June 19, 2025 | Volume 30 ■ Issue 12

ISMP Institute for Safe Medication Practices
An ECRI Company

Acute Care
ISMP Medication Safety Alert!®
Educating the Healthcare Community About Safe Medication Practices

# Prevent potentially catastrophic drug overdoses by properly configuring various technologies

**Problem:** According to the US Food and Drug Administration (FDA), a medication's maximum tolerated dose is defined as the highest dose that does not produce unacceptable toxicity. However, several medications, including opioids, benzodiazepines, anticonvulsants, and anticoagulants, do not have a universal maximum dose published in the official prescribing information; instead, they have variable dosing recommendations based on the medication's indication, patient-specific parameters, tolerability, or clinical response. For example, the dosing of opioids varies widely based on a patient's opioid status (i.e., naïve versus tolerant) and depends on the context of use (e.g., acute pain, chronic pain, palliative care). Even when medications have established maximum limits in the prescribing information, healthcare organizations may not always have adequate safeguards built into all systems (e.g., electronic health record [EHR], automated compounding device, smart infusion pump drug library) to prevent practitioners from inadvertently exceeding the threshold, resulting in a medication overdose.

When establishing maximum dose limits, organizations must consider the broader clinical context including the indication for therapy, underlying disease states, patient tolerability, and concurrent medication use. These factors can significantly influence drug pharmacokinetics and pharmacodynamics, potentially leading to increased drug concentrations and heightened risk of adverse effects or toxicity. For example, impaired organ function or drug-drug interactions may amplify drug levels even when prescribed within the normal dosing range.

## Maximum Dose Limits in EHRs

Errors have been reported to ISMP in which a practitioner administers a patient's medication dose that is above the maximum limit due to a lack of clinical decision support in the EHR. In one case, a patient received 5 g of acetaminophen within 16 hours, exceeding the hospital's established maximum recommended daily dose of 4 g per day. The prescriber ordered 1 g of oral acetaminophen as a one-time dose, and the nurse administered the dose to the patient at 1050. The prescriber also ordered oral acetaminophen 1 g every 6 hours as needed (PRN) for pain. The nurse administered the first PRN dose at 1440, and a second nurse administered additional doses at 2008 and 2339, and the following morning at 0157. The nurse identified that a total of 5 doses (i.e., 5 g) had been administered within a 24-hour timeframe and notified the prescriber. There was no harm reported. The organization did not have a maximum dose calculator integrated into the EHR to alert practitioners that the maximum daily dose had been administered. It is unknown if the nurse received any barcode medication administration (BCMA) alerts when they scanned the medication barcode to notify them that it was too soon to administer the acetaminophen (e.g., less than 6 hours since the last administered time).

In our February 8, 2024 article, *Limit ketorolac therapy to 5 days*, we discussed how the nonsteroidal anti-inflammatory drug (NSAID) ketorolac, which is indicated for short-term acute pain, has a *Boxed Warning* to avoid exceeding 5 days of therapy, due to the risk for serious adverse effects (e.g., peptic ulcer, gastrointestinal bleeding, perforation). One hospital reported that a patient received a total of 85 doses of ketorolac over a 4-week period. Despite the organization's EHR defaulting the order to an automatic stop time of 48 hours, the prescribers continued to reorder the medication for additional doses. Fortunately, no harm was reported. In another report, a hospitalized patient also inadvertently

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## SAFETY briefs

**Hazard! Broselow Rainbow Tape contains incorrect information.** The Broselow Rainbow Tape is a tool used during emergencies that has color zones with pre-calculated information for medication dosages, equipment sizes, and other procedures based on the child's height, measured using the tape. ECRI recently published an alert stating that on May 15, 2025, AirLife released an urgent medical device recall for its branded version of the Broselow Rainbow Tape product code 7700REA. They have notified customers that "AirLife brand, 2025 Edition, and 36-23446 Rev 2 Print Version" Broselow Rainbow Tape has been manufactured with incorrect information. The letter details the following:

