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Original Research

Evaluation of knowledge of pediatric drug dosing and errors among dental practitioners and students in and around Lucknow city: A questionnaire based cross-sectional survey

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ABSTRACT:

Introduction: Children differ significantly from adults in their physiological, pharmacokinetic, and pharmacodynamic parameters, which makes pediatric drug dosing a complex task in dental practice. Inappropriate prescriptions and errors such as tenfold dosing mistakes can result in serious adverse events. Knowledge of correct dosage calculation methods, mathematical competence, and adherence to prescribing guidelines are crucial for ensuring safe pediatric drug administration. The present study aimed to evaluate the knowledge of dental practitioners and students in and around Lucknow city regarding pediatric drug dosing and related errors. **Materials and Methods:** This cross-sectional questionnaire-based survey was conducted over three months among 108 dental practitioners, equally divided into three groups: Group A – General Practitioners (BDS), Group B – Other Dental Specialists (MDS in specialties other than Pediatric Dentistry), and Group C – Pediatric Dentists (MDS in Pediatric Dentistry). A validated online questionnaire comprising 10 multiple-choice questions was distributed electronically. The questions assessed awareness of pediatric dosing principles, methods of dose calculation, mathematical skills, awareness of tenfold errors, and prescription practices. Responses were collected anonymously, tabulated, and subjected to statistical analysis. **Results:** Among participants, 61.1% of general practitioners, 83.3% of other specialists, and 47.2% of pediatric dentists agreed that children are not miniature adults. Young's formula was the most commonly used method of calculation among general practitioners (52.8%) and other specialists (66.7%), while pediatric dentists (38.9%) more often applied mg/kg-based dosing. Awareness of essential mathematical operations was low, reported by only 36.1% of general practitioners, 38.9% of specialists, and 13.9% of pediatric dentists. A considerable proportion of participants were unaware of tenfold errors, with unawareness highest among pediatric dentists (63.9%). Prescription practices were encouraging, with nearly all respondents cross-checking prescriptions, giving specific dosing instructions, and advising the use of appropriate measuring devices. **Conclusion:** The study revealed that while prescription cross-checking and patient instruction practices are widely followed, major gaps persist in knowledge of pediatric drug dosing principles, reliance on appropriate calculation methods, and awareness of tenfold errors. Pediatric dentists, despite their specialty, demonstrated limited mathematical competence, which highlights the need for continued emphasis on dosage calculation training. Incorporating pediatric pharmacology modules into dental curricula and conducting continuing education programs can bridge these gaps and reduce the risk of medication errors in pediatric dental practice.

Keywords: Pediatric drug dosing, medication errors, tenfold errors, dosage calculation methods, dental practitioners

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INTRODUCTION

The use of various drugs, particularly non-steroidal anti-inflammatory drugs (NSAIDs) and antibiotics, has become a routine component of pediatric medical and dental practice. In dentistry, most infections are polymicrobial in origin; hence, a clinician must not only correctly diagnose the cause of infection but also carefully select an appropriate drug regimen that maximizes therapeutic benefits for the pediatric patient [1,2]. Infants and children represent one of the

most vulnerable groups for contracting infections and illnesses, which makes the routine use of drugs common in these age groups [1,3].

Unlike adults, newborns, children, and adolescents exhibit distinct physiological, pharmacokinetic, and pharmacodynamic parameters that influence how drugs are absorbed, distributed, metabolized, and excreted [4]. These maturational differences necessitate dosage adjustments and careful consideration before prescribing medications in pediatric dentistry. In relation to antibiotic therapy, several unique aspects must be considered in children. Firstly, young children often lack documented medical histories that might otherwise suggest the possibility of drug allergies or prior adverse drug reactions. Secondly, children have a greater proportion of water in their tissues and increased bone sponginess, which facilitates faster diffusion of infections and alters drug distribution, thus requiring accurate dose adjustments. Additionally, poor oral hygiene in most children increases the risk of bacteremia following dental treatments due to higher microbial loads in the oral cavity [2,5].

