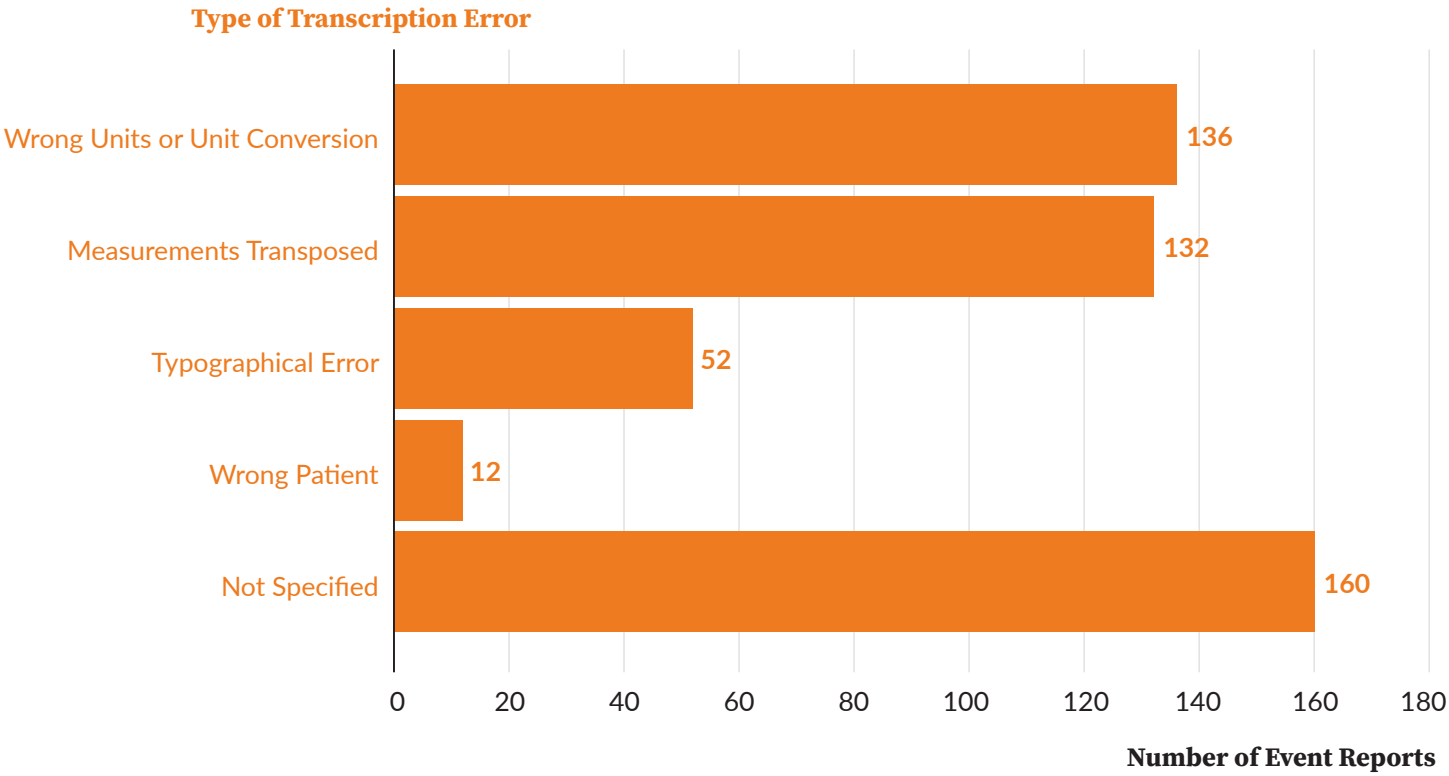
B1 – An event occurred but it did not reach the individual ("near miss" or "close call") because of chance alone

B2 – An event occurred but it did not reach the individual ("near miss" or "close call") because of active recovery efforts by caregivers

C – An event occurred that reached the individual but did not cause harm and did not require increased monitoring (an error of omission such as a missed medication dose that does reach the individual)

D – An event occurred that required monitoring to confirm that it resulted in no harm and/or required intervention to prevent harm

Figure 3. Frequency of Event Reports Related to Inaccurate Patient Height by Type of Transcription Error, n=492



measured incorrectly or explicitly stated that the patient had not been measured at all were categorized as measurement errors (7.4%; 50 of 679). The remainder of event reports were categorized as etiology of error unclear (20.2%; 137 of 679). This category included event reports that specified that the patient height field had been left blank (49.6%; 68 of 137) or that conflicting heights had been recorded in the patient record (16.1%; 22 of 137), and event reports that lacked sufficient detail to determine whether there had been a transcription error, a measurement error, or both (34.3%; 47 of 137). Distribution of event reports across these categories was similar when the single facility identified as the largest reporter was excluded.