- The values for the **Red zone** (6 to 11 months, 8 to 9 kg) in the Cardioversion/Defibrillation section contain the incorrect Joules. See Image B in the letter, which shows the incorrect information highlighted. Using the correct Joule level is crucial for effective cardioversion and defibrillation while minimizing the risk of harm to the patient. Shocking an 8 to 9 kg patient with an excessive dose of Joules may cause significant harm, including burns, heart damage, and potential cardiac arrest. **The correct Cardioversion/Defibrillation information for a 6 to 11 month patient (8 to 9 kg) in the Red zone of the Broselow Rainbow Tape is:**
  - **Synchronized Cardioversion 1st Dose should be 9 Joules**
  - **Synchronized Cardioversion 2nd Dose should be 18 Joules**
  - **1st defibrillation should be 18 Joules**
  - **2nd defibrillation should be 36 Joules**
  - **3rd defibrillation should be 54 Joules**

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received ketorolac for more than 5 days. Although the original order was discontinued, it fell outside of the hospital's 72-hour standard view timeframe in the EHR and was not visible to practitioners. Not being able to see the previous doses of ketorolac and lacking any clinical alerts, the prescriber ordered a second course of ketorolac therapy, thereby exceeding the established limit.

## Maximum Dose Limits in Automated Compounding Devices

Errors exceeding maximum doses have also been reported when prescribing parenteral nutrition (PN) additives and using automated compounding devices, particularly for pediatric patients. Similar to a 1,000-fold fatal error in a preterm infant that occurred more than a decade ago, a report shared in our July 4, 2019 article, *Too close for comfort: fatal zinc overdose narrowly avoided*, involved a prescriber mistakenly ordering 700 mg instead of 700 mcg of zinc for a child when the pediatric PN template defaulted to mg dosing units. In both cases, a maximum dose warning did not fire for the prescribers entering the orders or the pharmacists transcribing and/or verifying the PN orders.

## Maximum Dose Limits in Smart Pump Drug Libraries

Without a maximum dose built into the smart pump library, a programming error, including programming doses or rates 10-times greater than intended (e.g., entering 200 mg instead of 20 mg, 19 units/hour instead of 1.9 units/hour) could lead to significant patient harm. In our April 20, 2023 article, *Incorrect lidocaine infusion option selected in smart pump drug library*, we discussed how an anesthesiologist inadvertently administered lidocaine at a rate of 30 ***mg/minute*** instead of 30 ***mcg/kg/minute***. The anesthesiologist had inadvertently selected a lidocaine option in the smart pump drug library that was intended for ventricular tachycardia with a dose rate of mg/minute, instead of the option in mcg/kg/minute that was intended for perioperative infusions in this organization. Although the dose error-reduction system (DERS) was set with a hard maximum limit (5.5 mg/minute) for the selected lidocaine option, the pump was running in anesthesia mode, and the hard stop feature was not available to protect end users from a potentially catastrophic programming error. When the anesthesiologist programmed a dose of "30," the soft maximum alert (greater than 5 mg/minute) fired but was overridden. The patient subsequently received 1,544 mg over 50 minutes rather than the intended dose of 85 mg. When the programming error was discovered, the patient was immediately treated with a lipid rescue infusion and recovered.

**Safe Practice Recommendations:** Organizations should determine the circumstances in which maximum doses of medications should be established and implement safeguards to ensure they are not exceeded. Consider the following recommendations:

**Determine oversight.** Assemble an interdisciplinary team (e.g., clinical informaticist, medication safety officer, prescriber, pharmacist, nurse) to review current maximum dose functionality (e.g., limits, alerts, calculators) in the organization's various technologies (e.g., EHR, automated compounding device software, smart infusion pump). This team should be tasked with assessing the need for modifying and/or adding additional maximum dose functionality on a regular basis.

