Comparison of Potassium Salts

US products are prescription unless otherwise indicated. In Canada, oral potassium salts do not require a prescription; however, those with more than 5 mEq (mmol) per single dose are only available from the pharmacist and must be kept behind the counter.[1] To reduce esophagitis with oral potassium, counsel patients to drink at least 125 mL of water and stay upright for at least 30 minutes after administration.[2] Divide larger daily oral doses (such as more than 20 mEq [mmol]) to reduce the risk of GI problems.[3] Also see our chart, *Potassium Content of Foods and Salt Substitutes*.

1 mEq of potassium = 1 mmol of potassium

Potassium Salt/Forms	Example Brands/Strengths[a]	Comments
POTASSIUM CHLORIDE: 750 mg of potassium chloride is equivalent to 10 mEq (mmol) of potassium.		
Wax-matrix tablet, slow-release	Generics: 8 mEq, 10 mEq (US), 20 mEq (US) *K-Tab* (US): 20 mEq *Klor-Con* (US): 8 mEq, 10 mEq	• Choice for most patients due to effectiveness for most common causes of potassium loss (i.e., diuretic- and diarrhea-induced).[3] • Potassium chloride has better GI absorption compared to other potassium salts.[4] • Microencapsulated forms may cause less GI irritation/bleeding compared to wax-matrix tabs.[3,5] • Oral liquid formulations act quickly and are usually inexpensive; however, they must be diluted and have poor adherence due to a strong unpleasant/bitter taste.[3,5] • Microencapsulated **tablets** can be dispersed in 120 mL water, let sit two minutes, stir 30 seconds, then drink. Rinse cup with 30 mL of water and drink, then repeat with 30 mL more.[4] • Microencapsulated capsules can be opened and sprinkled onto a small amount of soft food (e.g., applesauce, pudding).[4] Food should be swallowed immediately, without chewing, and followed by a full glass of water.[4] • Some wax-matrix formulations produce a "ghost" tab in the stool.[4] • Concentrated injectable solution is considered a high-alert medication by ISMP.[6]
Microencapsulated tablet, sustained-release	Generics: 10 mEq (US), 20 mEq *Klor-Con M10* (US): 10 mEq *Klor-Con M15* (US): 15 mEq *Klor-Con M20* (US): 20 mEq	
Microencapsulated capsule, sustained-release	Generics: 8 mEq, 10 mEq (US) *Klor-Con Sprinkle* (US): 8 mEq, 10 mEq	
Powder packets for oral solution (US only)	Generics: 10 mEq, 20 mEq *Klor-Con*: 20 mEq	
Oral liquid	Generics: 20 mEq/15 mL (10%), 40 mEq/15 mL (20%) (US)	
Injectable solution	Generics (**must be diluted**): 2 mEq/mL vials Premixed intravenous bags are also available with various diluents, in several concentrations and sizes.	

Potassium Salt/Forms	Example Brands/Strengths[a]	Comments
POTASSIUM PHOSPHATE: 1,350 mg of monobasic potassium phosphate is equivalent to 10 mEq (mmol) of potassium.		
Tablet (US only)	*K-Phos*, generic: 500 mg (to be dissolved in liquid)	• Choice when phosphate deficit accompanies potassium depletion (e.g., diabetic ketoacidosis).[3] • Also used for the prevention and treatment of hypophosphatemia.[4] • Injectable solution is considered a high-alert medication by ISMP (US).[6]
Injectable solution	Generics (**must be diluted**): 3 mmol/mL (US), 1.29 mmol/mL (Canada)	
POTASSIUM BICARBONATE: 1,000 mg of potassium bicarbonate is equivalent to 10 mEq (mmol) of potassium.		
Capsule (US only)	*K-Bicarb* (OTC): 99 mg Generics (OTC): 300 mg, 500 mg, 1,020 mg, 2,100 mg	• Can be considered in patients with hypokalemia and metabolic acidosis due to its alkalinizing effect.[3,4]
Effervescent tablet (US only)	*Effer-K*: 10 mEq, 20 mEq, 25 mEq *Klor-Con EF*: 25 mEq	
POTASSIUM GLUCONATE: 2,350 mg of potassium gluconate is equivalent to 10 mEq (mmol) of potassium.		
Tablet/caplet/capsule	Generics (US, OTC): 90 mg, 99 mg Generics (Canada): 50 mg, 99 mg	• Considered a dietary supplement to prevent hypokalemia.[4] • Gluconate metabolizes to bicarbonate, so can be considered in patients with hypokalemia and metabolic acidosis.[7]
Extended-release tablet/caplet	Generics (US, OTC): 99 mg, 100 mg, 195 mg Generics (Canada): 100 mg, 195 mg	
POTASSIUM ACETATE: 975 mg of potassium acetate is equivalent to 10 mEq (mmol) of potassium.		
Injectable solution	Generics (**must be diluted**): 2 mEq/mL (US), 4 mEq/mL (Canada)	• Consider for treatment and prevention of hypokalemia if acidemia is also present, when oral therapy is not an option.[4] • Alternative to potassium chloride when you want to avoid administering chloride.

Potassium Salt/Forms	Example Brands/Strengths[a]	Comments
POTASSIUM CITRATE: 1,075 mg of potassium citrate is equivalent to 10 mEq (mmol) of potassium.		
Extended-release tablet	*Urocit-K*: 5 mEq, 10 mEq, 15 mEq (US) Generics: 5 mEq, 10 mEq, 15 mEq (additional strengths available OTC in Canada) *K-Citra* (Canada): 10 mEq	• Generally used for the management of renal tubular acidosis with calcium stones, uric acid kidney stones, or calcium kidney stones in patients with hypocitruria (low urinary citrate levels).[8] • *K-Citra* is recommended for treatment or prophylaxis of hypokalemia and to help reduce the formation of kidney stones.[9] • Can be considered in patients with distal renal tubular acidosis plus hypokalemia, high blood and urine calcium levels, or calcium kidney stones.[10] • Some formulations (slow-release wax matrix; e.g., *Urocit-K*) produce a "ghost" tab in the stool.[11]
Oral solution	*K-Citra*: 10 mEq/5 mL	
Capsules (Canada only)	Generics: 99 mg (~0.9 mEq), 316 mg (~3 mEq), others	

Abbreviations: GI = gastrointestinal; ISMP = Institute for Safe Medication Practices; OTC = over-the-counter.

a. Note that OTC potassium formulations are available in multiple strengths and this list may not be all-inclusive.