Transcription errors leading to an inaccurate patient height contributed to nearly three-quarters of event reports (see **Figure 3**). The following are examples of event reports coded as transcription errors:

> *Height was entered in EMR [electronic medical record] as 35 cm instead of 135 cm. Error was identified and corrected in the EMR by the nurse before it reached the patient.*

> *Height was documented as 65 cm and weight as 210 kg. Called bedside nurse to verify, believe this should have been 65 inches and 210 lbs.*

The most common mistakes were the use of the wrong unit of measurement (e.g., the patient was measured at 62 inches, but the height was entered into the patient record as 62 centimeters, or the patient was measured at 5 feet 2 inches, but the height was entered into the patient record as 52 inches); the transposition of another measurement with height (e.g., patient weight or head circumference was entered into the height field in the patient record); and typographical errors (e.g., a height measurement of 134 centimeters was entered into the patient record as 13.4 centimeters or 124 centimeters). Event reports in which measurements were transposed were submitted almost entirely by the single facility identified as the largest reporter.

Measurement errors occurred less frequently and included event reports in which the patient height was not measured (58.0%; 29 of 50), height measurement equipment (e.g., an electronic scale with a stadiometer) malfunctioned (12.0%; 6 of 50), or the clinician employed the wrong technique (e.g., the patient was measured with shoes on) when measuring the patient (12.0%; 6 of 50). The following are examples of event reports coded as measurement errors:

> *Patient was seen in oncologist's office for initiation of care. Per the patient, height was not measured at initial office visit. Accurate height was measured upon arrival to chemotherapy infusion center for first treatment. Height measured in the infusion center was 5 cm less than the height documented in the office. Medication doses were calculated based on the incorrect height documented at oncologist's office rather than the patient's actual height. Call was made to oncologist's office to fix the discrepancy, and a new order was obtained.*

> *Patient height measured without shoes as 63 inches. Height that was entered in EMR at earlier visit was 69 inches, and this was used to calculate chemotherapy doses. New height of 63 inches was verified by two staff members. Chemotherapy doses had to be recalculated based on new height.*

Among measurement errors in which the patient height was not measured, the event report indicated that a placeholder such as 0 or 1 was entered into patient record without the patient actually being measured (34.5%; 10 of 29), the height was copied from an earlier admission (27.6%; 8 of 29), or the patient or caregiver reported the height or the clinician estimated the height (27.6%; 8 of 29).

Among event reports for which the etiology of the error was unclear, either the height field was left completely blank (49.6%; 68 of 137) or two or more conflicting heights were entered into the patient record (16.1%; 22 of 137). The following are examples of event reports coded as etiology of error unclear:

> *Patient was admitted through the emergency department yesterday, but no height was entered into the EMR. Pharmacist is unable to calculate creatinine clearance for medication dosing and adjustments.*

> *Patient was seen in oncologist's office and height was documented there as 4'11". I reverified the patient's height today at the cancer center as 5'1", and a second nurse verified this height. Height and weight are very important because they are used by the pharmacy to calculate chemotherapy doses.*

In cases in which the height field was left blank, it was possible that the patient had not been measured at all, or that the patient had been measured but the measurement had not been recorded. The remaining event reports (34.3%; 47 of 137) did not include any information beyond that an inaccurate height was listed in the patient record.

About one-third of event reports (30.8%; 209 of 679) included detail about the result associated with the inaccurate patient height. Two-thirds of those event reports (67.9%; 142 of 209) indicated that the inaccurate patient height led to an inaccurate medication dosing. One hundred event reports involving an inaccurate medication dose included more detail about the type of wrong dose, and underdoses (57.0%; 57 of 100) were observed more often than overdoses (43.0%; 43 of 100).

A total of 142 event reports specified that a medication had been dosed incorrectly as a result of an inaccurate patient height; some of these events did not include any additional details about the medication involved, while others listed specific medications or medication classes. The most common medication class was cancer chemotherapy (64.1%; 91 of 142), which included antineoplastic agents, targeted therapies (e.g., monoclonal antibodies), and other anticancer agents. Other medication classes were anti-infectives, which included antibiotics, antivirals, and antifungals (14.1%; 20 of 142); anticoagulants (11.3%; 16 of 142); and other classes (4.9%; 7 of 142), such as corticosteroids, antiemetics, anesthetics, and total parenteral nutrition. The remaining event reports (5.6%; 8 of 142) did not specify a medication or medication class.