Despite these concerns, studies have shown that lack of awareness and limited skills among oral health care providers often contribute to medication errors. A key issue is miscalculation of pediatric dosages, with error rates reported to be as high as 17.8%—nearly three times higher than in adults [6]. Furthermore, pediatric drug prescriptions frequently lack uniformity, with many drugs being administered in an off-label manner. This arises because there are fewer licensed medicines and appropriate dosage forms available for children compared to adults, and limited pharmaceutical formulations are designed specifically for pediatric use [7]. Such limitations, combined with insufficient research in this area, exacerbate the challenges in safe pediatric drug administration.

Accurate dosage calculation in pediatric dentistry also requires competence in basic mathematics, including arithmetic operations and understanding of decimal fraction [8]. Inadequate mathematical skills among prescribers often contribute to preventable medication errors. Therefore, the present study was designed with the objectives of: (i) evaluating the knowledge, attitude, and mathematical competence of dental professionals regarding pediatric drug dosing; (ii) understanding the reasons behind higher medication error rates in children compared with adults; and (iii) improving awareness among dental practitioners about pediatric drug dosing and related errors, with the ultimate goal of preventing drug-related morbidity and potential mortality in child patients.

MATERIALS AND METHODS

Study Design and Duration

The present study was designed as a cross-sectional, questionnaire-based survey. It was conducted over a period of three months among dental practitioners in and around Lucknow city, Uttar Pradesh, India.

Ethical Considerations

Permission to conduct the study was obtained from the Institutional Ethical Committee of Sardar Patel Post Graduate Institute of Dental and Medical Sciences, prior to the commencement of data collection. Informed consent was obtained electronically from all participants before they filled out the questionnaire. Participation was voluntary, and confidentiality of responses was assured.

Sample Size Estimation

Sample size estimation was performed using G*Power software (version 3.0). A minimum total of 108 participants (36 per group) was calculated to be sufficient for achieving statistical power.

Study Groups

The dental practitioners were categorized into three groups:

- Group A: General Practitioners (BDS)
- Group B: Other Dental Specialists (MDS in specialties other than Pediatric Dentistry)
- Group C: Pediatric Dentists (MDS in Pediatric Dentistry)

Inclusion Criteria

- General practitioners, pediatric dentists, and other dental specialists practicing in and around Lucknow city.
- Practitioners willing to voluntarily participate in the survey.

Exclusion Criteria

- Dental practitioners practicing outside the vicinity of Lucknow city.
- Undergraduate dental students.

Data Collection Tool

Data were collected using a pre-validated online questionnaire comprising 10 multiple-choice questions (MCQs) adapted from a previous study [4]. The questionnaire was designed to assess the knowledge, attitude, and mathematical skills of dental practitioners regarding pediatric drug dosing and medication errors.

The MCQs included items related to:

- Understanding of pediatric dosing principles (e.g., mg/kg/day).
- Awareness of pediatric drug handbooks.
- Most commonly used dosage calculation methods (Young’s, Salisbury’s, Clarke’s, Fried’s, BSA, mg/kg, etc.).
- Knowledge of mathematical operations involved in dosage calculation.
- Awareness of causes of tenfold errors (use of leading or trailing zeroes).
- Cross-checking prescriptions and providing patient/guardian instructions.

- Use of appropriate measuring devices for dispensing liquid medications.

Administration of Questionnaire

The questionnaire was distributed online via secure survey links. Respondents were not differentiated by age, sex, type of practice (clinical/academic), or years of experience to maintain focus on knowledge and skills rather than demographic variables. Anonymity of participants was ensured throughout the study.

Data Management and Statistical Analysis

All completed questionnaires were collected electronically, tabulated, and stored securely. Data were checked for completeness before analysis. Descriptive statistics were applied to summarize categorical responses, and inferential statistical tests were conducted to compare knowledge scores between the three groups of dental practitioners. A p-value <0.05 was considered statistically significant. Statistical analysis was performed using SPSS software (version XX; IBM Corp., Armonk, NY, USA).