Users of this resource are cautioned to use their own professional judgment and consult any other necessary or appropriate sources prior to making clinical judgments based on the content of this document. Our editors have researched the information with input from experts, government agencies, and national organizations. Information and internet links in this article were current as of the date of publication.

Levels of Evidence

In accordance with our goal of providing Evidence-Based information, we are citing the **LEVEL OF EVIDENCE** for the clinical recommendations we publish.

Level	Definition	Study Quality
A	Good-quality patient-oriented evidence.*	1. High-quality randomized controlled trial (RCT) 2. Systematic review (SR)/Meta-analysis of RCTs with consistent findings 3. All-or-none study
B	Inconsistent or limited-quality patient-oriented evidence.*	1. Lower-quality RCT 2. SR/Meta-analysis with low-quality clinical trials or of studies with inconsistent findings 3. Cohort study 4. Case control study
C	Consensus; usual practice; expert opinion; disease-oriented evidence (e.g., physiologic or surrogate endpoints); case series for studies of diagnosis, treatment, prevention, or screening.	

***Outcomes that matter to patients** (e.g., morbidity, mortality, symptom improvement, quality of life).

[Adapted from Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. Am Fam Physician 2004;69:548-56. https://www.aafp.org/pubs/afp/issues/2004/0201/p548.html.]

References

1. National Association of Pharmacy Regulatory Authorities. National drug schedules. https://napra.ca/national-drug-schedules?letter=p&page=2. (Accessed June 13, 2024).
2. Antunes C, Sharma A. Esophagitis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing;2024-. 2023 August 7.
3. Flurie RW. Disorders of potassium and magnesium homeostasis. In: DiPiro JT, Yee GC, Haines ST, et al, eds. Pharmacotherapy: A Pathophysiologic Approach. 12th ed. New York, NY: McGraw-Hill; 2023.
4. Clinical Pharmacology powered by ClinicalKey. Tampa (FL): Elsevier; 2024. www.clinicalkey.com. (Accessed June 10, 2024).
5. Lewis JL III. Hypokalemia. September 2023. https://www.merckmanuals.com/professional/endocrine-and-metabolic-disorders/electrolyte-disorders/hypokalemia. (Accessed June 12, 2024).
6. ISMP. ISMP list of high-alert medications, acute care settings. 2024. https://online.ecri.org/hubfs/ISMP/Resources/ISMP_HighAlert_AcuteCare_List.pdf. (Accessed June 10, 2024).
7. PubChem. Potassium gluconate. February 14, 2003. https://pubchem.ncbi.nlm.nih.gov/source/hsdb/3165. (Accessed December 8, 2020).
8. Product information for Urocit-K. Mission Pharmacal. San Antonio, TX 78230. May 2024.
9. Seaford Pharmaceuticals. K-Citra. https://seaford.ca/k-citra/. (Accessed June 7, 2024).
10. National Kidney Foundation. dRTA: how is it treated? https://www.kidney.org/atoz/content/drta-how-it-treated. (Accessed June 10, 2024).
11. Leslie SW. Hypocitraturia and renal calculi. May 30, 2023. https://www.statpearls.com/ArticleLibrary/viewarticle/120007#ref_30139463. (Accessed June 7, 2024).

Cite this document as follows: **Clinical Resource,** ***Comparison of Potassium Salts. Pharmacist's Letter/Pharmacy Technician's Letter/Prescriber Insights.*** **July 2024. [400760]**

Technician Tutorial:
Automated Dispensing Cabinets and Devices

The use of technology in pharmacies and healthcare in general has often been seen as a way to improve efficiency and patient safety. In fact, reports from safety groups continue to push for automation in sterile compounding and other pharmacy processes to reduce errors. Some of us might think of automated dispensing devices such as *Baker Cell* machines in community settings and cabinets (*Pyxis*, etc) in hospital settings as some of the earlier technology we encountered in pharmacy practice. Their use has expanded over time and functionality has improved in many ways. It's important to know the "ins and outs" of using these cabinets and devices properly in order to optimize their benefits while preventing errors and other issues. This tutorial focuses on practical tips for working with automated dispensing cabinets and devices.

What are automated dispensing cabinets used for in hospital settings?

In the most basic terms, automated dispensing cabinets, sometimes called ADCs for short (or automated dispensing machines [ADMs for short], or automated dispensing devices [ADDs for short]), provide compartments to securely store meds. There are different brands of cabinets, such as *AcuDose*, *Omnicell*, and *Pyxis*. Some hospitals use the cabinets to store controlled substances and meds (e.g., acetaminophen, injectable hydralazine or metoprolol, regular insulin) that might be needed urgently on a patient care unit. Other hospitals use the cabinets to store the majority of meds that patients on a patient care unit or in procedural areas need at any given time. (Note that these differences can impact other workflow in the pharmacy, such as whether a cart fill is necessary for dispensing meds to patients.) Cabinets may also be used in the pharmacy to securely store meds, such as controlled substances needed for prepping doses in an IV room.

Depending on the way a hospital uses cabinets, med stock may remain mostly static (i.e., the first example above, where mainly controlled substances are stored), or it may be very dynamic (i.e., the second example above, where most meds a patient is taking are stored). Changing the meds stocked in a cabinet will typically involve "loading" a med using the computer system and possibly removing a med that's not currently being used by a patient, to make room for a new med in a cabinet. For example, some pharmacies might periodically run reports and remove meds that haven't been used in a specified time period to make room for other needed meds.

Automated dispensing cabinets help with accountability of meds since they track activity such as restocking, inventorying, removal of doses, return of unused doses, etc. And they also help with security of meds in a non-physical sense, in that they may track activity by user. Users must sign in to access meds, such as with a password or a fingerprint scan.

The most common users of automated dispensing cabinets are nurses, accounting for about 80% of transactions. Pharmacy technicians are users, of course, since they're typically responsible for managing meds in cabinets, restocking them when a supply runs low, etc. Other users include pharmacists and possibly prescribers, such as anesthesia clinicians in an operating room setting.

