Review Article

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Digital Medicine Crushers in Paediatric Care: A Narrative Review

Nursing Section

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ABSTRACT

Ensuring safe and reliable oral medication administration in paediatrics has been a clinical challenge for years, due to the absence of age-specific formulations and difficulties in preparing accurate doses. A comprehensive evaluation of the efficacy, handiness, and safety of a new wave of digital medicine crushers reveals a promising frontier in paediatric oral medication administration. However, a critical analysis of the methodologies used to assess these devices highlights the need for more rigorous and standardised approaches to validate their superiority over conventional crushing methods. Yet, existing studies comparing these devices are not methodologically uniform, and thus, conclusions are weakened. Few measures recover the dose quantitatively using validated methods, such as high-performance liquid chromatography, and paediatric dosing evaluations are still limited. Usability testing has mainly assessed qualitative impressions as opposed to validated rating tools or time-motion analysis. Safety findings are encouraging but await controlled comparisons across devices and settings. The current research has identified differences in drug recovery, particle size uniformity, and patient experience based on device and environment. Closed-unit automated systems with disposable parts have shown the ability to reduce medication residues, decrease aerosol formation, and enhance dose consistency, especially in paediatric dosing where weight-based precision is critical. Early investigation also reveals workflow-related advantages, such as lowered preparation time and physical workload for healthcare providers. This review examines the complex challenges of paediatric dosing, the inherent risks associated with traditional practices, and the technological promise of digital solutions, while providing a framework for their robust comparative evaluation.

Keywords: Administration, Equipment design, Patient safety, Pharmaceutical technology, Tablet crushers, Usability testing

INTRODUCTION

Oral drug administration to children is routinely accomplished by altering adult formulations because paediatric-specific alternatives are not frequently available. This procedure poses risks to dose inaccuracy, palatability, administration mistakes, and safety for the patients and the caregivers as well. Although manual pill crushing is frequently utilised in a variety of paediatric care environments, few consolidated data are available comparing conventional tools with new automated crushing technologies [1]. The administration of oral medication to children is a persistent challenge in healthcare, fraught with difficulties ranging from refusal and spitting to the critical risk of inaccurate dosing [1]. The frequent lack of age-appropriate liquid formulations necessitates the manipulation of adult solid dosage forms, a practice that, while common, is laden with potential for error and adverse events [2,3]. A new cohort of digital or automated medication crushers has surfaced in this arena, offering a safer, more efficient, and more dependable alternative to the traditional mortar and pestle or ad-hoc spoon. This review of the literature pulls together what is known, critiques the evaluation methods used to compare these technologies, and suggests a conceptualised model for future research.

The Perils of the Past: Conventional Medication Crushing

For many years, healthcare professionals and caregivers had only a few tools to use for crushing medication. The most widely used of these tools is the mortar and pestle, and currently, various manual pill crushers have met a basic need but have a significant number of documented limitations.

Methodologically, the evaluation of these conventional methods has centred on several key areas of concern:

- **Dose accuracy and medication loss:** A major worry with any crushing method is the risk of losing an amount of Active Pharmaceutical Ingredient (API). Data has shown that a large percentage of drug potency is lost during manual crushing [4]. A study by the University of Queensland has documented significant drug loss during manual crushing, with some analyses suggesting that as much as one-fifth of the active drug may be lost because of surface adhesion, aerosolisation, or transfer inefficiency [4]. Several controlled evaluations of manual crushing techniques have reported inconsistent recovery rates, underscoring the importance of standardised handling procedures to minimise drug loss [3]. Evaluating manual crushing procedures has documented variability in recovery rates and stressed the importance of standardised handling procedures for minimising loss of dose [5,6]. In a paediatric setting, where doses are often small and precisely calculated based on weight, even a minor loss can have significant clinical implications [4].
- **Cross-contamination:** In environments where multiple medications are crushed using the same device, the risk of cross-contamination is a serious safety concern [4,7]. Without meticulous and validated cleaning procedures between uses, residual powder from one medication can be inadvertently mixed with another, leading to unintended drug interactions or the administration of a contraindicated substance [7].
- **Particle size inconsistency:** The fineness and uniformity of a powdered drug product are very important for several reasons. Uneven particle size can impact a drug's dissolution rate and therefore its bioavailability [4]. When taking a drug through an enteral feeding tube, a large particle or an irregularly shaped particle could potentially block the feeding tube [8]. Finally, a gritty texture or unpleasant texture will likely be rejected by a child. This will affect adherence [1,2].
- **Occupational exposure:** Crushing tablets can lead to inhalation of airborne drug within the working environment,