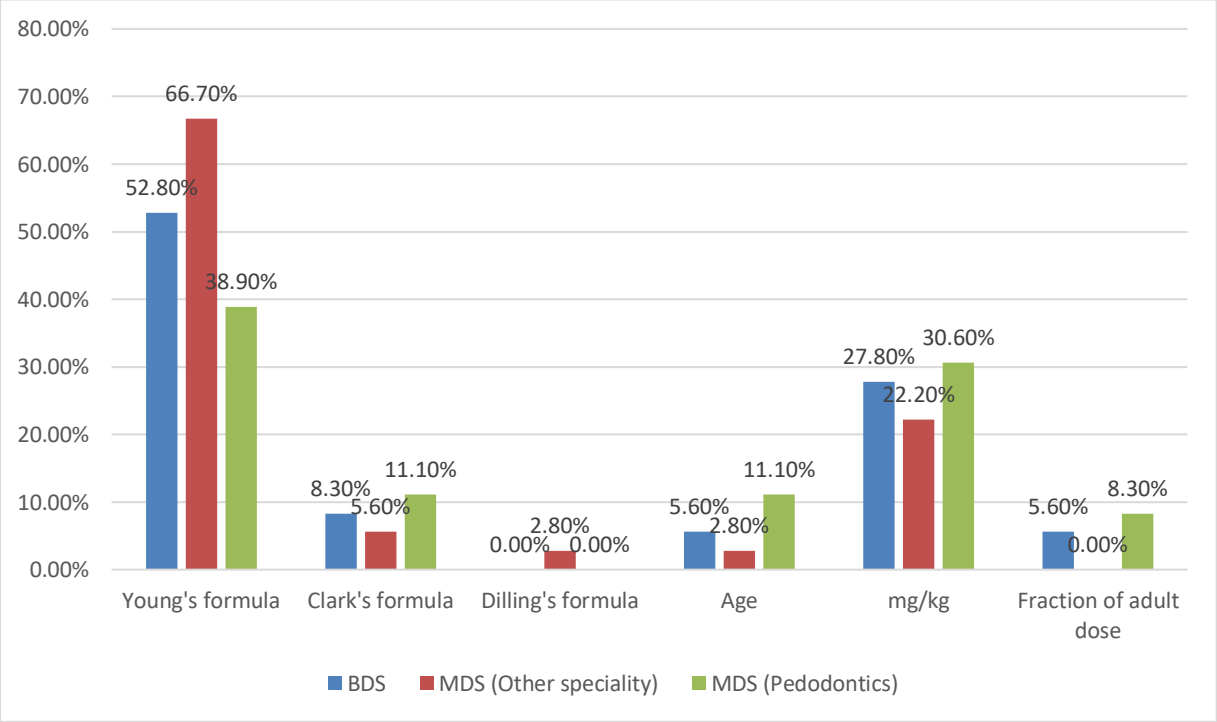
RESULTS

A total of 108 dental practitioners participated in the study, comprising 36 General Practitioners (Group A), 36 Other Dental Specialists (Group B), and 36 Pediatric Dentists (Group C). All participants responded to the 10-item questionnaire. The results have been summarized in tables and figures below.

The majority of practitioners across all groups agreed that a child is not simply a miniature adult. However, reliance on pediatric drug handbooks was more common among pediatric dentists compared to general practitioners as seen in Table 1.