There may be variation in the locations where automated dispensing cabinets are placed in hospitals, such as which patient care units have them. In addition, there are different kinds of drawers or compartments where meds can be placed. For example, controlled substances may be kept in compartments with locked lids, so that only one med in an open drawer can be accessed at a time. Certain non-controlled substances may be kept in an open-grid or matrix-type a drawer.

Some cabinets might be "profiled," which means that the system is connected to patient profiles of meds that have been ordered by a prescriber. Other cabinets might be non-profiled, meaning that a user can simply sign in and have open access to remove any med in the cabinet for a patient.

What are some rules of thumb for stocking meds in automated dispensing cabinets?

The way you stock meds in automated dispensing cabinets may impact the risk of med use issues and errors. The following are some important points to consider to help ensure safety.

Choose "par" levels carefully. Having too much of a drug in an automated dispensing cabinet can increase the risk of a nurse accidentally administering an overdose. However, not having enough can increase the risk of treatment delays due to frequent stock outs and the need to restock a cabinet. Follow your pharmacy's policies on setting par levels for meds in cabinets. Other considerations for par levels might include med cost, temporary drug shortages, etc.

Check expiration dates of meds. Follow your pharmacy's policies on not placing "short dated" meds in cabinets. For example, meds with an expiration date sooner than one or two months may be prohibited from being stocked in cabinets, due to the increased risk of expired meds being accidentally administered if they aren't used up or replaced before the expiration. When stocking a med in a cabinet, be sure to enter the actual expiration or beyond-use date of the shortest dated med of the bunch, and not an arbitrary value.

Also, be sure to follow your pharmacy's policies on identifying and removing expired meds from cabinets. For example, in some cases, expiration dates may need to be checked each time a compartment in an ADC is accessed by pharmacy staff.

As mentioned, using **extra security for controlled substances**, such as locked-lidded drawers or pockets, is important. Another extra security measure is setting "blind counts" for controlled substances. This means that the user must enter the counted number of capsules, tablets, vials, etc, rather than confirming an inventory that the cabinet displays. This helps catch discrepancies in counts. If an incorrect count is entered, a discrepancy is created in the computer system, with the user's name attached to it, and resolution of the discrepancy in a timely manner will be required.

Avoid unloading emergency meds in order to make space for routine meds a patient is taking. If possible, unload a non-emergency med that is not being used. For example, you should avoid removing injectable epinephrine from a machine to make space for cephalexin capsules.

Also, **be cognizant of where you place meds** with regard to convenience and safety. Avoid placing the most commonly used meds in the very back of a drawer or up high on a tall machine, to keep nurses from having to reach far for them. And avoid placing breakable meds such as vials in spots where they could easily fall out and break.

Try to **avoid restocking automated dispensing cabinets at common med administration times** in your hospital. This can create delays if nurses have to wait, and nurses may be tempted to grab extra doses and take other shortcuts to save time. Plus, it can be distracting for nurses and for you, which could lead to errors.

What strategies can reduce errors with meds dispensed from automated dispensing cabinets?

Strategies such as separation of look-alike/sound-alike meds can be used to prevent errors when meds are dispensed from automated dispensing cabinets. For example, placing hydrALAZINE beside hydrOXYzine in an open matrix drawer could increase the chance that a nurse will remove the wrong med to administer to a patient. Not only do these med names look similar, but they also come in overlapping strengths.

Typically, you will be able to determine the location of a med when you are first loading it into the machine. So, at this step, be cognizant of other meds that will surround the newly loaded med, including different doses of the same med. Also, check your pharmacy's policy on preventing errors with look-alike/sound-alike meds for additional guidance. These policies are required to be in place by The Joint Commission (US).

Another consideration is which type of compartment a med should be loaded in. For instance, high-alert meds such as insulin, or meds that are prone to diversion such as opioids, should not be loaded into compartments with open access, such as open matrix drawers. And whenever possible, individual doses of meds should be used to stock cabinets, rather than bulk or multidose containers.

Organize meds when setting up to restock cabinets before you even leave the pharmacy. For example, place each different product in a separate bag. If cabinets require barcode scanning prior to restocking, follow proper procedures and avoid workarounds, such as scanning one package multiple times if each package should be scanned. Try to avoid interruptions or distractions once you reach the cabinet and start restocking. (As mentioned, cabinets should generally not be restocked during common med administration times.) These measures can help prevent accidental misfills of meds that could lead to the wrong med being dispensed and administered.

Also, be sure to comply with your pharmacy's policies on having double checks of meds, especially high-alert meds such as heparin or insulin, prior to restocking automated dispensing cabinets.

Speak up about any issues that could lead to confusion, such as if the drug name on your pick list, the med label, and the cabinet display don't match. These should be standardized to help prevent mix-ups.

An additional measure to consider is watching out for packaging changes that could be confusing to nurses. Alert your admin to encourage communication with your nurse colleagues to prevent errors. One example is the labeling change of meds with ratio strengths, such as epinephrine and isoproterenol, to mg strengths. Also watch out for any look-alike packaging that could lead to errors. For example, *Cardene* (nicardipine [US only]) and *Nexterone* (amiodarone) premixed drips (US only) come in similar boxes, and the same size and type of IV bags.

Another important safety issue is the use of "overrides." This refers to a clinician removing a med without having an order for the med or without having the order for the med reviewed by a pharmacist. One of the problems with the override function is that problems such as duplicate therapy, patient allergies, or inappropriate dosing can be missed. Or the wrong med could be removed from the cabinet. This is why the use of overrides should be limited to situations where a delay could result in patient harm. For example, injectable epinephrine may be needed immediately if a patient has a serious allergic reaction, such as anaphylaxis, where their airways swell and breathing becomes difficult. In fact, hospitals typically have a list of meds that are allowed to be accessed on override, along with which patient care units and clinicians can access them. And in some cases, a system can be set up so that certain meds can't be removed from cabinets using override.

Last but not least, regularly observe the area where cabinets on your units are placed. Problems such as dim lighting or a tight or chaotic location could increase the risk of errors. Let your admin or medication safety officer know about any potential issues, so they can work with nursing colleagues to come up with a solution.

How do automated dispensing devices work in the community pharmacy setting?

In the community setting, automated dispensing devices work differently, but they have similar benefits as in the hospital setting. These include streamlining workflow and controlling inventory. The extent of benefits can depend on the type of device. Some devices (e.g., *Baker Cell* machines, *Kirby Lester 1*) simply count pills, while others (e.g., *Parata Max*, *ScriptPro*) also label prescription vials and track inventory. The more advanced devices are often referred to as robots.

