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Research Article

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Investigation of Awareness of Pediatric Nurses Regarding the Determination of Dry Powder Displacement Volumes of Powder Medicines in Vial Form

Mahmude Uysal[1] and Fatma Birgili[2*]

[1]RN, Fundamentals of Nursing, Tepecik Education and Research Hospital, Ankara, Turkey, ORCID ID: 0000-0002-7720-1244

[2]Associate Professor, RN, PhD, Fundamentals of Nursing, Muğla Sıtkı Koçman University, Faculty of Health Sciences, Department of Nursing, Department of Fundamentals of Nursing, Muğla, Turkey, ORCID ID: 0000-0003-0942-2122

[*]Corresponding author

Fatma Birgili, Associate Professor, RN, PhD, Department of Nursing, Faculty of Health Sciences, Muğla Sıtkı Koçman University, Kötekli, Muğla, 48000, Turkey.

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ABSTRACT

This study was conducted as a descriptive study to examine the awareness of pediatric nurses regarding the determination of dry powder volumes of vial powder drugs. The study was conducted between June and July 2021 with 162 nurses working in a Training and Research Hospital in the west of our country. Data were collected using a questionnaire form prepared in line with the literature regarding the personal characteristics of nurses and the most frequently used vial drugs and dry powder volume calculations. Data were evaluated using the SPSS 24 package program using numbers, percentages, averages, standard deviations, minimum and maximum values, and chi-square tests. In this study, the findings were considered statistically significant at a confidence interval of 95% and a significance level of $p<0.05$. The mean age of the nurses was 29.91±6.81, 87% were female, 70.4% were single, 71% had a bachelor's degree, the mean working year was 7.36±6.63, 58.6% had been working in pediatrics for 1-5 years and the mean working year was 5.36±5.12, 77.2% received training on drug administration and dose calculation, but more than half did not know this difference. It can be said that nurses are aware of calculating the dry powder volume of drugs, but they need to be supported in being informed about this issue.

Keywords: Nurse, Drug, Dry Powder Volume, Displacement Value

Introduction

Nurses' drug calculation skills remain a concerning issue. However, there is little evidence to suggest that nurses are weak in solving drug calculations in practice [1]. Drug dosage calculation skills are the most critical function for nurses to ensure patient safety [2-4]. In clinical settings, nurses are responsible for administering drugs to patients, including the timing of administration, dose calculations, and ensuring that no medication errors ocur [5]. Medication errors are defined as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer" [6]. Medication errors lead to increased morbidity and mortality, prolonged hospital stays, increased medical costs, decreased trust and satisfaction in the healthcare system, anxiety and ethical dilemmas among nurses, and reduced quality of care [7,8].

There is limited knowledge and a need for more research on medication errors and their prevention in children. The prescription, distribution, storage, and administration of medications in children present many challenges in the system. For example, the need for weight-based dosing in children and the difficulties nurses face in calculating drug dosages can be cited [9]. Dosage calculation errors are the most common medication errors in pediatric and neonatal units [2], and such errors play a significant role in threatening patient safety, leading to increased medication administration error rates, ineffective treatment, overdose, toxic reactions, and even death [10]. Calculating the correct dosage for pediatric patients can be challenging because they may require only a fraction of the adult döşe [11,12]. Therefore, there is a need to focus on improving medication

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safety in children. Generally, weight-based dosage adjustments, decimal calculations, and incorrect weight recordings are more common problems in children than in adults [13]. Such errors can also lead to secondary kidney and liver failure in children [14]. Since there are no specific drug calculations for children, calculations are usually based on adult drug formulations [15-17].

Most antibiotic drugs are in the form of dry powder in vials and are diluted with sterile water for use. The amount of liquid added to the diluted drug affects the amount of powder in the drug. When calculating drug doses for children, the dry powder volume (DPV) of the drug is important, and the prepared drug should not contain more or less than the required döşe [18]. Accurate pediatric dosage calculation is an important component of drug administration, and a systematic literature review found that the median rate of medication administration errors in children was 14.6 per 100 medication orders and 6.4 to 9.1 per 1000 patient days [19]. Two methods are used to calculate the correct dosages for pediatric patients: the more common method is based on the drug unit per kilogram of body weight, while the other uses body surface area [20]. Using only the body weight method increases the risk of incorrect drug calculations, which in turn leads to subsequent medication administration errors. This limitation of the method has been documented [21], indicating that nurses need to be trained to calculate low and high safe dosage ranges. There are few studies in the literature on the DPV of vial drugs. A study conducted in our country found that the DPV of drugs was not calculated in 86.7% of pediatric patients [22]. Therefore, this study was conducted to determine the awareness of pediatric nurses regarding the determination of dry powder volumes of vial powder drugs. Additionally, this study aims to draw attention to the importance of children receiving the correct dose of medication and preventing antibiotic resistance due to incorrect dosing of antibiotics.