Table 1. Response to 1st and 2nd questions in the questionnaire

Question	General Practitioners (n=36)	Other Specialists (n=36)	Pediatric Dentists (n=36)
Q1: Child is not just a miniature adult (Agree)	22 (61.1%)	30 (83.3%)	17 (47.2%)
Q2: Refer to Pediatric Drug Handbook (Yes)	14 (38.9%)	22 (61.1%)	26 (72.2%)



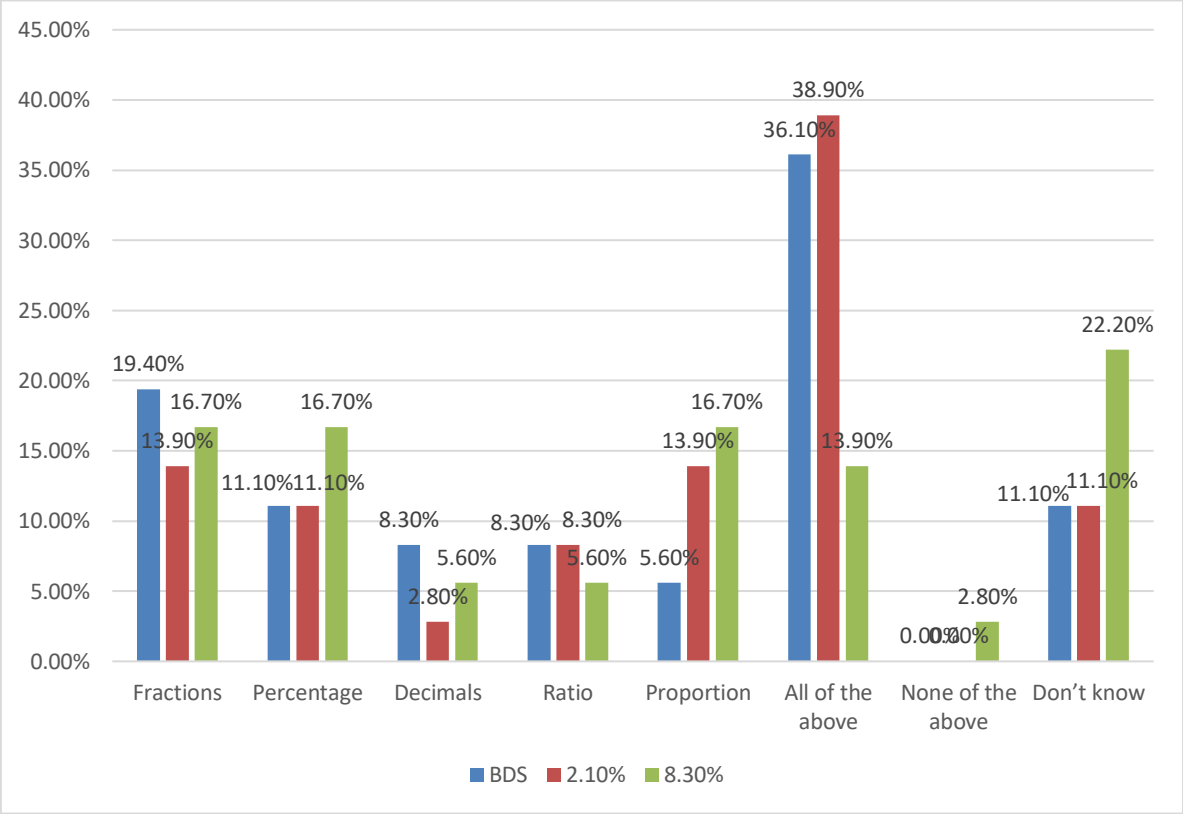
Graph 1. Most common method of dosage calculation

Graph 1 shows;

- General Practitioners: 19 (52.8%) preferred Young's formula, followed by mg/kg.
- Other Specialists: 24 (66.7%) reported Young's formula, followed by mg/kg.
- Pediatric Dentists: 14 (38.9%) used Young's formula, but a higher proportion relied on mg/kg compared to other groups.