Similar errors can occur with automated dispensing devices in the community setting as well, such as filling the devices with the wrong meds, incorrect strengths of meds, or expired meds.

What are some rules of thumb for using automated dispensing devices in the community setting?

It's easy to see how the same care must be taken when working with automated dispensing devices in the community setting as in the hospital setting. Here are some helpful tips:

- Use your own sign in or badge to access the device.
- Match the information on stock bottles with the information on the cell before filling it with medication. Check NDC (or DINs in Canada), keep a close eye on drug strengths and suffixes, and be extra careful with look-alike/sound-alike meds. Always scan bar codes as a double check.
- Follow pharmacy policies on meds that should not be placed in the automated dispensing device (e.g., hazardous meds, original container meds).
- Do a visual check to make sure the meds in the cell match the ones in the stock bottle, especially if you use multiple bottles to fill cells, return a med to stock, or are interrupted during this step.
- Follow your pharmacy's policy on having a double check when you refill a cell.
- Don't mix meds from different manufacturers in the same bin or cell. This can lead to patient confusion and throw off inventory counts.
- Make sure each cell or bin is properly labeled with the drug name, strength, NDC number (or DIN), and expiration date, and that bar codes on labels are readable.
- Avoid adding broken tablets, package inserts, cotton, or desiccants into cells.
- Follow your pharmacy's policy and the manufacturer's instructions for calibrating, cleaning, and maintaining automated dispensing devices.
- Consider doing "sample" counts weekly to check the accuracy of automated dispensing devices. Devices can miscount if they aren't calibrated correctly.
- For robots, make sure supplies such as labels and vials don't run out to avoid delays in the dispensing process.

What are discrepancies in automated dispensing cabinets and how should they be handled?

As mentioned, a discrepancy in an automated dispensing cabinet typically refers to a difference between the amount of a med in a drawer or compartment and the amount of the med that's SUPPOSED to be in the drawer or compartment according to computer inventory. For example, if a cabinet's inventory of immediate-release oxycodone 10 mg tabs is 23 tabs, but a nurse opens the drawer and finds 21 tabs, there's a negative discrepancy.

Discrepancies with non-controlled meds can happen when a nurse takes out more than one dose at a time for a patient or for multiple patients. This is a workaround that can increase the risk of errors, but most often, is not as critical to be resolved. On the other hand, a discrepancy with a controlled med is a very big deal and should be addressed as soon as it's discovered and before the end of the involved parties' shifts. Reasons for these discrepancies could range from a simple miscount to actual drug diversion, administration of an incorrect dose, etc.

What issues come up with operation of automated dispensing cabinets and devices and what are tips for addressing them?

Malfunctions with automated dispensing cabinets and devices are not uncommon. They can be very simple, such as a medication package sticking out of a cabinet drawer causing it to jam. On the other hand, malfunctions can be more complicated to resolve, and may require calling the vendor for assistance.

Be familiar with the steps required to troubleshoot problems with the type of automated dispensing cabinets in your hospital or automated dispensing device in your community pharmacy. Discourage measures such as kicking or shaking a machine. These can make the user feel better but do little to resolve the actual issue! Keep the vendor's phone number handy, in case you need to contact them on your shift. Having this information close by can help resolve problems quickly, minimizing the need for workarounds and workflow interruptions.

If there are updates to functionality of automated dispensing cabinets or devices, ensure that you are trained properly on these, and ready for them when they go live. They may be limited to a new safety feature, or the system may be upgraded completely. Even better, if you know that changes are coming, provide feedback to an appropriate person to help avoid unanticipated snags. Input from frontline staff can be very valuable; you may know details about workflow that would be critical to consider but may otherwise be overlooked.

What information can I get from an automated dispensing cabinet?

One benefit of automated dispensing cabinets is that they can provide records of activity. Here's an example of a practical application. Say there's a shortage of a particular med, and your administration has decided that it's most important to reserve doses of that med for pediatric patients. A report can be run to show which cabinets contain the med, and possibly how much of the med is in each cabinet. This is helpful because pharmacy staff can target these machines to remove the med from adult patient care units and redistribute it to pediatric units. Another example is if a med is recalled. A report can be run to see which cabinets have the med in stock, and efforts can be directed to those cabinets to check for recalled lots.

Functionality for running reports can vary between systems, so check with a pharmacist or an administrator if you need help learning what reports you can run, or are required to run, for your automated dispensing cabinets. A required report might be one that tracks the use of overrides by nurses, to make sure that the use of overrides was limited to appropriate situations such as emergencies and not routine administration of meds.

Cite this document as follows: **Technician Tutorial,** ***Automated Dispensing Cabinets and Devices. Pharmacist's Letter/Pharmacy Technician's Letter.*** **March 2023. [390382]**

--Continue to the next section for a "Cheat Sheet" for Automated Dispensing Cabinets and Devices--

"Cheat Sheet" for Automated Dispensing Cabinets and Devices

What are automated dispensing cabinets used for in hospital settings?

- Automated dispensing cabinets (ADCs), also referred to as machines (ADMs) or devices (ADDs), help provide secure storage to meds both outside and inside the pharmacy.

What are some rules of thumb for stocking meds in automated dispensing cabinets?

- Place reasonable quantities of meds in cabinets, so very frequent restocking isn't required, but also so an excess quantity is not available for administration to patients.
- Avoid placing meds that'll soon be out of date in cabinets in most cases. Enter actual expiration or beyond-use dates of meds when stocking cabinets, not an arbitrary value.
- Avoid placing controlled substances in compartments with open access, to help prevent diversion.
- Keep in mind that emergency meds may need to be kept in cabinets at all times. Avoid replacing these with non-emergent meds.
- When loading meds into a cabinet, be aware of potential issues such as look-alike/sound-alike drug names, or physical barriers such as placing fast movers on high shelves in a tower.
- Avoid restocking cabinets at common med administration times.

What strategies can reduce errors with meds dispensed from automated dispensing cabinets?