which can result in occupational exposure for the healthcare worker. This is of particular concern with hazardous drugs, including chemotherapy and hormone medications, as repeated inhalation has the potential for adverse health effects [8-11]. Studies have shown that healthcare professionals involved in manual pill crushing are at risk of inhaling drug particles, which can lead to adverse health effects over time [12,13].

- **Ergonomics and user strain:** Manual crushing, especially of hard tablets, can be physically demanding and lead to repetitive strain injuries for nurses and pharmacists who perform this task frequently [1].

The Dawn of Digital: Defining the New Technology

The "new digital medicine crusher," more commonly referred to in the literature as an automated or electric pill crusher, represents a significant technological leap. These devices are designed to address the shortcomings of their manual predecessors by combining various features [9].

Key characteristics of these digital crushers often include:

- **Automated grinding mechanism:** Powered by batteries or an electrical outlet, these devices use a motorised mechanism to crush tablets, eliminating the need for manual force and reducing the risk of repetitive strain injuries [1,11].
- **Disposable containment systems:** Many automated crushers utilise single-use plastic pouches or cups [4,14,15]. This design feature is crucial for minimising cross-contamination, as the medication is contained within the disposable element throughout the crushing process [16]. It also simplifies the cleaning process.
- **Consistent powder fineness:** Manufacturers often claim that these devices produce a fine, uniform powder, which is beneficial for dissolution, palatability, and administration through feeding tubes [3,9].
- **Hands-free operation:** Some models offer hands-free operation, further simplifying the workflow for healthcare professionals [11].

A Methodological Framework for Comparative Evaluation

A robust comparison of new digital medicine crushers and conventional methods requires a multi-faceted methodological approach that rigorously assesses efficacy, handiness (usability), and safety.

Efficacy: The primary measure of a crusher's efficacy is its ability to deliver the prescribed dose accurately and in a form that is optimal for absorption.

1. **Dose accuracy and drug loss:**

- **Methodology:** The gold standard to assess dose loss is to quantitatively assess the drug content before and after crushing. This can be accomplished with High-Performance Liquid Chromatography (HPLC) or UV spectrophotometry, both of which will accurately measure the amount of API recovered [1,17]. A simpler, but less accurate, methodology is gravimetric analysis. Gravimetric analysis weighs the powder, but does not differentiate between the active ingredient and the excipients. Therefore, gravimetric analysis is also less precise than other methods and more affected by environmental errors, such as moisture absorption or static electricity [18].
- **Paediatric considerations:** Methodologies must be adapted to assess the accuracy of preparing small, individualised doses often required in paediatrics [13,14]. This involves starting with a whole tablet, crushing it, and then attempting to extract a specific, smaller portion of the powder, mimicking real-world practice [2]. Studies have shown significant drug loss in these scenarios, highlighting the need for devices that can facilitate accurate dose division [13]. Various studies examining manual crushing techniques have provided evidence of dose recovery variability, with differences depending on the type of device employed, tablet hardness, and operator technique [8,9].
- **Recovery from the device:** A critical aspect of the methodology is accounting for the drug that remains in the crushing device. This is often done by rinsing the device or its components (like disposable pouches) with a solvent and then analysing the rinse solution for the presence of the API [16]. Studies have demonstrated that multiple rinses are often necessary to recover a significant portion of the lost drug [16,17]. Differences in particle size across handheld and automated devices have been associated with dissolution rates, tube compatibility, and reliability in dosing in several independent studies [12]. The particle size analysis performed amongst various crush devices has demonstrated a consistent relationship in granule variability affecting dissolution, palatability, and tube administration [1,13,14].