Research Questions

1. Does the DPV of drugs affect the dose of the diluted drug?
2. Do pediatric nurses correctly calculate the DPV of the drug to be administered?

Method

Research Design and Methodology

The research is descriptive and cross-sectional in nature. The population of the study consisted of nurses working in the pediatric unit of İzmir Tepecik Training and Research Hospital (n=162). No sampling method was used, and the study was conducted with 162 nurses who were accessible and willing to participate in the research. The questionnaire form prepared in line with the literatüre [13,22-24] included questions about the nurses' personal characteristics (age, gender, education, unit of work, years of experience, number of patients per nurse), their knowledge about drugs (reading drug leaflets, knowledge of DPV, awareness of changes in drug quantity due to DPV, and training on DPV calculation). Additionally, the most frequently used drugs in pediatric wards were listed, and nurses were asked to mark the displacement volume in cc for each drug. Expert opinion was sought for the prepared questionnaire.

The research was conducted in the pediatric clinics and pediatric intensive care units of İzmir Tepecik Training and Research Hospital. The pediatric units included pediatric oncology, pediatric emergency, pediatric subspecialties, milk room, general pediatric ward, pediatric surgery ward, pediatric intensive care, neonatal intensive care, and neonatal surgical intensive care. Data were collected between June and September 2021. The questionnaire forms were distributed to nurses who agreed to participate in the study during suitable hours, with permission from the head nurse of the clinic. The forms were then collected. Filling out the questionnaire took an average of 15-20 minutes.

Statistical Analysis

The data obtained were evaluated using the SPSS 26 package program. Numbers, percentages, averages, standard deviations, minimum and maximum values, and chi-square tests were used for data evaluation. In this study, the findings were considered statistically significant at a confidence interval of 95% and a significance level of $p<0.0525$.

Ethical Considerations

Ethical approval for the study was obtained from in a west of our country the University Health Sciences Ethics Committee (protocol no: 200287, decision no: 3, date: 17.01.2021) and the in the west of our country Training and Research Hospital Scientific Research and Publication Ethics Committee (E-420566799-619). Nurses were informed about the study, and they were assured that all data would be kept confidential and that they could withdraw from the study at any time.

Results

In the study, 56.2% of the nurses were in the 21-27 age group and their average age was 29.91±6.81, their average working year was 7.36±6.63, and their average working year in the current clinic was 3.86±4.09. 87% of the nurses were female, 70.4% were single, 71% had a bachelor's degree, 71.6% had worked in pediatrics for 1-10 years and 58.6% had worked for 1-5 years and their average working year was 5.36±5.12, they had worked in the current clinic for 1-4 years, 27.8% worked in the emergency department, 84.6% worked voluntarily, 88.9% were clinical nurses, 77.2% worked during the day/on-call, and 95.7% had participated in in-service training.

In the study, it was determined that 77.2% of the nurses received training on drug applications and KTH dose calculation, 51.9% did not receive training on drug applications and KTH during the training period, 78.4% read the prospectus, 77.3% gave importance to KTH when diluting drugs, 5.6% were warned by doctors not to take KTH into account, and 6.8% did not experience any problems with not taking KTH into account. It was determined that 64.2% of the nurses answered correctly the questions "KTH is calculated based on the amount of liquid used in diluting vial drugs in children," 11.7% "After diluting vial drugs, the difference between the diluent and the dose to be given to the patient is insignificant," and 14.8% "After diluting vial drugs, if the difference between the amount of liquid is not taken into account, it does not affect the patient's treatment".

In the study, it was determined that the majority of the nurses did not know the difference in DPV. A difference was determined between the average years of working in pediatrics of the nurses and their knowledge of the difference in DPV of "equizoline" ($p=0.000<0.05$).

The difference between receiving training on calculating drug doses and knowing the DPV of the drug "vfend", receiving training on calculating DPV and knowing the DPV of the drugs "eqizolin" and "eqitax", reading the prospectus and knowing the DPV of the drugs "tazoper, seffur, penbisin", paying attention to the DPV when diluting drugs and knowing the DPV of the drug "tazoper" was found to be significant ($p<0.05$).

Discussion

The aim of this study was to determine pediatric nurses' awareness of the dry powder displacement volume (DPV) of vial-form medications they most frequently use in treatment. The World Health Organization's 2017 Global Patient Safety Challenge theme and slogan was "Medication Without Harm" [26]. This campaign focused on the fact that unsafe medication practices and medication errors are a leading cause of preventable harm worldwide. Nurses play a critical role in ensuring medication safety; thus, pediatric nurses must graduate from nursing programs equipped with the skills to calculate drug doses for children, including infants [27]. Differences in organ development in children (e.g., liver enzyme systems, renal systems, delayed gastric emptying, reduced intestinal motility) can affect drug metabolism and excretion, particularly in cases of overdose. Therefore, preventing medication errors is critical. Threats to patient safety in pediatric medication administration are influenced by factors such as newly introduced medications, emergencies, and changes in clinical settings, all of which disrupt nurses' routines. These factors, combined with nurses' demanding, stressful, and often understaffed work environments, must be considered [28].