Some of these event reports listed multiple medications; for example, one event named two antibiotics that were incorrectly dosed, and another event listed three different medications within the cancer chemotherapy class. Across 142 event reports that indicated that a medication was dosed incorrectly, 125 specific medications were mentioned by name (see **Table 1**). The medications that were most often dosed incorrectly across all event reports were heparin (9.6%; 12 of 125), vancomycin (9.6%; 12 of 125), cyclophosphamide (8.0%; 10 of 125), and rituximab (8.0%; 10 of 125).

Calculated measurements, lab values, and test results were affected in about one-third of events (30.6%; 64 of 209) that included detail about the result associated with the inaccurate patient height. The most common inaccurate calculated measurement was BMI (25.0%; 16 of 64); other inaccurate calculated measurements included BSA and ideal body weight (IBW). The most common inaccurate calculated lab value was CrCl (43.8%; 28 of 64); other inaccurate calculated lab values included blood volume, glomerular filtration rate, and a vancomycin trough. Inaccurate calculated test results included an echocardiogram, an electrocardiogram, and a pulmonary function test.

Discussion

To our knowledge, this is the first study of its kind to examine inaccurate patient heights in the context of patient safety events. Much of the existing literature and research on the topic of inaccurate patient heights focuses specifically on measurement errors. Some measurement errors that were observed in both our study and in the literature include the use of improper measurement equipment or techniques (e.g., measuring a patient with shoes on) or reliance on an estimated patient height provided by a patient, caregiver, or clinician. Numerous studies have shown that patient height estimates among inpatients in particular are not reliable, emphasizing the importance of measuring patient height at each encounter.[4-7] Additionally, although most events in our analysis were not explicitly the result of measurement errors, some events categorized as transcription errors or etiology of error unclear may have involved errors in measurement, such as events in which the wrong units were transcribed, the height field was left blank, or conflicting measurements were recorded. For example, when a clinician measures a patient, the units of measurement on the ruler would be in centimeters or inches, while a patient would usually report their own height in feet and inches; so a transcription error in which feet and inches were transcribed as inches might also have been an event in which the patient height was not measured.

Errors explicitly related to transcription of inaccurate patient heights were observed in nearly three-quarters of event reports in our study. An evaluation of computer entry by nonprescribers revealed that inconsistent expression of height and weight data in the EMR contributed to medication errors.[8] In another study, researchers analyzed over 200,000 weight and height values to develop a method for reducing the problems of transcription and recording errors for height and weight; they observed that patterns in the data indicated that many outliers for individual patients were not true outliers, but rather could be attributed to unit conversion errors, which we observed in 40.4% of event reports involving transcription errors.[9] Considering this research, it follows that frequent measurement and recording of patient height may serve as a double check and highlight errors in the patient record.

Wrong medication doses were the most common result of an inaccurate patient height observed in our study, accounting for more than two-thirds of event reports in which a result was specified. The classes of medications most frequently involved in medication errors related to inaccurate patient heights in our study were cancer chemotherapy, anti-infectives, and anticoagulants. Although none of the events in our study resulted in an unanticipated injury requiring the delivery of additional healthcare services, cancer chemotherapy and anticoagulants are considered high-alert medications in the acute care setting, meaning

Table 1. Medications Dosed Incorrectly as a Result of an Inaccurate Patient Height, n=125

Medication Class[a]		Medication Name	No. of Occurrences[b]
Cancer Chemotherapy[c]		azacitadine	1
		bevacizumab	1
		busulfan	1
		carfilzomib	1
		cetuximab	2
		cisplatin	3
		cyclophosphamide	10
		cytarabine	2
		daptomycin	1
		decitabine	2
		doxorubicin	7
		etoposide	1
		fluorouracil	5
		gemcitabine	7
		irinotecan	5
		leucovorin	4
		melphalan	1
		methotrexate	5
		oxaliplatin	4
		paclitaxel	6
		pemetrexed	2
		rituximab	10
		vinblastine	1
		vincristine	2
Anti-Infective Agents	Antibiotics	ampicillin/sulbactam	2
		ceftriaxone	1
		gentamicin	1
		piperacillin/tazobactam	1
		tobramycin	1
		vancomycin	12
	Antifungals	caspofungin	1
	Antivirals	ganciclovir	1
		oseltamivir	1
Anticoagulants		enoxaparin	4
		heparin	12
Other	Corticosteroids	hydrocortisone	3
	Antiemetics	promethazine	1
Total			125

[a]Medication classes are listed in order of frequency, and individual medications are listed in alphabetical order within each class for ease of reference. Occurrences in which only a medication class was indicated are not included in this table.