2. **Particle size analysis:**

- **Methodology:** The technique with the same accepted pinnacle of accuracy for determining particle size distribution is laser diffraction [4]. Laser diffraction assesses how particles scatter light to calculate their size. Sieve analysis, the oldest method of determining size, is simply sifting powder through several screens with various mesh sizes and is less robust than laser diffraction [4].
- **Clinical relevance:** The output of particle size analysis should be directly linked to clinically relevant outcomes. For example, the percentage of particles small enough to pass through a specific gauge of enteral feeding tube without clogging should be a key metric [4]. Also, the effect of particle size on texture and palatability when mixed into food or liquids needs to be addressed by the study of particle size; however, this often requires sensory analysis and behavioural outcomes reported by the caregiver. Investigations employing laser diffraction and sieve analysis have shown that automated crushers tend to yield more consistent powder than the manual versions, although results depend on the model and formulation used [15,16].
- **Handiness:** For a new technology to be adopted, it must be demonstrably easy and efficient to use by its intended operators, who in a paediatric context are often both healthcare professionals and caregivers at home. Studies evaluating usability among nurses and pharmacists have shown that automated crushers reduce preparation time and physical strain compared to manual devices, while also improving workflow consistency [17-19].

1. **Usability for healthcare professionals:**

- **Methodology:** A mixed-methods approach is most effective here.
- **Quantitative assessment:** Time-motion studies allow us to empirically measure how long it takes to complete the full crushing and administration workflow with each device. Standardised, validated questionnaires such as the System Usability Scale (SUS) can deliver average quantitative scores of how usability is perceived [19,20].
- **Qualitative assessment:** Semi-structured interviews and focus groups with the pharmacists and nurses involved in the study would provide rich contextually based feedback about the design, ergonomics, ease of cleaning, and integration of the device into their workflow [9]. Bower RA et al., explored how nurses think through medication tasks under time pressure, competing priorities, and interruptions—offering themes (e.g., prioritising, renegotiating routines) that directly inform usability/ergonomic requirements for a crushing device [10]. Lee SV et

al., concluded that when implementing a tablet crusher in a clinical workflow, ergonomics (especially for staff with varying hand strength) and minimal physical demand are critical for adoption [14]. Woerdenbag HJ et al., highlighted that cleaning/maintenance burden and how the device fits into existing workflow (setup, crushing, transferring, cleaning) were major determinants of overall "usability in practice" - not just efficiency of crushing [1]. Observational studies, where investigators observe users interacting with the device in their own natural environment, could provide insights into usability problems that would remain hidden in a controlled setting.

2. **Usability for caregivers:**

- **Methodology:** Usability testing needs to be performed when a device is used by parents and other caregivers in their home environments [21]. Such testing should seek to replicate the home environment and its challenges, including distractions and differences in technology comfort levels [7,9].
- Key assessment points:
  - Clarity of instructions for use.
  - Ease of operating the device, especially for individuals with limited hand strength or dexterity [22].
  - Simplicity of the cleaning process.
  - Caregiver' confidence in their ability to prepare the correct dose [19].
  - Preference studies can directly compare caregiver choices between different devices [19].

Safety: Protecting Patients and Providers

The safety of both the child receiving the medication and the person administering it is paramount. Investigations in hospital and long-term care settings have reported that users perceive automated crushing systems as easier to operate and more reliable than traditional mortar-and-pestle methods, particularly for frequent dosing needs [19,20].

1. **Cross-contamination:**

- **Methodology:** For devices that can be reused, validation of the cleaning procedure is necessary [23,24]. This can be accomplished by contaminating the device with a drug, completing cleaning as per the manufacturer's instructions, and cleaning the surfaces of the device. The samples are then analysed for residual API through a highly sensitive technique like HPLC. Acceptable residual drug levels should be based on toxicology [5,25].
- **Digital crusher advantage:** Conveyor-style automated crushers that utilise disposable pouches or cups are designed to reduce the risk of cross-contamination inherently, a strong methodological benefit to emphasise in comparative studies [15].