- Load meds into appropriate locations, such as by placing high-alert meds in compartments with locked lids as an extra safeguard.
- Prevent misfills of cabinets by keeping meds for restocking cabinets organized in the pharmacy, such as by placing different products in separate bags.
- Follow your pharmacy's policies for having meds that are meant for restocking a cabinet double checked before leaving the pharmacy.
- Check to be sure med names match on pick lists, med labels, and cabinet displays.
- Follow your pharmacy's policies that apply to overrides from cabinets.
- Report any potential issues about locations of cabinets, such as dim lighting or a chaotic area.

What are discrepancies in automated dispensing cabinets and how should they be handled?

- A discrepancy is when the physical count of a med does not match the computer count.
- Help ensure discrepancies are resolved in a timely manner, or reported to the appropriate person if they are not or cannot be resolved.

What issues come up with operation of automated dispensing cabinets and what are tips for addressing them?

- Malfunctions of cabinets are not uncommon. These can prevent meds from being removed, which could delay patient care.
- Cabinet malfunctions may be caused by something simple, such a jam in a drawer, or something more complicated requiring technical assistance from the vendor.
- Know how to troubleshoot cabinet issues. Have needed contact information on hand in case the vendor must be called to help resolve an issue.

[March 2023; 390382]

Technician Tutorial:
Dispensing Drugs for Pediatric Patients

Preventing medication errors is a top priority in the care of all patients. This is especially true in the pediatric population. Between 2.5% and 5.7% of pediatric patients are subject to a medication error while in the hospital. This rate is approximately three times of that seen in adults. In the outpatient setting, the rate of reported preventable medication errors in pediatric patients is closer to 3%. It is thought that rates are actually higher than these numbers due to underreporting.

Pediatric patients are not just "little adults." Essentially, this group encompasses children who weigh one pound or less, up to those who are the same size as adults. Pediatric patients are usually grouped according to age, and these groupings can vary, depending on the source. Pediatric age groups can help differentiate different stages of development. Examples of age groupings include:

- Pre-term - born before 37 weeks of pregnancy
- Neonate - newborn to one month of age
- Infant - one month up to 12 months
- Toddler - 12 months up to 36 months
- Child - three years up to 12 years
- Adolescent - 12 years up to 18 years

Pharmacy technicians play an important role in preventing medication errors and ensuring patient safety when filling prescriptions or orders for pediatric patients.

NYSTATIN 100,000 UNITS/ML SUSPENSION
DAW: 0=NOT SPCFD
UOM: SUSPENSION
QTY: QS
REFILLS: 0 DAYS' SUPPLY: 14
WRITTEN 12/8/2020
TAKE 200,000 UNITS BY MOUTH FOUR TIMES A DAY X 14 DAYS

Your pharmacy receives an electronic Rx for nystatin oral suspension for a 5-week-old baby girl. Her mother calls the pharmacy to make sure you received the Rx and to see if you need any additional information since this is the first time she's filling a prescription for her child. What information would you need from the mother before you can fill the Rx?

How are pediatric patients different from adult patients?

From birth to adulthood, a pediatric patient's body is still developing. As the body develops, biological systems react to and process drugs differently. As a result of this, there are several ways that pediatric patients are different from adult patients.

Pediatric patients have different proportions of fat, body water, and muscle than adult patients. These proportions also differ throughout the stages of development. It's important to consider these differences because they can impact drug dosing. For example, an adult's body is made up of about 60% water, which is less than neonates (over 70%) and premature infants (85%). Differences in water composition can impact the dosing of certain water-soluble drugs. To illustrate this point, let's look at the seizure med phenobarbital. The dose in adults is 1 to 3 mg/kg/day, while the dose in infants is 4 to 8 mg/kg/day. This is

Phone: 209-472-2240 ~ Fax: 209-472-2249
pharmacist.therapeuticresearch.com ~
pharmacytech.therapeuticresearch.com

because phenobarbital is very water soluble and gets diluted out in the body's water. It's like making *Kool-Aid*. The more water (body water) you have, the more *Kool-Aid* powder (drug) you need.

Infants' and children's bodies don't eliminate drugs in the same way as adults. The liver and kidneys are the organs mainly responsible for breaking down and removing drugs from the body. As age increases, the liver and kidneys mature. In neonates and infants, for example, drugs are broken down and eliminated more slowly than in older children and adults. As a result of this, infants and children often get lower doses of meds, and in some cases, reduced dosing frequencies. For instance, in adults, the acid reflux drug famotidine is usually given twice a day. But in neonates, it's often given only once per day. Think of this as a slow leak versus a fast leak. Very young children have a slow leak (i.e., get rid of drug more slowly). Older children and adults have a fast leak (i.e., get rid of drug more quickly).

Why are medication errors more likely to happen in kids?

Children are prone to drug errors for a variety of reasons. Often, pediatric drug therapy involves complex steps that aren't necessary for adults. For example, many commercially available drugs are formulated and packaged for adults, so they may need to be compounded and/or repackaged for children. In addition, individualized doses are usually calculated based on the child's age and/or weight. Caregivers must precisely measure and administer medications to children. And many healthcare providers don't have formal training in pediatrics and may lack current pediatric drug references. All of these factors introduce the potential for mistakes to happen.

If a mistake occurs, children are less able to tolerate a drug error. As previously discussed, the absorption, distribution, metabolism, and elimination of medications in children can be different from that seen in adults due to immature organ systems (e.g., kidney, liver, immune system, etc). In addition, young pediatric patients cannot effectively communicate side effects they're experiencing.

How are drug doses for pediatric patients determined?

Drug doses for pediatric patients are usually determined on a milligram per kilogram (mg/kg) basis. For example, if a two-year-old patient weighs 12 kg and the age-appropriate dose of a drug is 25 mg/kg/dose, the patient's dose would be 300 mg.

Dose (mg/dose) = weight-based dose (mg/kg/dose) x patient weight (kg)

x = (25 mg/kg/dose)(12 kg)

x = 300 mg/dose

Pediatric doses can also be determined using body surface area (BSA). BSA is calculated from the patient's height and weight. This method is most commonly used for cancer meds. You'll rarely see it used for calculating the dose of any other type of drug. If you need to calculate a patient's BSA, you'll need their height and weight. You can then use an online calculator, instead of trying to do the math by hand. Make sure you enter the height and weight in the correct units. BSA is measured in kg/m^2, but some calculators may allow you to enter weight in either kilograms or pounds, or height in meters, centimeters, feet, or inches.