**Evaluate medications on formulary.** For medications on your organization's formulary, review prescribing information, clinical guidelines, and primary literature to determine which medications have established maximum doses. Consider starting with known problematic drug classes (e.g., opioids, benzodiazepines, anticonvulsants, anticoagulants). Review the maximum dose when preparing drug monographs and proposals for new formulary additions. Establish a process to review medications that may have updates to the maximum dosing recommendations that are already a part of the formulary. When a medication is considered for formulary addition or when conducting an annual formulary review, think through the entire medication-use process to consider if the medication has a maximum dose that requires a system change (i.e., hard stop) and, if so, where it might be incorporated. For example, institute a hard maximum dose limit

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- The information for sodium bicarbonate in the **Orange zone** of the tape (7 to 9 years, 24 to 28 kg) is incorrect. See Image C in the letter, which shows the incorrect information highlighted. The incorrect concentration listed may lead to overdosing the patient and may cause metabolic alkalosis, electrolyte imbalances, tissue damage, and potentially worsen respiratory status. **The correct sodium bicarbonate concentration for the Orange zone (7 to 9 years, 24 to 28 kg) should be 27 mEq (27 mL).**

- The information for sodium bicarbonate concentration in the **Grey zone** of the tape (less than 3 months, 3 to 5 kg) is incorrect. See Image D in the letter, which shows the incorrect information highlighted. The incorrect concentration listed may lead to underdosing the patient and may cause reduced myocardial contractility, decreased response to vasopressors, and increased risk of dysrhythmia. **The correct sodium bicarbonate concentration for the Grey zone (less than 3 months, 3 to 5 kg) should be 8.4%.**

Conduct a thorough search and check the inventory in all locations where this product may be used. If impacted product is identified, immediately discontinue use and destroy affected product. Complete the Response Form and Certificate of Destruction Form provided in the recall letter, and return the forms to AirLife, who will provide replacement product. Educate practitioners about this safety concern and the actions you have taken. Report issues to the US Food and Drug Administration (FDA) and ISMP.

HIGH-ALERT

**Paralytic agent mistaken for insulin.** A nurse went to remove a 10 mL vial of 100 units/mL **HUMULIN-R** (regular insulin human injection) (Eli Lilly) from the automated dispensing cabinet (ADC) refrigerator. She discovered 7 vials of rocuronium 50 mg/5 mL (Meitheal), mistakenly stored with Humu**LIN**-R vials in the insulin ADC bin (**Figure 1**, page 3). The vials were similar in size and with a yellow cap. Although

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for conventional amphotericin B in order entry software (prescriber and pharmacy) and infusion pumps to ensure that a single daily dose of conventional amphotericin B never exceeds 1.5 mg/kg.

**Use hard stops judiciously.** When safeguarding maximum doses, consider scenarios in which a hard stop may be warranted. In our June 29, 2023 article, *A hard look at hard stops and workarounds in the acute care setting*, we discussed how hard stops should be limited to prevent absolute contraindications or catastrophic errors. They should not prevent practitioners from prescribing, dispensing, or administering a clinically appropriate, but perhaps unusual dose. Rather, hard stops should be in place to at least force a time-out and protect against massive overdoses or contraindications. In addition, display the rationale for hard stops for practitioners to help identify the problem.

**Maximize clinical decision support in the EHR.** Determine which medications have maximum dose warnings in the EHR, where that information is displayed (e.g., dose range checking, order sentence/special instruction notes, alerts upon barcode scanning), and test to evaluate what different practitioners can see. Run reports to determine the effectiveness of current maximum dose limits (e.g., single maximum dose, daily maximum dose, BCMA alerts for maximum dose administered within 24 hours) and consider if adjustments are needed. Check your EHR settings to determine how long discontinued orders are visible to practitioners (i.e., ensure practitioners can view recent doses ordered and administered) and evaluate how long alerts (e.g., drug-drug interaction, maximum dose) will fire after the medication order has been discontinued. Consider which medications require enabling a cumulative dose calculation (e.g., acetaminophen, chemotherapy) to alert practitioners if the maximum dose has been reached. Provide alerts regarding significant drug-drug interactions which may increase concomitant serum drug concentrations and for changes in renal and hepatic function which may further alter drug metabolism. When calculating whether a maximum dose has been exceeded, all sources of that drug should be considered including all routes (e.g., oral, suppositories, intravenous) and combination products. With any alerts, have the clinical informaticist regularly monitor the alert frequency and override rate to address concerns for alert fatigue and adjust as needed.