Ferro Uriguen A et al., highlighted that for 11 critical drugs, even in "maximum contamination" state, the residue transfer remained below defined permitted limits (e.g., < 1/1000 of minimum daily dose) after cleaning [21].

2. **Occupational exposure to aerosolised particles:**

- **Methodology:** An evaluation of airborne particles emitted over time from crushing steps will require specialised equipment. Air sampling devices that can be located near the crushing will collect the airborne particles onto a filter. These filters can be analysed to determine the mass and chemical composition of the particles. Particle counters provide real-time data on the number and size of airborne particles [12].
- **Comparative studies:** A well-designed study would assess aerosolisation levels created by traditional methods (typically open systems) versus digital crushers that employ a sealed disposable system. In addition, the use of a fume hood as a control can provide another level of reduced exposure as a benchmark. It is found in a study by Tavares E et al., that the method and intensity of crushing (vigorous vs moderate) significantly influenced the number of aerosolised particles (p-value<0.001 for most combinations). This directly shows that healthcare personnel who crush tablets are exposed to aerosolised drug particles, and that device choice and method matter significantly [13].

3. **Patient safety:**

- **Overdose/underdose risk:** Benefits of providing the incorrect dose due to device failure or incorrect use must be considered. This is particularly important with medications that have a narrow therapeutic index.
- **Impact on drug formulation:** A methodological review should also consider the potential for the crushing process itself to alter the properties of the medication. This is especially true with enteric-coated or modified-release tablets that will dump a dose, resulting in possible toxicity. This is an issue that presents with any method of crushing, so it is important that studies have provided assurances that the grinding action of the digital crusher allows minimal generation of heat that could compromise thermolabile properties of the medication. Evidence from occupational health studies indicates that enclosed or pouch-based crushing devices significantly reduce airborne exposure compared to an open manual system [20] .

Administration of crushed medications in patients with swallowing difficulty (dysphagia) may lead to tube obstructions. Modification of the dosage form (crushing) may alter drug bioavailability, leading to under- or overdosing. Blaszczyk AT et al., emphasise that crushing or opening capsules should be done cautiously—and that not all medications are suitable for modification, from a safety/efficacy perspective [16].

Gaps in the Research and a Call for a More Rigorous Future

While the existing literature provides a solid foundation, there are notable gaps in the research comparing digital medicine crushers to conventional methods, particularly within the paediatric context. There is a scarcity of head-to-head randomised controlled trials that simultaneously evaluate efficacy, usability, and safety. Many existing studies focus on a single aspect, such as drug loss, without considering the broader user experience or safety implications [17].

Future research should embrace a more holistic and rigorous methodological framework:

- **User-centered design:** The development of new pediatric medication administration devices should be grounded in user-centered design principles, involving caregivers and children throughout the process to ensure the final product is not only functional but also accepted and preferred by its users [4,9].
- **Standardised Protocols:** It is important to have standardised protocols for evaluating important outcomes such as drug loss, particle size, and cross-contamination to allow for more relevant comparisons between studies and devices.
- **Real-world evidence:** While laboratory-based studies are necessary to obtain precise measurements, more studies done in the real world, such as clinical or home settings, are needed to determine how well these devices can perform given the complexities of daily life [4].
- **Cost-effectiveness analysis:** The higher initial cost of these digital medicine crushers will always pose a big challenge to their larger utilisation. Cost-effectiveness analyses that are of good methodological quality are needed to assess whether there are sufficient benefits in terms of safety, medication waste, and efficiency to justify the initial investment.