It is important to remember that generally, even in very large children, doses should not exceed the maximum adult dose.

What information should I gather about pediatric patients?

You can help prevent mistakes by making sure that needed information is available for the pharmacist. In the community setting, this might involve asking parents or caregivers of pediatric patients for information

when they bring in prescriptions. In the hospital setting, this might involve requesting information from nurses or looking at information on the patient's medication profile, medical chart, etc.

Verify current patient allergy information for all pediatric prescriptions. This should be done every time an Rx is processed for a patient. With the increase in use of electronic Rxs in the community setting, it's likely that the caregiver will not be there at the time of Rx data entry. Be sure to make a note to ask about allergies at pick-up.

Get the patient's date of birth so that age can be determined. Pediatric doses can vary significantly based on age, and the pharmacist will need this information to determine if a dose is appropriate. For example, the dose of amoxicillin/clavulanate 125 mg/5 mL (*Augmentin* [U.S.], *Clavulin* [Canada]) suspension is 30 mg/kg/day divided every 12 hours for children under three months of age when treating urinary tract infections. But it's 20 to 40 mg/kg/day divided every eight hours, or 25 to 45 mg/kg/day divided every 12 hours, for children three months or older.

Get the patient's weight. Ask for the patient's weight so the pharmacist can double check the patient's drug dose. Make sure you always clarify the unit of a patient's weight, either pounds or kg. One kg is equal to about 2.2 pounds. A misunderstanding about the patient's weight can lead to an underdosing by about half or overdosing by double. Always record weight in kilograms when entering it into any computer system to avoid confusion. Keep in mind that kids grow quickly. This means their weight will frequently change. Make a habit to ask caregivers for the most current weight of the child whenever possible.

Know how to convert from pounds to kg. Using the conversion of 1 kg equals 2.2 pounds (lbs), calculate how much a 45-pound child weighs in kg.

(45 lbs)(1 kg/2.2 lbs) = 20.5 kg

When asking for a patient's weight, take a glance at the patient if he or she is present. This is a good way to double check that the weight is roughly accurate. Ask yourself if the weight that you are recording makes sense. Drug dosing mistakes caused by using the wrong weight to calculate doses are common, yet so preventable. For example, a pharmacist recounts a situation where the infusion rate for an IV fluid for a **4.9 kg** (10.8 lb) three-month-old baby appeared to be unusually high. The pharmacist called the physician, who said "I disagree with you, this child weighs **30 lbs**." As it turned out, the physician read the weight as **14.9 kg**, which *is* roughly 30 lbs. But as he spoke it out loud to the pharmacist, he realized there was no way that the three-month-old baby weighed 30 lbs!

You confirm the patient's date of birth and ask for her weight. She is five weeks old as of today and she weighs 15 lbs. You calculate this to be 6.8 kg and enter it into the computer system (15 lbs x 1 kg/2.2 lbs = 6.8 kg). You also ask if the patient has any known allergies and gather her insurance information so that you can bill for the prescription.

What should I do to help prevent errors when dispensing prescriptions for pediatric patients?

When you dispense prescriptions for pediatric patients, there are a few things you should be sure to do.

Identify if a prescription may need to be compounded. Since some drugs are not available as liquids, but are used in pediatric patients, there may be a need to compound a liquid formulation. This is a fairly common practice in many hospital settings. In the community setting, even if your pharmacy does compound, sometimes you might not have the right "recipe." You may be able to get it by calling the hospital from which the patient was discharged (if this was the case). If you don't compound, the parent or caregiver may need a referral to a pharmacy that will be able to provide the product. Check with your pharmacist to find out what to do, and how you can help.

Double-check that you are picking the right product. A number of drugs come in different concentrations, but not all concentrations are appropriate for all pediatric patients. For example, amoxicillin/clavulanate 600 mg/5 mL (*Augmentin ES-600* [U.S.]) is not approved for use in kids under three months of age. As per product labeling, amoxicillin/clavulanate 125 mg/5 mL is the most appropriate product for those below three months. Or in the hospital setting, injectable vitamin K doses for newborn babies should be dispensed as the 1 mg/0.5 mL product, not the 10 mg/mL product, which is for older patients.

Drugs also come in a variety of dosage forms: regular tablets and capsules, extended-release tablets and capsules, sprinkle caps, chewable tabs, orally disintegrating tabs, oral solutions, etc. For example, in the U.S., generic versions of methylphenidate used for ADHD include a chewable tablet, capsule, tablet, and oral solution.

Determine the correct dose and be careful when entering it into the computer. Ten-fold dose errors are not uncommon in pediatric patients. This occurs when patients inadvertently receive either ten times more or one-tenth the amount they were supposed to receive. In the hospital, this error is often associated with morphine and other opioids, as well as antimicrobials. (For instance, you may need to prepare a 4 mg/mL dilution of gentamicin or tobramycin from the commercially available 40 mg/mL concentration for babies.) The wide range of doses that can be appropriate for pediatric patients increases the risk for dosing errors. Ten-fold dose errors occur most often during prescribing or administration. Always check calculations and make sure you have the patient's correct weight. Assess doses with decimal points very carefully. Leading zeros should always precede a decimal (e.g., 0.5 mg rather than .5 mg) but trailing zeros should never follow a whole number (e.g., 1 mg rather than 1.0 mg).

In most cases, doses will be written out, just like an adult dose. For example, an Rx for azithromycin suspension might simply say: 250 mg PO once daily. On the other hand, a dose might be written as mg/kg/dose or as mg/kg/day. It's important to make sure that the dose is clear on the Rx so that it can be calculated correctly. For example, if an Rx were to say 25 mg/kg given every 12 hours, this is not clear. Alert the pharmacist to clarify whether the intended dose is 25 mg/kg/**dose** or 25 mg/kg/**day**.

Make sure the label directions have the right amount of drug per dose. Since prescriptions for pediatric patients are usually liquids, you need to make sure that the volume of drug per dose is correct.