**Include maximum dose limits in automated compounding devices.** The ISMP ***Guidelines for Sterile Compounding and the Safe Use of Sterile Compounding Technology*** calls for organizations to implement automated compounding devices that are interfaced with the EHR to eliminate transcription errors. If an interface is not available, organizations should build, test, and heed maximum dose warnings in automated compounding devices, with a maximum dose hard stop for critical overdoses (e.g., elemental zinc above 250 mcg/kg for pediatric PN). For example, check your system to determine if a hard stop warning would appear if a zinc overdose were entered, and if not, build and test a hard stop for this product.

**Optimize maximum dose limits in the drug library.** Establish and/or evaluate maximum dose limits for each medication infusion and loading/bolus dose and ensure the smart pump limits match the EHR limits. Create drug libraries with soft dosing limits that reflect the maximum expected dose and rate prescribed as well as a buffer for patients who may require more or less than the typical default doses and rates. Set hard dosing limits as a forcing function to prevent catastrophic errors, while considering patients who may clinically require atypical doses, to prevent end users from needing to program the infusion without engaging the DERS. If different indication-based library entries are needed for certain medication infusions, determine if the infusion is only used for a single indication in a specific location (e.g., palliative care), and limit the drug library for that location to only one option, when possible. Refer to the ISMP ***Guidelines for Optimizing Safe Implementation and Use of Smart Infusion Pumps***. Smart infusion pump dosing limits should not cause nuisance alerts or prevent the programming of incremental doses. The smart infusion pump team should regularly monitor drug library usage and alerts, including overridden soft maximum dose alerts, and adjust the dose limits as needed based on current practice and the literature.

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the rocuronium vial label states, "Warning: Paralyzing Agent" and "Warning: Paralyzing agent. Causes Respiratory Arrest. Facilities must be immediately available for artificial respiration," and has a warning on the top of the cap (**Figure 2**), this could be easily missed, especially when reaching into a bin that is supposed to contain insulin.

**Figure 1.** Similar-sized vials of Humu**LIN**-R and rocuronium, both with yellow caps, were found mixed in the Humu**LIN**-R ADC refrigerator bin.

**Figure 2.** The cap on the rocuronium 50 mg/5 mL vial by Meitheal states, "Paralyzing Agent."

In this hospital, in the ADC refrigerator, rocuronium is stored in an orange lidded bin with labels stating "Warning: Paralytic agent," and insulin is stored in a blue bin that does not have a lid. During the event investigation, a pharmacist found that a pharmacy technician student had refilled the ADC. They were unfamiliar with rocuronium and did not realize that it was a paralytic agent. Thus, they did not know that the rocuronium vials were supposed to be placed in the lidded bin labeled with warnings. The pharmacist also uncovered that the ADC was not configured

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**Develop an escalation process to address workarounds.** During orientation and annual competency assessments, educate practitioners about what they should do if they receive a maximum dose alert (e.g., do not assume the system is wrong and that the dose is safe). Develop an escalation process that outlines required actions or notifications to designated individuals for assessment prior to a maximum dose limit being circumvented (e.g., independent double-check, approval by a supervisor). If a prescriber orders a dose above the organization's approved limit, a reference to support this dose should be available and documented to ensure the dosing is appropriate and not an error. The need and frequency of bypassing a maximum dose limit should be monitored and the limits should be re-evaluated to determine if modifications are needed.

**Use objective measures to determine maximum dose alert appropriateness.** Proactively test technologies and evaluate responses by practitioners to a maximum dose alerts in those technology systems. Did the practitioner make an alert-indicated change? Was the response appropriate? Technology should also be used to aggregate instances of workarounds. Frequent bypassing of maximum dose limits or system warnings should prompt a review of their appropriateness. Metrics within technologies that should be evaluated include:

- EHR (e.g., maximum dose alerts generated through clinical decision support and corresponding actions taken)
- Automated compounding device (e.g., hard maximum dose override attempts, overridden soft maximum dose alerts and rationale)
- Smart infusion pump (e.g., hard maximum dose alerts generated, overridden soft maximum dose alerts, actions taken in response to alerts)
- BCMA (e.g., dose exceeds maximum daily limit, dose administered too soon)

**Gather feedback.** Encourage practitioners to provide feedback on the maximum dose functionality design with a focus on unintended consequences that may lead to error-prone scenarios or unsafe choices. Elicit ways in which the maximum dose limit may be or has been bypassed. Use this information to adjust alerts as needed.