CONCLUSION(S)

Administering oral medication to children is a critical and often challenging aspect of paediatric care. Conventional medication crushing methods, while widely used, present significant methodological and practical challenges related to dose accuracy, safety, and usability. New digital medicine crushers offer a technologically advanced solution that has the potential to mitigate many of these risks. For these advanced devices to become standard of care, authors will need to show across a broad, thorough, and methodologically sound comparative assessment that they are better. For the healthcare community to make knowledge-based assessments around future safer and more effective medication delivery to children, assessments of efficacy, handiness, and safety must be significantly focused on, with consideration of child and caregiver-specific needs. Despite potentially being the future of paediatric dosing, the road to get there must be paved with the asphalt of rigorous scientific inquiry.

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REFERENCES

[1] Woerdenbag HJ, Visser JC, Leferink op Reinink MPAM, van Orsoy RR, Eissens AC, Hagedoorn P, et al. Performance of tablet splitters, crushers, and grinders in relation to personalised medication with tablets. Pharmaceutics. 2022;14(2):320.

[2] Nguyen D, Secretan PH, Auvity S, Vidal F, Postaire M, Cisternino S, et al. Assessment of practices for suspended oral drugs by tablet crushing in pediatric units. Eur J Pharm Biopharm. 2020;157:175-82.

[3] Golhen K, Buettcher M, Kost J, Huwyler J, Pfister M. Meeting challenges of pediatric drug delivery: The potential of orally fast disintegrating tablets for infants and children. Pharmaceutics. 2023;15(4):1033.

[4] Hilden J, Schrad M, Kuehne-Willmore J, Sloan J. A first-principles model for prediction of product dose uniformity based on drug substance particle size distribution. J Pharm Sci. 2012;101(7):2364-71.

[5] Feufel MA, Rauwolf G, Meier FC, Karapinar-Çarkit F, Heibges M. Heuristics for designing user-centric drug products: Lessons learned from Human Factors and Ergonomics. Br J Clin Pharmacol. 2020;86(10):1989-99. Doi: 10.1111/bcp.14134. Epub 2020 Jan 23. PMID: 31663157; PMCID: PMC7495287.

[6] Kremer TA, Felgar J, Rowen N, McDonnell G. Validation of the device feature approach for reusable medical device cleaning evaluations. Biomed Instrum Technol. 2023;57(4):143-52. Doi: 10.2345/0899-8205-57.4.143. Epub 2024 Jan 3. PMID: 38170936; PMCID: PMC10764062.

[7] Shin J, Lee H. Optimal usability test procedure generation for medical devices. Healthcare (Basel). 2023;11(3):296. Doi: 10.3390/healthcare11030296. PMID: 36766871; PMCID: PMC9914048.

[8] Maeda S, Takahashi E, Tayama Y, Kitamura S, Tsukamoto T, Miyake K, et al. Estimation of occupational exposure to drugs during tablet crushing. Fundam Toxicol Sci. 2016;3(4):177-83.

[9] Dimitri P, Pignataro V, Lupo M, Bonifazi D, Henke M, Musazzi UM, et al. Medical device development for children and young people—reviewing the challenges and opportunities. Pharmaceutics [Internet]. 2021;13(12):2178. Available from: https://www.mdpi.com/1999-4923/13/12/2178.

[10] Bower RA, Coad JE, Manning JC, Pengelly TA. A qualitative, exploratory study of nurses' decision-making when interrupted during medication administration within the Paediatric Intensive Care Unit. Intensive Crit Care Nurs. 2018;44:11-17. Doi: 10.1016/j.iccn.2017.04.012. Epub 2017 May 23. PMID: 28549742.

[11] Money AG, Barnett J, Kuljis J, Craven MP, Martin JL, Young T. The role of the user within the medical device design and development process: Medical device manufacturers' perspectives. BMC Med Inform Decis Mak. 2011;11:15. Doi: 10.1186/1472-6947-11-15. PMID: 21356097; PMCID: PMC3058010.

[12] Amiri A. Medication Crushing and Nurses' Personal Exposures to Airborne Particle [Internet]. LOUIS. 2019. [cited 2025 Oct 30]. Available from: https://louis.uah.edu/rceu-proposals/170/?utm_source=louis.uah.edu%2Frceu-proposals%2F170&utm_medium=PDF&utm_campaign=PDFCoverPages.