To calculate the volume of medicine needed per dose for a prescription, you can use a simple ratio. For example, let's say the concentration of an antibiotic suspension is 250 mg/5 mL. You get an Rx for a patient with a dose of 125 mg twice a day for 10 days. To figure out how many mL are needed per dose, follow the steps below:

1. Set up a ratio: 250 mg/5 mL = 125 mg/x mL
2. Cross-multiply on each side of the equal sign: (x mL)(250 mg) = (5 mL)(125 mg)
3. Divide by 250 mg on each side to find the unknown variable: x mL = (5 mL)(125 mg)/250 mg
4. Solve for x: x = 2.5 mL

Alternatively, you could note that 125 mg is half of 250 mg, so the volume needed will also be half of 5 mL, or 2.5 mL. It's good to get in the habit of double-checking your calculations by using two different methods, or by working backwards.

Recall that the Rx in this example instructed the patient to take "125 mg twice a day for 10 days." It's helpful to give caregivers specific dosing instructions on the Rx label to avoid confusion. In this case, it would be good to include a dose volume on the label. For example, the label may read as follows:
"Give 2.5 mL (125 mg) by mouth twice a day for ten days."

Be careful not to mix up units of measurement on prescription labels. One teaspoonful is equal to 5 mL. And one tablespoonful is equal to three teaspoonfuls, or 15 mL. Some prescribers may write directions in terms of teaspoons or tablespoons. So, it's important to know that the abbreviation for a teaspoon is usually a lower case "t," while tablespoon is an upper case "T." Using teaspoons, tablespoons, ounces, and other non-metric dosing units for oral liquids isn't preferred. This is because of mix-ups and errors. For example, caregivers may be tempted to use a household teaspoon. Unfortunately, typical household teaspoons can hold 2 to 10 mL, which can lead to inaccurate doses. Stick to using mL on label directions to avoid confusion. Or talk to your pharmacist about including both metric and non-metric units on Rx labels.

Prescribers might use the abbreviation "cc" instead of "mL" on prescriptions. These mean the same thing, but don't use cc on prescription labels. Use mL instead. Patients are unfamiliar with cc and may mistake it for teaspoons instead of mL, which can lead to a five-fold overdose.

For the baby's Rx, the dose is 200,000 units and the concentration of nystatin suspension is 100,000 units per mL. What would be the volume of the dose?

The volume is 2 mL (set up as 100,000 units/1 mL = 200,000 units/x mL).

Calculate the correct quantity and choose the right container size. Since most pediatric meds are liquids, you'll need to make sure you dispense the right amount so there's enough drug for the course of therapy. Usually, pediatric antibiotic suspension Rxs are written with the duration of treatment. This info is sometimes needed to help determine the correct quantity and container size. Talk to the pharmacist if the duration of treatment is NOT given on these Rxs. The prescriber may need to be contacted for clarification.

You will need to calculate the total volume of medicine needed so that you can select the correct container size. In the above example about the antibiotic suspension, the patient will be taking 125 mg (2.5 mL) twice a day for 10 days. Calculate the entire volume needed to dispense using the following method:

Total dispensing volume = (volume/dose)(doses/day)(total number of days of therapy)

For this patient, the calculation would be as follows:

(2.5 mL/1 dose)(2 doses/1 day)(10 days) = 50 mL suspension needed to complete therapy

Sometimes, pediatric suspensions for reconstitution might not come in the exact volume needed. In the example above, if only a 100 mL bottle is available then there will be excess medication remaining. It's important to let the caregiver know about this so that they don't give more drug than needed. Check with the pharmacist on how they prefer to communicate this information. Be aware that there are auxiliary labels that can help get this message across. Conversely, sometimes the volume that needs to be dispensed may be too large for one package size. Some patients may need two bottles or more. Make sure you check with your pharmacist regarding how to handle these situations. Some pharmacies may reconstitute the entire amount and dispense the volume needed in one bottle. However, this might not be feasible if the suspension won't be stable for the length of therapy. For example, cefdinir suspension only lasts 10 days once reconstituted, which could be a problem if the patient needs to take it for 14 days. Check the label on the stock bottle to find out how long a product lasts after reconstitution.

The patient will be taking doses of 2 mL each, four times per day, for 14 days. So, (2 mL per dose)(4 doses per day)(14 days) = 112 mL. This is the total volume that will need to be dispensed.

Refer computer or payer alerts to the pharmacist for review. For example, you may see "drug-age" warnings pop up when filling certain medications for kids, such as drugs on the KIDs List (codeine, tramadol, paroxetine, etc). And "high-dose" alerts can help draw attention to a dose that was calculated incorrectly.

Use auxiliary labels to help caregivers remember how to administer or store meds. For instance, you'll want to make sure to include the appropriate auxiliary labels, such as "shake well" for suspensions (e.g., amoxicillin, amoxicillin/clavulanate, nystatin, etc) and "refrigerate" for liquids such as amoxicillin/clavulanate, cefprozil, etc.

It is also important to indicate the beyond-use date for a reconstituted liquid. For example, cephalexin suspension is good for 14 days when stored in the fridge after it is mixed. Apply a "discard unused portion" or "discard after date" label to drugs that are likely to have an excess amount remaining or that must be discarded after a certain date. Labels about taking the drug on an empty stomach or with food should be given attention too; for example, cefuroxime should be taken with food to avoid stomach upset.

Nystatin suspension should be shaken before use, so you add an appropriate auxiliary label to the amber bottle containing the patient's nystatin.

Make sure a calibrated measuring device is provided with all oral liquids. As mentioned, household spoons aren't good for measuring pediatric doses. Caregivers should use the measuring device that comes with the product if possible. If the product doesn't come with a device, provide a proper calibrated measuring device such as an oral syringe or dosing spoon. Make sure that the dosing units on the device match the dosing units on the Rx label. Try to choose a device that's a correct size for the caregiver to measure the dose just once. For example, if a dose is 15 mL, dispense a device that holds at least 15 mL. If you dispense one that holds only 5 mL, the caregiver has to measure the dose three separate times to get to 15 mL. This increases the risk for error. Suggest that patients mark these dosing devices with a permanent marker to indicate how much drug to give. The pharmacist may want to do this for the caregiver before dispensing the drug. If that is the case, let the caregiver know that the device has been marked by the pharmacist. Also let them know to throw away any marked device after treatment is complete to avoid confusion with future meds.

Since each dose of the patient's nystatin will be 2 mL, you choose an oral syringe that measures out at least 2 mL to dispense with the Rx.