[b]Some event reports listed multiple medications by name.

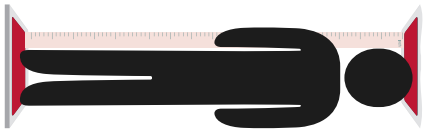
[c]Cancer chemotherapy includes antineoplastics, targeted therapies such as monoclonal antibodies, and other anti-cancer agents.

they bear a heightened risk of causing significant patient harm when they are used in error.[10] Wrong medication doses could also have been the downstream result of events in which there were errors in the calculation of BSA or CrCl if those errors were not identified and corrected, because these values are used in the calculation of dosing for numerous medications. Aside from medication dosing, patient height is also important to accurately assess renal, cardiac, and lung function, as well as nutritional status, and to set appropriate ventilation tidal volumes.[1,2,11]

Although our study looked specifically at reports submitted by hospitals, the most common care area group where events took place was outpatient/clinic, which emphasizes that accurate patient heights are a concern in both the inpatient and outpatient setting. Additionally, cancer chemotherapy was the most common medication class observed in our study, and since these medications are often administered in the setting of an outpatient oncology clinic, this further reinforces the importance of accurate patient heights in the outpatient setting.

Overall, our findings reinforce the importance of measuring patient height at the beginning of every healthcare encounter, because routine measurement of height ensures an accurate measurement is available for healthcare providers and serves as a double check to identify inaccurate measurements in the patient record.[9] Best practices for patient height measurement based on the currently available evidence in the medical literature are summarized in **Table 2.**[1,2,8,11-13] Facility leadership should ensure that policies and equipment support best practices that have been put in place, and that any changes in policy are effectively communicated to all involved healthcare providers and support staff that practice in that facility.

Table 2: Best Practices for Patient Height Measurement in the Healthcare Setting[1,2,8,11-13]

When should patient height be measured?	Healthcare providers should measure patient height at the beginning of every healthcare encounter or transfer to a new facility (e.g., from a nursing home to a hospital). Additionally, patient height should be reassessed whenever it could impact the course of care, such as when dosing medications based on BSA or calculating tidal volumes for ventilation. Frequent measurement also provides a double check to ensure accuracy.
How should patient height be measured?	**Standing:** Patients who are mobile should be measured using a wall-mounted stadiometer, which is a device consisting of a vertical ruler with a sliding horizontal arm adjusted to rest on the top of the head. The patient should stand upright on a firm surface with shoes removed, feet together, looking straight ahead, with shoulders, buttocks, and heels touching the wall.  **Supine:** Patients who are nonmobile should be measured while supine from the vertex of the head to the heel using a flexible tape measure. A more accurate method for measuring height while supine is the bookend method (BEM). For this method, the mattress must be laid flat and the head pillow removed. One BEM board (positioned upright 90° from the bed) is placed under the feet with the heels touching the board. The second BEM board (same positioning) is placed under the head with the head touching the board. An inflexible tape measure is used to measure between the BEM boards. 
What units should be used for patient height measurement?	The electronic medical record (EMR) should record height in centimeters, and patients should be measured in centimeters to eliminate errors in conversation between units. If the EMR records height in inches, patients should be measured in inches for the present time, but ultimately, the EMR should be converted to record in centimeters.

Limitations

Despite mandatory event-reporting laws in Pennsylvania, our data are subject to the limitations of self-reporting. Because a standard taxonomy for reporting patient safety events related to an inaccurate patient height does not exist, we may have missed relevant event reports with our query. In addition, because the details included in each event report are left up to the discretion of the reporter, information was missing or incomplete in some reports, including specific details about what may have contributed to the event or the impact of an inaccurate patient height on clinical care.

Conclusion

Our study highlights the many potential problems that arise during the measurement and transcription of patient height in the hospital setting. Errors were more common in the transcription of patient height, related largely to mixing up of either units or measurements. The most frequently observed result of an inaccurate patient height was a wrong medication dose, and the most common medications involved were cancer chemotherapy, anti-infective agents, and anticoagulants. In order to ensure accuracy of patient height measurements, patients should be measured at the beginning of every healthcare encounter, units of measurement should be consistent from measurement to transcription into the EMR, and estimated patient height should never be relied upon or recorded. In the future, measurement equipment that interfaces directly with the EMR could eliminate errors that occur between measurement and transcription of patient height. In addition, future quality improvement studies at one or more healthcare facilities may help to determine the impact of other solutions on the measurement and transcription of patient height.

Notes

This analysis was exempted from review by the Advarra Institutional Review Board.

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