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Assessment of Paracetamol Dosing Accuracy among Caregivers in Under-5 Children

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Abstract

Paracetamol is one of the most commonly used antipyretics and analgesics for febrile children worldwide. Inaccurate dosing by caregivers, particularly for under-5 children who require weight-based calculation, poses a significant risk of toxicity or therapeutic failure. A prospective, cross-sectional study was conducted at the Community Based Medical College, Bangladesh (CBMC,B) Hospital, Mymensingh, Bangladesh, from January to December of 2023, to assess the accuracy of paracetamol dosing by caregivers for their under-5 children. A total of 113 caregivers administering liquid paracetamol to their under-5 children were enrolled in this study. Data was collected through structured interviews and direct observation of the dosing process using the caregivers' own measuring devices. Dosing accuracy was determined by comparing the intended dose with the weight-based recommended dose (15 mg/kg). Among those 113 caregivers, the prevalence of dosing inaccuracy was 68.1%, with under-dosing (52.2%) being more common than over-dosing (15.9%). Dosing accuracy was significantly associated with the measuring device used ($p<0.001$), with standard syringes demonstrating the highest accuracy (72.7%). Caregiver education level and the complexity of dosage instructions were also significantly associated with dosing errors ($p<0.05$ and $p<0.01$ respectively). This study reveals a high prevalence of paracetamol dosing inaccuracy, primarily underdosing, among caregivers. Urgent public health interventions, including providing standardized syringes and simplifying dosing instructions, are essential to ensure medication safety and efficacy for young children.

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Introduction

Paracetamol (acetaminophen) is universally regarded as a first-line antipyretic and analgesic agent for the management of fever and mild-to-moderate pain in the pediatric population.[1] Its excellent safety profile when administered at appropriate doses and widespread over-the-counter availability have cemented its status as one of the most commonly used medications by caregivers for children under five years of age globally.[2,3] However, this very accessibility presents a significant public health challenge: the risk of inaccurate dosing. The pharmacological management of children, particularly those under five, is uniquely complex due to the imperative of weight-based dosing calculations. Unlike adults, for whom fixed doses are standard, pediatric dosing requires precise titration based on body weight (typically 10-15 mg/kg per dose) to achieve therapeutic efficacy while avoiding toxicity.[4] Inaccurate dosing, whether sub-therapeutic (under-dosing) or supra-therapeutic (over-dosing), leads to undesirable clinical outcomes. Underdosing fails to provide adequate antipyresis or analgesia, prolonging the child's discomfort and potentially leading to unnecessary healthcare visits.[5] Conversely, overdosing, particularly repeated supratherapeutic ingestion, is a well-documented cause of acute liver failure, a serious and potentially fatal condition in young children.[6,7] The primary responsibility for administering liquid formulations of paracetamol falls uopn caregivers, most often parents. Numerous studies across various settings have demonstrated that a high proportion of caregivers' experience

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difficulty in measuring the intended dose accurately.[8,9] Common errors include misinterpretation of complex dosing instructions on product labels, confusion between different product concentrations, and the use of inappropriate household measuring tools like teaspoons and tablespoons, which are notoriously unreliable and variable in volume.[5,10] The cognitive stress and anxiety associated with managing a febrile child can further exacerbate these measurement errors.[11] In Bangladesh, where infectious diseases are a leading cause of childhood fever,[12] paracetamol use is ubiquitous. However, data on the accuracy of dosing practices by caregivers in a community setting within our country is strikingly limited, which leaves a critical gap in understanding the specific challenges faced by caregivers at home.[11,13,14] Such lacking in local evidence hinders the development of targeted public health interventions to promote safe medication use. Therefore, this study aims to assess the accuracy of paracetamol dosing by caregivers for their under-5 children at a tertiary care setting in Bangladesh. It seeks to quantify the prevalence and magnitude of dosing errors, identify the types of measuring devices used and their associated error rates, and explore factors contributing to these inaccuracies.