Be sure that powders for suspension are reconstituted before handing them to a caregiver. A number of errors of this type have been reported, where caregivers actually administered unreconstituted powders to children. This can lead to an overdose which may require medical care to treat. Use "Mix" cards or other ways to flag these Rxs to alert your colleagues that a medication needs to be reconstituted before given to the patient.

Is there anything that I should consider for pediatric medications in the hospital setting?

In the hospital setting, exact doses are usually prepared individually for pediatric patients. This is different from adult doses. If a container doesn't have the exact adult dose that was ordered, it will still be provided along with a "note dose" sticker; but this is a risky practice for pediatric patients and should be avoided.

Ensure you're capturing ALL meds pediatric patients take when obtaining medication histories. Omissions are one of the biggest problems when these patients are admitted. Make sure to document the

Phone: 209-472-2240 ~ Fax: 209-472-2249
pharmacist.therapeuticresearch.com ~
pharmacytech.therapeuticresearch.com

drug name (include both generic and brand names, if applicable, and both prescription and over-the-counter meds), drug strength, route of administration, regimen (dose and dosing schedule), and indication for use. Since pediatric patients are often on liquid formulations, you'll want to make sure to include doses in milligrams, not just milliliters. For example, azithromycin (*Zithromax*) 200 mg/5 mL oral suspension, 250 mg (6.25 mL) by mouth three times a week, for cystic fibrosis. Keep in mind, med lists from previous admissions may be a less reliable resource for pediatric patients than adults, since med regimens can change as children grow. Verify pediatric med histories with parents whenever possible.

Know when to prepare pediatric dilutions. There will be times when a dose ordered for a pediatric patient is so small that it cannot be measured accurately. This may be especially true for newborn babies. For example, if a drug comes in a concentration of 100 mg/mL, and the ordered dose is 5 mg, the volume of drug needed for the dose will be 0.05 mL. Usually, the minimum measurable dose is 0.1 mL. To solve this problem, you will need to make a pediatric dilution. Most commonly, the drug is diluted by ten times. The drug concentration in our example would then be 10 mg/mL. The volume needed for the 5 mg dose would be 0.5 mL, which is measurable. Follow your pharmacy's policies for pediatric dilutions, including the formulation, beyond-use dating, and storage.

Dispense oral liquids in amber oral syringes, never in IV syringes. There are reports of patients receiving drugs meant for oral administration through their IV lines. This is very dangerous, and it is easy to see how this could happen since most oral liquids for pediatric patients are dispensed in syringes in the hospital. Never draw up an oral liquid in an IV syringe. Always use syringes, usually amber, that are designated for oral meds only. Also, attach an "oral use only" auxiliary label over the cap of the syringe, to prevent IV administration of the oral med.

Stock only appropriate drug formulations in automated dispensing cabinets, on patient care units, etc. Some medications or concentrations of medications are inappropriate for use in pediatric patients. An example of this is heparin flushes that contain preservatives. Some preservatives are dangerous, when given in adequate amounts, to very young children. Another example is hepatitis B vaccine, which is routinely given to newborn babies. Specific formulations are meant for newborns and others are only for older patients. When you're stocking meds for use in pediatric patients, be extra careful to make sure you have the right drugs in the right concentrations and formulations. If you're not sure about something, check with the pharmacist.

Prepared by the Editors of Therapeutic Research Center (370182)*; last modified September 2021.*

Cite this document as follows: **Technician Tutorial, *Dispensing Drugs for Pediatric Patients. Pharmacist's Letter/Pharmacy Technician's Letter.* January 2021.**

-Continue to the next page for a "Cheat Sheet" about dispensing drugs to pediatric patients-

Phone: 209-472-2240 ~ Fax: 209-472-2249
pharmacist.therapeuticresearch.com ~
pharmacytech.therapeuticresearch.com

"Cheat Sheet" for Dispensing Pediatric Meds

What are the different pediatric age groups?

Pediatric patients are usually grouped according to age, and these groupings can vary, depending on the source. Pediatric age groups can help differentiate different stages of development. Examples of age groupings include:

- Pre-term - born before 37 weeks of pregnancy
- Neonate - newborn to one month of age
- Infant - one month up to 12 months
- Toddler - 12 months up to 36 months
- Child - three years up to 12 years
- Adolescent - 12 years up to 18 years

Why are pediatric patients at a greater risk for medication errors?

There are several factors that increase the risk for mistakes and medication errors to occur in pediatric patients:

- From birth to adulthood, a pediatric patient's body is still developing; these patients have immature organ systems responsible for processing, breaking down, and eliminating drugs.
- Young children often cannot effectively communicate side effects they're experiencing.
- Caregivers must be relied upon to precisely measure and administer individualized doses to children.
- Complex steps, such as compounding or unique calculations, are often required when preparing drug therapy.
- Many healthcare providers don't have formal training in pediatrics.

What can I do to help prevent errors when dispensing prescriptions for pediatric patients?

- Obtain or verify date of birth, current allergy information, and patient weight with every encounter.
- Always record weight in kilograms to avoid confusion (1 kg = 2.2 pounds).
- Handle Rxs that need to be compounded carefully, such as by double-checking calculations, ingredients, and quantities before they're combined; reaching out to a hospital pharmacy to get a compounding formula; etc.
- Confirm you are picking the right product with the right concentration, strength, and dosage form.
- Make sure that doses calculated based off of weight do not exceed the maximum adult dose.
- Assess doses with decimal points very carefully – leading zeros should always precede a decimal, but trailing zeros should never follow a whole number.
- Ensure label directions have the right volume of drug to be given per dose for liquid meds.
- Use mL on Rx directions to prevent confusion with teaspoons (5 mL) and tablespoons (15 mL).
- Be careful to select the right container size, especially when dispensing antibiotic suspensions to ensure there's enough drug for the entire course of therapy.
- Refer computer or payer alerts to the pharmacist for review.
- Apply the appropriate auxiliary labels, such as "shake well" for suspensions or "discard unused portion" for meds that are only used for a specific length of time (e.g., antibiotics).
- Provide a proper calibrated measuring device, such as an oral syringe, which has the same dosing units as the dosing units on the Rx directions and that is the correct size (volume not too large or small).
- Be sure powders for suspension are reconstituted before handing them to caregivers or patients.

[January 2021; 370182]

Phone: 209-472-2240 ~ Fax: 209-472-2249
pharmacist.therapeuticresearch.com ~
pharmacytech.therapeuticresearch.com