



Metric Units and the Preferred Dosing of Orally Administered Liquid Medications

COMMITTEE ON DRUGS

abstract

Medication overdoses are a common, but preventable, problem among children. Volumetric dosing errors and the use of incorrect dosing delivery devices are 2 common sources of these preventable errors for orally administered liquid medications. To reduce errors and increase precision of drug administration, milliliter-based dosing should be used exclusively when prescribing and administering liquid medications. Teaspoon- and tablespoon-based dosing should not be used. Devices that allow for precise dose administration (preferably syringes with metric markings) should be used instead of household spoons and should be distributed with the medication.

BACKGROUND

Each year, more than 70 000 children visit emergency departments as a result of unintentional medication overdoses.¹ Volumetric dosing errors and use of incorrect dosing delivery devices are 2 frequent sources of these overdoses.² In 2008, the PROTECT (Preventing Overdoses and Treatment Errors in Children Taskforce) Initiative^{3,4} was launched as a collaborative effort between public health agencies, private sector companies, professional organizations, consumer/patient advocates, and academic experts to develop strategies to prevent unintentional medication overdoses. Among the recommendations from the ongoing collaboration is the explicit preference for exclusive use of metric unit dosing of orally administered liquid medications.

Until May 2011, when the US Food and Drug Administration (FDA) finalized nonbinding recommendations to the pharmaceutical industry to address inaccurate dosing,⁵ there was no standard guidance for labels, packaging, or dosing devices for orally administered liquid medications. The need for such direction was emphasized in the 2010 study of Yin et al.⁶ This study showed that commonly used over-the-counter pediatric liquid medications often contained discordance between volumetric dosing instructions on the label and the markings on the delivery device (eg, metric dosing in milliliters on 1 device and alternative terms such as teaspoon on the other). These discrepancies were cited as a source of confusion for caregivers. Abbreviations for these units of measure also

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were inconsistent (mL, ml, ML, and cc for milliliter). One other study found that medications prescribed with metric dosing are, at times, dispensed with nonmetric instructions for administration.⁷

Recognizing the importance of clarity and precision for dosing orally administered liquid medications, numerous organizations (including the Institute for Safe Medication Practices, the Academic Pediatric Association, the American Academy of Family Physicians, the American Medical Association, the National Council for Prescription Drug Programs, and the FDA) have issued statements in support of metric dosing, a practice some electronic prescribing systems also are enforcing.^{8–13} Although some physicians may be concerned that milliliter-only dosing practices will increase confusion and errors by caregivers, experience from abroad suggests that minimal education of the public is needed to ensure safety.¹⁴ Furthermore, it is probable that most pediatric providers have some experience with dosing in milliliters, in particular for small volumes of concentrated infant medications (eg, 15 mg/mL of ranitidine syrup).

The American Academy of Pediatrics (AAP) has previously supported the recommendation for metric dosing of orally administered liquid medications through federal testimony before the FDA and metric-only labeling in a policy statement on electronic prescribing.^{15,16} Two articles in *AAP News* have further emphasized the metric-only dosing approach.^{17,18} These communications echo sentiments put forth by a policy statement from the AAP Committee on Drugs from a generation ago. In the 1975 statement entitled “Inaccuracies in Administering Liquid Medication,” the committee detailed that inconsistent volumes are administered when medications are dosed by using teaspoons

(particularly when household spoons are the dose delivery device).¹⁹ One recent study demonstrated that medication-dosing errors are significantly less common among parents using milliliter-only dosing compared with those using teaspoon- or tablespoon-based dosing.²⁰ The 1975 policy statement also suggested that oral syringes be used to deliver more precise volumes. Recent studies have demonstrated that syringes achieve more precise dosing than dosing cups or dosing spoons.^{21–23} Unfortunately, household spoons are still commonly used to administer liquid medications, particularly among those caregivers with low health literacy.^{24–26} Therefore, pediatricians should cease prescribing liquid medications to children that use teaspoon or tablespoon volumes and advocate for the use of oral syringes with metric markings. Notably, use of syringes combined with caregiver education on dosing has been shown to markedly improve dosing precision.²⁷