Methods

This prospective, cross-sectional study was conducted from January 2023 to December 2023 at the outpatient department (OPD) and paediatric wards of the Community Based Medical College, Bangladesh (CBMC,B) Hospital, Mymensingh, Bangladesh. The study population consisted of primary caregivers (parents or others), who were engaged in administering liquid paracetamol to under-5 children. Caregivers were included if they were administering a liquid paracetamol formulation to a child aged 1 to 59 months for a current febrile or painful episode. Only caregivers who provided voluntary written informed consent were enrolled in the study. Caregivers were excluded if the child had severe hepatic or renal impairment, was critically ill, or required hospitalization for reasons other than fever management. Caregivers unable to communicate effectively in Bengali were also excluded.

Data was collected through a structured interviewer-administered questionnaire. Following the interview, caregivers were directly observed while preparing and measuring a dose of paracetamol for their child using their own measuring device. The intended dose volume was recorded and later compared to the weight-based recommended dose (15 mg/kg) calculated using the child's actual body weight.

Collected data was compiled, coded and analyzed using SPSS version 23.0 for Windows. Data was expressed as frequency and percentage. Chi-square test was employed to assess associations between categorical variables. A p-value <0.05 was considered statistically significant.

The study was approved by the Ethical Review Committee of Community Based Medical College, Bangladesh (CBMC,B), Mymensingh, Bangladesh.

Results

A total of 113 caregivers of under-5 children were included in the present study. The majority of caregivers were mothers (78.8%), and most had completed at least secondary education (65.5%) (Table-I). The mean age of the children was 26.4±14.3 months, with a nearly equal gender distribution (51.3% male and 47.7% female). The overall prevalence of inaccurate paracetamol dosing was 68.1%. Under-dosing was the most common error, accounting for 52.2% of all participants, while

over-dosing occurred in 15.9% of cases. The mean deviation from the correct dose was -18.5% for under-dosed administrations, meaning caregivers gave, on average, 18.5% less than the recommended dose. In cases of overdosing, the mean deviation was +27.8% (Table-II). Using a standard syringe was associated with the highest accuracy rate (72.7%), followed by a medicine cup (35.0%). In contrast, using a household spoon was associated with the highest error rate (92.1%). Those associations were statistically significant ($p<0.001$) (Table-III). Dosing accuracy showed a significant positive association with the caregiver's level of education. Caregivers having education at graduate level or above had significantly higher accuracy rate (58.3%) compared to those having primary education or less (20.0%) ($p<0.05$) (Table-IV). Furthermore, a significant association was found between the complexity of the dosage instruction on the label and the error rate. Instructions requiring mathematical calculation (e.g., "give 5 ml") had a lower error rate than those requiring interpretation of a weight-based table ($p<0.01$) (Table-V). However, no significant association was found between dosing accuracy and the caregiver's relation with child (mother vs. other) or age group of children ($p>0.05$) (Table-VI).

Table-I: Demographic features of the caregivers of the children (N=113)

Variables	Percentage
Caregiver's relation with child	
Mother	79
Father	16
Grandparent/other	5
Education level	
Primary or less	22.1
Secondary/higher secondary	41.6
Graduate and above	36.3

Table-II: Prevalence and magnitude of paracetamol dosing errors among caregivers (N=113)

Dosing category	Frequency (Percentage)	Mean deviation from correct dose
Accurate dosing	36 (31.9)	0
All Inaccurate dosing	77 (68.1)	-
Under-dosing	59 (52.2)	-18.5±22.3
Over-dosing	18 (15.9)	+27.8±15.4

Table-III: Association between measuring device used and dosing accuracy

Measuring device	Accurate dosing Frequency (Percentage)	Inaccurate dosing Frequency (Percentage)	Total
Standard syringe	16 (72.7)	6 (27.3)	22
Medicine cup	7 (35.0)	13 (65.0)	20
Household spoon	9 (7.9)	105 (92.1)	114

*Some caregivers used multiple devices. Chi-square test was applied; $p<0.001$.