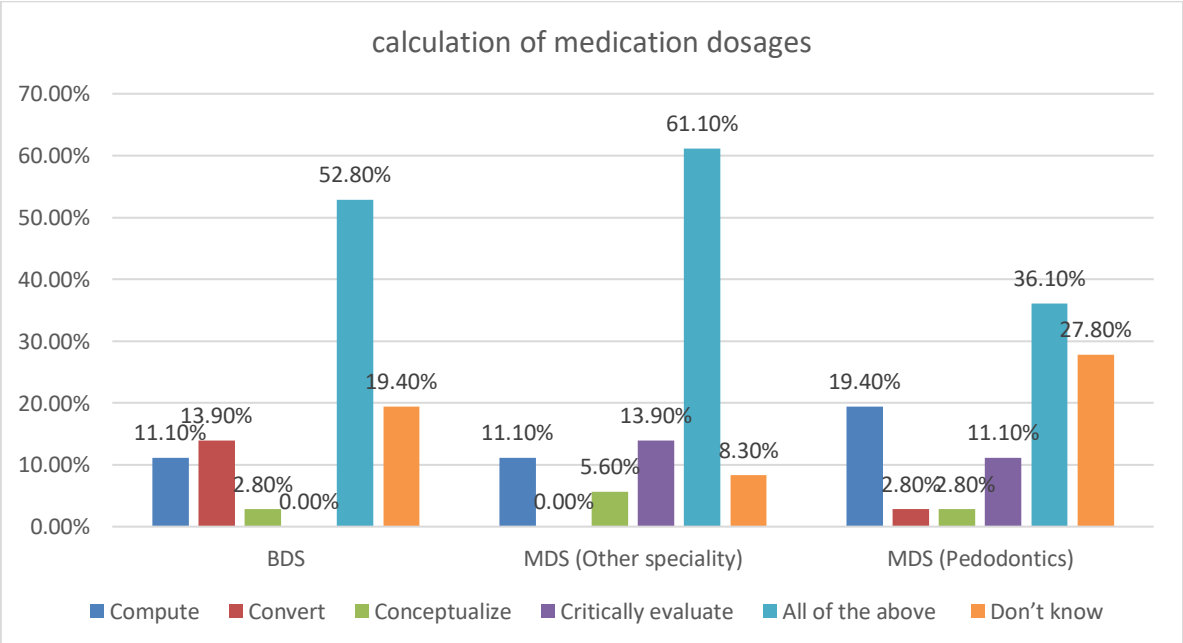
Age-based formulas, particularly Young's formula, were most widely used across all groups, although pediatric dentists more frequently applied weight-based (mg/kg) methods.

13 General Practitioners (36.1%), 14 Other Specialists (38.9%), and 5 Pediatric Dentists (13.9%) correctly identified that fractions, decimals, ratios, percentages, and proportions are all essential for accurate dosage calculations.Awareness of mathematical skills required for dosing was low overall, especially among pediatric dentists as seen in Graph 2.



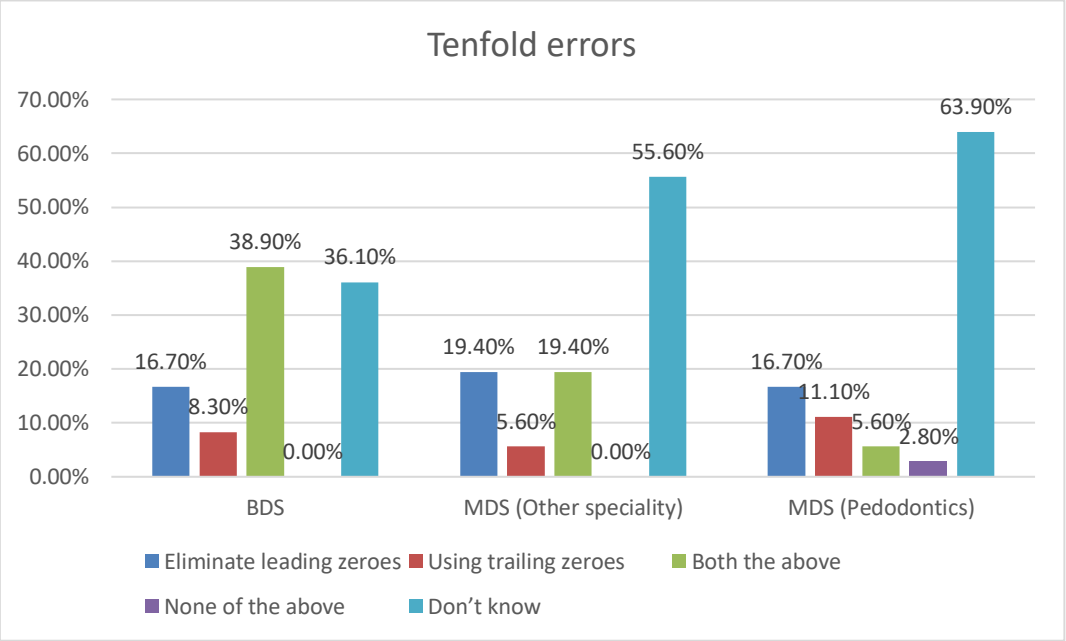
Graph 2. Awareness of mathematical calculations required for dosing