[13] Tavares E, Loosley B, Shaik A. Healthcare workers' exposure to aerosolised medications while crushing oral tablets. J Occup Environ Hyg. 2025:01-07. Doi: 10.1080/15459624.2025.2544747. Epub ahead of print. PMID: 40864830.

[14] Lee SV, Aplin T, Sefidani Forough A, Steadman KJ. Perceived Usability of Tablet Crushers: Comparison of Devices by People with and without Limited Hand Functions. Pharmaceutics. 2023;15(2):517. Doi: 10.3390/pharmaceutics15020517. PMID: 36839840; PMCID: PMC9961238.

[15] Thong MY, Manrique YJ, Steadman KJ. Drug loss while crushing tablets: Comparison of 24 tablet crushing devices. PLoS One. 2018;13(3):e0193683. Doi: 10.1371/journal.pone.0193683. PMID: 29494695; PMCID: PMC5832315.

[16] Blaszczyk A, Brandt N, Ashley J, Tuders N, Doles H, Stefanacci RG. Crushed tablet administration for patients with dysphagia and enteral feeding: Challenges and considerations. Drugs Ageing. 2023;40(10):895-907. Doi: 10.1007/s40266-023-01056-y. Epub 2023 Sep 14. PMID: 37707775; PMCID: PMC10511598.

[17] Douze L, Schiro J, Heyndels L, Pazart L, Pelayo S. Evaluations of medical device usability during clinical investigations: A scoping review of clinical study protocols. Expert Rev Med Devices. 2024;21(8):781-88. Doi: 10.1080/17434440.2024.2378093. Epub 2024 Jul 9. PMID: 38982753.

[18] Anthony SJ, Pol SJ, Selkirk EK, Matthiesen A, Klaassen RJ, Manase D, et al. User-centred design and usability of Voxe as a pediatric electronic patient-reported outcome measure platform: Mixed methods evaluation study. JMIR Hum Factors. 2024;11(1):e57984.

[19] Cheng CF, Werner NE, Doutcheva N, Warner G, Barton HJ, Kelly MM, et al. Codesign and usability testing of a mobile application to support family-delivered enteral tube care. Hosp Pediatr. 2020;10(8):641-50.

[20] U.S. Food and Drug Administration (FDA). Validation of Cleaning Processes. Inspection Guides. Silver Spring (MD): FDA; 2022. Available from: https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/inspection-guides/validation-cleaning-processes-793.

[21] Ferro Uriguen A, Beobide Telleria I, Martínez Arrechea S, Miró Isasi B, Sampedro Yangüela C, Urretavizcaya Anton M. Determination of the cross-contamination and validation of the cleaning process for an automated personalised dosing system. Eur J Hosp Pharm. 2022;29(3):157-63. Doi: 10.1136/ejhpharm-2020-002301. Epub 2020 Aug 18. PMID: 32816898; PMCID: PMC9047934.

[22] Abdullahi MM, Datta A. Validating cleaning methods in pharmaceutical industries. J Pharm Innov. 2020;15(3):456-64.

[23] Kiran Deokate KD, Shrikrishna Baokar SB, Rajendra Patil RP. Comprehensive Overview of Cleaning-In-Place (CIP) Systems and Their Validation in Pharmaceutical Manufacturing. International Journal of Pharmaceutical Research and Applications [Internet]. 2025;10(4):440-47. [Cited 2025 Nov 3].

[24] Amiri A, Guess L, Gilder R, Showalter D, Hart L, Sattler B. Using a fume hood to reduce nurses' exposure to particulate matter dispersed into the air during pill crushing. Workplace Health Safety. 2023;71(9):412-18.

[25] Shariff Z, Kirby D, Missaghi S, Rajabi-Siahboomi A, Maidment I. Patient-centric medicine design: Key characteristics of oral solid dosage forms that improve adherence and acceptance in older people. Pharmaceutics. 2020;12(10):905.

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