Table-IV: Association between caregiver's education level and dosing accuracy

Education level	Accurate dosing Frequency (Percentage)	Inaccurate dosing Frequency (Percentage)	p-value
Primary or less	5 (20.0)	20 (80.0)	0.012^{S}
Secondary/higher secondary	13 (27.7)	34 (72.3)	
Graduate and above	18 (43.9)	23 (56.1)	

Chi-square test was applied to reach p-value; S=significant.

Table-V: Association between instruction type and dosing error

Instruction type	Accurate dosing Frequency (Percentage)	Inaccurate dosing Frequency (Percentage)	p-value
Volume-based	28 (41.8)	39 (58.2)	0.003^{S}
Weight/Table-based	8 (17.4)	38 (82.6)	

Chi-square test was applied to reach p-value; S=significant.

Table-VI: Factors not associated with dosing accuracy

Variables	Category	Accurate dosing Frequency (Percentage)	p-value
Caregiver's relation with child	Mother	27 (30.3)	0.482[NS]
	Other	9 (37.5)	
Age group of children (in months)	1–12	6 (28.6)	0.781[NS]
	13–36	20 (34.5)	
	37–59	10 (29.4)	

Chi-square test was applied to reach p-value; NS=not significant.

Discussion

This study provides a critical analysis of paracetamol dosing practices among caregivers of under-five children in a Bangladeshi tertiary care setting. The findings reveal an alarmingly high prevalence (68.1%) of dosing inaccuracy, a figure that aligns with, and in some cases exceeds, rates reported in similar studies from other countries.[8-11,14] The predominance of under-dosing (52.2%) over over-dosing (15.9%) is a particularly significant result. While overdosing carries the risk of hepatotoxicity,[6,7] the pervasive underdosing documented here suggests a substantial burden of therapeutic failure.[2] This implies that a majority of children may not be receiving adequate relief from fever or pain, potentially leading to parental anxiety, repeated dosing attempts, and unnecessary visits to healthcare facilities.[5,13] The strong association between the type of measuring device and dosing accuracy is a central finding of this research. The superior accuracy associated with standard syringes (72.7% accuracy) compared to medicine cups (35.0%) and household spoons (7.9% accuracy) reinforces a well-established evidence base.[8,13] Household spoons are highly variable in volume and are a known major source of measurement error, yet they remain the most commonly used device in this study. This highlights a critical gap between global best practices and local realities, underscoring the urgent need for interventions that promote the provision and use of standardized dosing syringes with paracetamol products.[13,14] Furthermore, this study identified a significant association between the caregiver's education level and dosing accuracy. Higher education likely improves comprehension of complex medication instructions and numerical information. This is supported by other previous evidence.[8.10,11,14] Instructions requiring mathematical calculation (e.g., a fixed volume) were associated with fewer errors than those requiring interpretation of a weight-based table.[11,13,14] Simplifying drug labels and providing clear, pictogram-based instructions could mitigate these literacy-related barriers and have been shown to improve dosing accuracy significantly.[15] The lack of significant association between dosing errors and factors like the child's age or the caregiver's relation (mother vs. other) suggests that the problem of inaccurate dosing is widespread and not confined to a specific demographic subgroup. This universality strengthens the argument for system-wide interventions rather than targeted approaches.[11]

This single-center study utilized purposive sampling, which may limit the generalizability of the findings. The observational nature of data collection may have also introduced the potential for a Hawthorne effect among participants.

Conclusion

This study demonstrates a high prevalence of paracetamol dosing inaccuracy among caregivers, predominantly underdosing, in a Bangladeshi setting.

The use of non-standard measuring devices and low health literacy were significant contributing factors. These findings underscore an urgent need for public health interventions. Mandatory packaging of paracetamol with standardized oral syringes and providing clear, pictogram-based dosing instructions are needed to ensure medication safety and efficacy for young children in resource-limited contexts.

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