19 General Practitioners (52.8%), 22 Other Specialists (61.1%), and 13 Pediatric Dentists (36.1%) recognized that computation, conversion, conceptualization, and critical evaluation are all necessary for accurate pediatric dosing as observed in Graph 3. Other specialists displayed better awareness than general practitioners and pediatric dentists regarding the broader conceptual skills required for safe drug dosing.



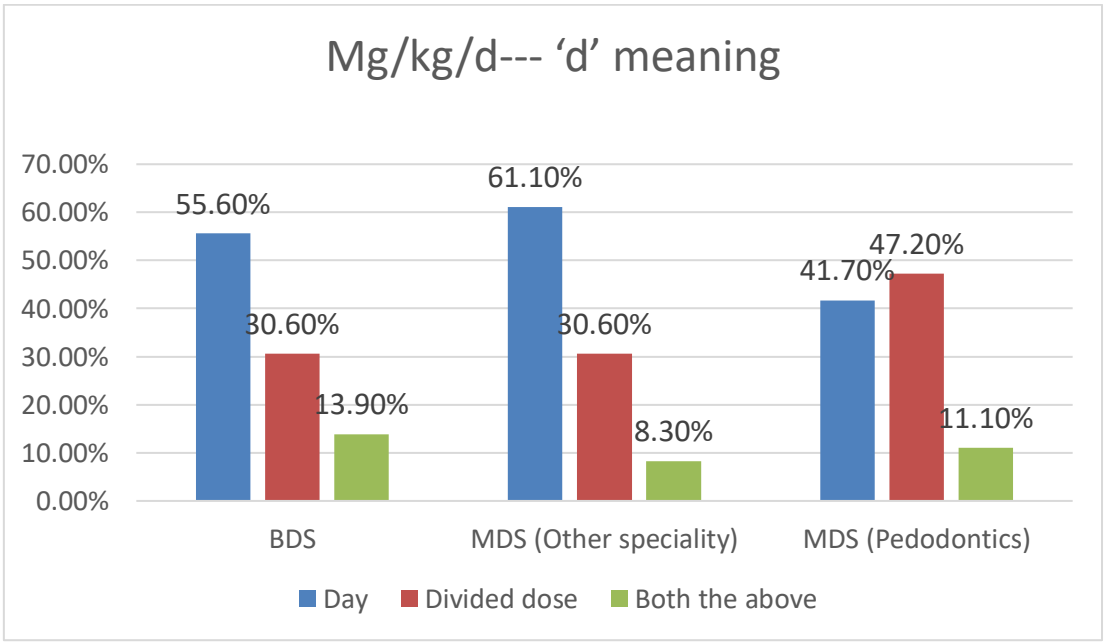
Graph 3. Essentials for calculation of medication dosages

13 General Practitioners (36.1%), 20 Other Specialists (55.6%), and 23 Pediatric Dentists (63.9%) were unaware of the causes of tenfold errors as seen in Graph 4. Lack of awareness about tenfold errors was strikingly high across all groups, particularly among pediatric dentists. This represents a critical area for educational intervention.