**Collaborate with vendors.** Work with technology vendors to discuss software capability for maximum dose limits and provide feedback for upcoming enhancements to prevent patient harm.

# Multiple barcodes and dates on oxytocin bags

A nurse scanned the linear barcode on the label of an oxytocin 30 units/500 mL intravenous (IV) bag (by QuVa Pharma) and administered the infusion to the patient. When discarding the bag, the nurse identified that the bag had expired prior to use. A pharmacy technician had stocked both QuVa Pharma (**Figure 1**, page 5) and Fagron (**Figure 2**, page 5) oxytocin 30 units/500 mL bags in the automated dispensing cabinet (ADC). Both products were made by 503B outsourcers and have multiple dates on each bag (e.g., compounded date, beyond-use date [BUD], expiration date of the 0.9% sodium chloride bag used to compound the product). When the technician who was loading the ADC documented the date of the first bag to expire in the ADC, they inadvertently entered the expiration date of the 0.9% sodium chloride bag, which was much further out than the compound's actual BUD, so no ADC warning was generated. The hospital discovered that many patients had received expired bags made by both QuVa Pharma and Fagron. There was no reported harm.

A second hospital reported that QuVa Pharma's oxytocin bag has multiple barcodes. It contains both a linear barcode and a 2-dimensional (2D) barcode on the oxytocin label, plus a linear barcode and 2D barcode on the 0.9% sodium chloride bag used to compound the product. The

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to require users to scan the bin barcode when refilling medications.

The hospital that reported this has changed the ADC configuration so that the user is required to scan the ADC bin and medication barcode for all paralytic agents. However, this would not prompt scanning or prevent situations like this, where the technician student was supposed to be refilling insulin or another medication, but unknowingly had a paralytic agent in hand. For this reason, the ISMP ***Guidelines for the Safe Use of Automated Dispensing Cabinets*** recommend using machine readable codes (e.g., barcode scanning technology, radio frequency identification [RFID]) to promote accurate placement of all medications in the correct ADC drawer or pocket location.

In addition, the ISMP ***Targeted Medication Safety Best Practices for Hospitals***, *Best Practice 7*, calls to segregate, sequester, and differentiate all neuromuscular blocking agents (NMBs) from other medications, wherever they are stored in the organization, and place them in a sealed box or, preferably, in a rapid sequence intubation (RSI) kit. If your organization purchases these products, ensure they are stored separately and that barcode scanning is used when receiving, dispensing, refilling the ADC, and prior to administration. During onboarding, educate new practitioners and students about high-alert medications, including paralytic agents and insulin, and the safeguards the organization has in place to prevent errors with these drugs.

**Do not use non-sterile ultrasound gel for percutaneous procedures.** The Centers for Disease Control and Prevention (CDC) released an alert about an ongoing multistate investigation involving the use of non-sterile ultrasound gel for ultrasound-guided percutaneous procedures that involve skin or tissue puncture (e.g., placement of central and peripheral intravenous lines, amniocentesis, paracentesis, tissue biopsy, surgical procedures). In addition, recent product testing identified *Paraburkholderia fungorum* (formerly *Burkholderia fungorum*) from two non-sterile ultrasound gel products. CDC is aware of 40 isolates of

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hospital was concerned that practitioners may scan the 0.9% sodium chloride barcode rather than the actual barcode that identifies the product as oxytocin. In addition, the 2D barcode on the oxytocin label contains the expiration date and lot number, which could help capture if a product has expired—but only if practitioners know which barcode to scan and the electronic health record software can recognize the information.