In our study, the majority of pediatric nurses reported paying attention to DPV when reconstituting vial medications. Similarly, Gerçeker et al. (2015) found that over half of nurses considered DPV during medication administration [24]. However, another study reported this rate as 12.8% [22]. Our study revealed that while most pediatric nurses were unaware of the DPV of vial medications, their knowledge of DPV increased with years of experience. Westbrook et al. (2011) found that nurses with more experience had a reduced risk of medication errors [29]. Another study reported that nurses with longer work experience paid more attention to DPV, with a statistically significant difference [22]. In a separate study, 83.4% of nurses reported making medication errors within their first five years of practice, with contributing factors including night shifts, high patient-to-nurse ratios, and limited experience [30]. These findings align with our results. Our study found that most nurses had received training on medication administration and dose calculation and read drug leaflets before administration, yet nearly half lacked training on DPV calculations. Savaşer et al. (2008) observed that drug leaflets often omit information on the DPV of vial medications and the volume of diluent required for reconstitution [22]. Nurses must be educated on DPV calculations to raise awareness [31]. The WHO identifies insufficient drug knowledge and experience as factors linked to medication errors [32].

In this study, over half of the nurses responded that "the amount of a vial medication to be administered to children is calculated based on the volume of diluent," indicating a need for further education on DPV. Few nurses agreed with statements such as "the displacement volume after reconstitution is negligible for the prescribed dose" or "ignoring the displacement volume has no negative impact on treatment," highlighting the importance of DPV in preventing underdosing.

Prior to the study, a table was prepared listing the DPV and dose loss amounts due to displacement for the 20 most frequently used vial medications in pediatric units (Appendix 1). DPV-related volume increases were identified in 18 of 20 medications. A previous study found that such volume increases reduce the drug concentration per milliliter [21]. The highest volume increases were observed with Tazoper and Vfend, while the greatest dose losses occurred with Penbisin and Sulcid. Without accounting for DPV, Penbisin showed a loss of 83 mg per milliliter and Sulcid 59 mg per milliliter. Meineche (2015) found that DPV was calculated for only one of seven powdered antibiotics [33]. In Turkey, 86.7% of nurses were found to disregard DPV [22], while Bülbül et al. (2014) reported that 85.7% of pediatric nurses calculated DPV [34]. Failure to account for DPV can result in ineffective treatment or severe complications.

Nurses trained in DPV correctly answered questions about Eqizolin and Eqtax. A significant correlation was found between nurses who considered DPV during reconstitution and those who knew Tazoper's DPV. This suggests that Tazoper's frequent use in pediatric clinics influenced awareness. Additionally, nurses with longer pediatric experience were more likely to know Eqizolin's DPV, indicating that experience improves accurate DPV calculation.

Conclusion

This study evaluating pediatric nurses' awareness of DPV in vial-form medications found that while most nurses received training and paid attention to DPV calculations, over half lacked knowledge of displacement volume. Nurses with longer work experience demonstrated better awareness of DPV for commonly used medications. Based on these findings, we recommend:

In-service training for pediatric nurses on DPV.

Inclusion of DPV and reconstitution guidelines in drug leaflets.

Reporting these issues to the Ministry of Health to improve drug safety standards.

Limitations of the Research

The results of the study are limited to the nurses working in the pediatric clinics where the study was conducted and the drugs used in these clinics. Data were collected through a questionnaire, and the results are limited to the responses given by the nurses to the questions asked.

Financial Resource

During this study, any pharmaceutical company that has a direct connection with the subject of the research, a company that provides and/or produces medical instruments, equipment and materials, or any commercial company, or any moral support.

Conflict of Interest

Regarding this study, the authors and/or their family members do not have a potential conflict of interest, scientific and medical committee membership or relationship with its members, consultancy, expertise, employment in any company, shareholding or similar situations.

Author Contribution

Study conception and design: Mahmude UYSAL, Fatma BİRGİLİ

Data collection: Mahmude UYSAL

Data analysis and interpretation: Mahmude UYSAL, Fatma BİRGİLİ

Drafting of the article: Fatma BİRGİLİ

Critical revision of the article: Fatma BİRGİLİ

This study is a master's thesis. Thesis advisor: Fatma BİRGİLİ

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Ethical approval

Ethical approval for the study was obtained from in a west of our country the University Health Sciences Ethics Committee (protocol no: 200287, decision no: 3, date: 17.01.2021) and the in the west of our country Training and Research Hospital Scientific Research and Publication Ethics Committee (E-420566799-619). Nurses were informed about the study, and they were assured that all data would be kept confidential and that they could withdraw from the study at any time. The research was conducted in accordance with the principles of the Declaration of Helsinki.

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