A switch to exclusive metric dosing for orally administered liquid medications is consistent with other AAP recommendations for the use of metric units. The 2009 joint policy statement “Guidelines for Care of Children in the Emergency Department,” issued by the AAP, the American College of Emergency Physicians, and the Emergency Nurses Association, emphasized that weights be measured and recorded in kilograms.²⁸ In 2012, the AAP endorsed the position statement of the Emergency Nurses Association, which further advocated that pediatric weights only be measured and documented in kilograms, that scales used to weigh pediatric patients only be configured to record weights in kilograms, and that e-healthrecords be standardized to allow only kilograms for pediatric weight entries.^{29,30} Metric-only labeling was also recommended for electronic prescribing systems by the AAP in a 2013 policy statement

entitled “Electronic Prescribing in Pediatrics: Toward Safer and More Effective Medication Management.”¹⁶ Therefore, to advance the adoption of consistent metric-only prescription and distribution of orally administered liquid medications for children by all stakeholders, numerous recommendations are now warranted.

RECOMMENDATIONS

1. Orally administered liquid medications should be dosed exclusively by using metric-based dosing with milliliters (ie, mL) to avoid confusion and dosing errors associated with common kitchen spoons.
 - a. Orally administered liquid medications should be dosed to the nearest 0.1, 0.5, or 1 mL, as appropriate based on the margin for safe and effective dosing, but dosing to the hundredth of a milliliter should be avoided.
 - b. The only appropriate abbreviation for milliliter is “mL,” and the use of alternatives (eg, ml, ML, cc) for dosing orally administered liquid medications should be avoided.
 - c. Milliliter-based dosing should include leading zeros preceding decimals for doses less than 1 mL (eg, 0.5 mL) to avoid 10-fold dosing errors.
 - d. Trailing zeros after decimals should not be included when dosing in whole number units to avoid 10-fold dosing errors.
2. The concentration (strength) of all orally administered liquid medication (eg, in milligrams per milliliter [mg/mL]) should be clearly noted on prescriptions to enable accurate calculation of the medication dose administered.
3. The frequency of administration of all orally administered liquid medications should be clearly noted, avoiding the use of

abbreviations that could lead to dosing errors (eg, use of “daily” is preferred over “qd,” which could be misinterpreted as “qid”).

4. Pediatricians should review milliliter-based doses with patients and families at the time that orally administered liquid medications are recommended or prescribed to ensure adequate health literacy for metric dosing units.
5. E-health record vendors should use metric units for orally administered liquid medications and eliminate the ability of providers to prescribe medications using non-milliliter-based dosing regimens.
6. Pharmacies, hospitals, and health centers should dispense orally administered liquid medications with metric dosing on the label.
7. Pharmacies, hospitals, and health centers should distribute appropriate-volume milliliter-based dosing devices with all orally administered liquid medications.
 - a. Syringes (optimally, those designed to partner with flow restrictors) are the preferred dosing device for administering oral liquid medications. Cups and spoons calibrated and marked in milliliters are acceptable alternatives.
 - b. Dosing devices should not bear extraneous or unnecessary liquid measure markings that may be confusing to caregivers.
 - c. When possible, dosing devices should not be significantly larger than the dose described in the labeled dosage to avoid twofold dosing errors.
 - d. Advanced counseling strategies (eg, teach-back, drawings/pictures, dose demonstration, show-back) may further reduce dosing errors when combined with provision of a dosing device.³¹

8. Manufacturers should eliminate labeling, instructions, and dosing devices that contain units other than metric units.
9. Researchers should study the effect of caregiver health literacy on dosing precision to determine the best strategies to prevent unintended dosing errors among minorities, immigrants, and those with low health literacy.

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