In our March 13, 2025 article, *Infusion errors can still occur with interoperability*, we warned about an error that occurred because an infusion bag had more than one barcode. In this case, a nurse scanned the manufacturer's barcode on the dextrose 5% water (D5W) bag that the pharmacy used as a diluent to compound an amiodarone infusion, rather than the pharmacy-generated barcode identifying the compounded amiodarone product. As the patient also had an order for a D5W infusion, the amiodarone was infused at the prescribed D5W rate, resulting in an overdose.

Having multiple barcodes and dates on an infusion bag can lead to confusion about which barcode to scan and when the product actually expires. We have reached out to QuVa Pharma and Fagron and recommended reviewing how barcodes and dates are displayed on IV bags. 503B outsourcers should ensure that the final BUD of the compounded product is more prominent and consider covering the manufacturer's diluent (e.g., 0.9% sodium chloride) barcode and expiration date, when possible.

Errors like this call for an evaluation of your policies and procedures regarding how the pharmacy displays barcodes and BUDs on pharmacy-prepared products and how they are displayed on outsourced infusion bags that the pharmacy purchases. Educate staff on where to find the product's BUD and which barcode to scan. The organization that reported the first event is now scanning the 2D barcode on the oxytocin label so that a product that has expired will generate an alert upon scanning. Gather feedback from end users and share close calls and errors related to multiple barcodes and expiration dates. Report errors to 503B outsourcers and to ISMP.

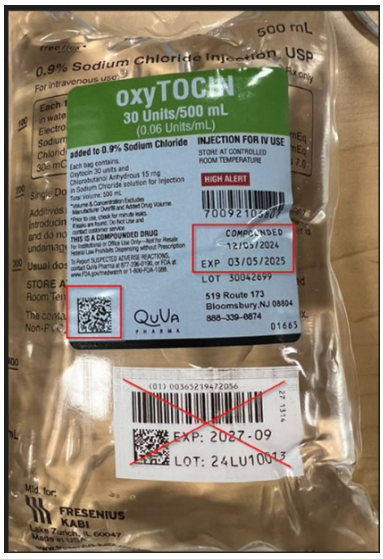


**Figure 1.** QuVa Pharma's oxytocin 30 units/500 mL bag has a compounded date (12/05/2024), an expiration date (EXP) or BUD of the compound (03/05/2025), and an expiration date of the 0.9% sodium chloride injection bag that was used to compound the product (2027-09).


**Figure 2.** Fagron's oxytocin 30 units/500 mL bag has a compounded date (04/23/2024), BUD (07/22/2024), and an expiration date of the 0.9% sodium chloride injection bag that was used to compound the product (2025-12).

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*P. fungorum* identified in patients' blood cultures who had undergone ultrasound-guided percutaneous procedures prior to culture collection. ECRI also released an alert, *Next Medical Products—ClearImage and MediChoice Ultrasound Gel: May Be Contaminated with Paraburkholderia fungorum* warning that improper use of ultrasound gel is a risk to patient safety.

Share this information within your organization and ensure only single-use ultrasound gel products for ultrasonography labeled as "sterile" are ready for use when preparing for and during percutaneous procedures. Practitioners who perform ultrasounds and/or ultrasound-associated procedures should be trained in the appropriate use of ultrasound gel products. An ultrasound gel product label's claim of "bacteriostatic" or "contains preservative" without a specific indication of sterility should be considered non-sterile. Report any adverse events with the use of ultrasound gel products to the product manufacturer, the US Food and Drug Administration (FDA), and ECRI/ISMP.

## Special Announcements

### CHEERS AWARDS nominations open

Each year, ISMP honors various healthcare disciplines that have demonstrated an exemplary commitment to medication safety through innovative projects with an ISMP **CHEERS AWARD**. Nominations for this year's **CHEERS AWARDS** are now open and will be accepted through **August 1, 2025**. For more details and to submit a nomination, click here.

### Short survey on automated dispensing cabinets (ADCs)

Med Safety Board, an ISMP company, is surveying the safe use of ADCs regarding storage configurations, error risks, and medication access concerns. This survey is for all healthcare professionals involved with ADCs. Please take 5 to 10 minutes to complete the survey by **June 30, 2025**. Thank you for your participation!



**ISMP Medication *Safety Alert!* Acute Care** (ISSN 1550-6312) 

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