Graph 4. Awareness of tenfold errors

20 General Practitioners (55.6%), 22 Other Specialists (61.1%), and 15 Pediatric Dentists (41.7%) correctly identified that "d" refers to day in the dosage equation as seen in Graph 5.Less than two-thirds of respondents in any group correctly understood the meaning of "d," suggesting limited familiarity with standard dosing notation.



Graph 5. Meaning of "d" in mg/kg/d

Prescription practices were generally encouraging as seen in Table 2. All general practitioners reported cross-checking their prescriptions, while nearly all practitioners across all groups gave dosing instructions and insisted on the use of appropriate measuring devices.

Table 2. Response to 8th, 9th and 10th questions in the questionnaire

Question	General Practitioners (n=36)	Other Specialists (n=36)	Pediatric Dentists (n=36)
Cross-check prescriptions (Yes)	36 (100%)	33 (91.7%)	33 (91.7%)
Provide specific dosing instructions (Yes)	35 (97.2%)	35 (97.2%)	35 (97.2%)
Insist on using appropriate measuring devices (Yes)	32 (88.9%)	35 (97.2%)	34 94.4%)

While most respondents recognized that children are not "miniature adults," reliance on pediatric-specific resources (e.g., drug handbooks) was inconsistent.Young's formula (age-based) was the most common method for dose calculation, though pediatric dentists were more likely to use weight-based (mg/kg) methods. Mathematical competence and awareness of tenfold errors were low, with a majority of respondents unaware of common pitfalls in pediatricprescribing.Encouragingly, most practitioners reported cross-checking prescriptions, giving clear dosing instructions, and advising use of appropriate measuring devices.

DISCUSSION

The present cross-sectional survey evaluated the knowledge, awareness, and prescribing practices related to pediatric drug dosing among 108 dental practitioners, equally divided into three groups: general practitioners (BDS), other dental specialists (MDS other than Pediatric Dentistry), and pediatric dentists (MDS in Pediatric Dentistry). The findings provide valuable insights into the current level of competence among dental professionals and highlight areas of concern that warrant attention to minimize medication errors in children.

Understanding Pediatric Drug Dosing

One of the fundamental principles of pediatric pharmacotherapy is that "a child is not just a miniature adult." In our study, the majority of respondents acknowledged this principle, with 61.1% of general practitioners, 83.3% of other dental specialists, and 47.2% of pediatric dentists agreeing with the statement. Although encouraging, the variation across groups underscores that some practitioners may still approach pediatric dosing using adult analogies, which can be inappropriate and unsafe. This observation aligns with the findings of Phillips et al. (2005), who highlighted methodological challenges in describing pediatric dosing errors and stressed the importance of recognizing the physiological and pharmacokinetic differences between children and adults [9].

Reference to Pediatric Drug Dosing Guidelines

The results indicated that a majority of respondents referred to pediatric drug dosing guidelines, with other specialists (86.1%) showing the highest adherence, followed by general practitioners (77.8%) and pediatric dentists (69.4%). This pattern is consistent with earlier findings by Phillips et al [9], who reported that guideline consultation reduces variability and improves accuracy in pediatric prescribing. However, the relatively lower reliance among pediatric dentists is concerning, given that this group is expected to have the highest level of expertise in pediatric pharmacology.

Method of Dose Calculation

The choice of dose calculation methods varied significantly. Young's formula, an age-based method, was the most commonly employed by general practitioners (52.8%) and other specialists (66.7%). Pediatric dentists (38.9%) were more likely to use the mg/kg regimen, which is widely considered the gold standard. Bartelink et al; [10] emphasized that weight-based (mg/kg) dosing is physiologically appropriate, whereas age-based methods often lack precision and can lead to under- or overdosing. Similarly, Mahale et al. [2] reported that most practitioners used age- and weight-based calculations but highlighted the tendency of general dentists to use fractional adult doses, which is clinically inappropriate.

Mathematical Competence in Dose Calculations

Mathematical knowledge is essential for accurate dose calculations. In our study, only 36.1% of general practitioners, 38.9% of other specialists, and 13.9% of pediatric dentists reported awareness of the mathematical principles required for pediatric dosing, such as fractions, ratios, decimals, and proportions. These findings are in line with Sangeetha et al. [4], who also reported low awareness among dentists regarding the role of mathematical competence in drug dosing. Weeks et al [11] and Polifroni et al.[12] similarly observed that poor conceptualization and inadequate numerical skills are major contributors to miscalculations in clinical settings.

Awareness of Tenfold Errors

Tenfold errors, often caused by misplaced decimal points or incorrect use of leading or trailing zeroes, are among the most dangerous medication errors in pediatric practice. Alarmingly, our study revealed that a significant proportion of practitioners were unaware of tenfold errors: 36.1% of general practitioners, 55.6% of other specialists, and 63.9% of pediatric dentists. Wong et al. [13] and Hoyle et al. [14] both documented the prevalence of tenfold dosing errors in

pediatric prescribing and highlighted the need for improved training and safeguards to prevent such catastrophic mistakes.

Understanding of mg/kg/d Notation

The interpretation of standard drug dosing notation was inconsistent among participants. Only 55.6% of general practitioners, 61.1% of other specialists, and 41.7% of pediatric dentists correctly identified "d" in mg/kg/d as referring to "day." Sangeetha et al. [4] similarly reported confusion among dental professionals in interpreting basic drug dosing terminology, which can contribute to prescription errors.

Prescription Practices

Despite the knowledge gaps, encouraging trends were observed in prescription practices. Cross-checking of prescriptions was universally reported among general practitioners (100%) and was also high among other specialists (91.7%) and pediatric dentists (91.7%). Almost all respondents (97.2% across all groups) gave specific dosing instructions to parents or guardians, which reflects an awareness of the importance of communication in reducing medication errors. This is consistent with the findings of Kaushal et al. [15], who emphasized caregiver education as a critical strategy in preventing pediatric dosing errors.

Use of Measuring Devices for Liquid Medicaments

Finally, most respondents insisted on the use of appropriate measuring devices for liquid medications—88.9% of general practitioners, 97.2% of other specialists, and 94.4% of pediatric dentists. This is in accordance with Madlon-Kay and Mosch [16], who reported that dosing errors are significantly reduced when standardized measuring devices are used instead of household spoons. Sangeetha et al. [4] also found high adherence to this practice among pediatric dentists and general dentists, though other specialists lagged behind.

The study findings reveal both strengths and weaknesses in the knowledge and practices of dental practitioners. While prescription cross-checking and patient instruction practices are commendably high, major deficiencies exist in conceptual understanding, reliance on age-based formulas, and lack of awareness about tenfold errors. These gaps suggest an urgent need for continuing education programs, integration of pediatric pharmacology into undergraduate and postgraduate curricula, and hands-on workshops to improve mathematical competence.

Limitations

This study had some limitations. The reliance on self-reported questionnaire responses introduces the possibility of recall and reporting bias. The sample was restricted to practitioners in and around Lucknow city, which may limit generalizability to other regions. Moreover, clinical validation of the knowledge and practices through prescription audits was not undertaken.

CONCLUSION

The study demonstrated that while dental practitioners show good attitudes towards safe prescribing practices, significant gaps remain in their knowledge of pediatric drug dosing and awareness of dosing errors. Strengthening training in pediatric pharmacology, improving mathematical competence, and raising awareness of tenfold errors are essential steps to ensure safer drug administration in pediatric dental practice.

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