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ASSESSMENT OF PEDIATRIC LIQUID MEDICATION DOSING ERRORS AND THE SATISFACTION WITH INFORMATION ABOUT MEDICINES AMONG FAMILY CAREGIVERS

MASTER THESIS

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APPROVAL

This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated ..... and numbered .....

Prof. Dr. Bayram YILMAZ

Director of Institute of Health Sciences

DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

Date: 23/06/2023

Signature

Name Surname: Soz Hardi Mustafa Bakhtyar

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LIST OF SYMBOLS AND ABBREVIATIONS

FDA: Food and Drug Administration

AAP: American Academy of Pediatrics

US: United States

WHO: The World Health Organization

STIs: Sexually transmitted infections

Tsp: Tablespoon

OTC: Over-the-counter

mL: Milliliters

Cc: Cubic centimeters

IT: Information technology

ADR: Adverse drug reaction

UK: United Kingdom

PCPs: Primary care providers

SIMS: Satisfaction with Information about Medicines Scale

HCPs: Healthcare providers

SD: Standard deviation

ABSTRACT

Background and Objective: Ensuring accurate dosing of liquid medications in pediatric populations is of paramount importance for both treatment efficacy and patient safety. This study aims to investigate the prevalence of liquid medication dosing errors in pediatric patients and associated factors along with parental satisfaction with information about medicine provided by healthcare providers.

Design: A cross-sectional study was carried out involving parents or legal guardians over 18 years old who administer liquid medication to children aged ≤8 years. A minimum sample size of 397 participants was determined. Parents satisfaction with counseling information was evaluated using the SIMS questionnaire. Dosing accuracy was evaluated by requesting the parent's measure of 2.5 ml, 5 ml, and 7 ml of liquid paracetamol and comparing it to the standard dose using calibrated cylinders. Dosing errors were defined as deviations of ≥20% from prescribed doses. Ethical approval and written consent were secured prior to data collection. Statistical analysis was performed using SPSS version 25.

Results: Totally 397 patient families responded. Overall 49% were women and 93% of these women were the child's mother. More than 90% of respondents reported being knowledgeable of indications, dosing techniques, and duration of medications for their children. Parents report both pharmacists and physicians (31%) to educate them regarding their disease or medicine. A total of 46% reported that they use spoons or dosing cups during the administration of liquid medications. Following evaluation of parents dose-measuring of 2.5 ml, 5ml, and 7ml the following readings (mean±SD, (range)) were attained respectively: 3.64±1.067 (2-7); 5.57±1.24 (3-12); 8.49±1.846 (4-17).

Conclusion: In Türkiye, the prevalence of inaccurate dosing practices among parents necessitates advanced counseling strategies and standardized dosing tools to improve pediatric medication administration. Healthcare providers' role in enhancing parental knowledge and promoting standardized instruments, like oral syringes, emerges as crucial for safe and effective dosing.

Keywords: Liquid medication, dosing error, pediatric, caregiver, Satisfaction about medicine information (SIMS).

ABSTRACT (Turkish)

Arka Plan ve Amaç: Pediyatrik popülasyonda sıvı ilaçların doğru dozajının sağlanması, hem tedavi etkinliği hem de hasta güvenliği açısından büyük önem taşımaktadır. Bu çalışmanın amacı, pediatrik hastalarda sıvı ilaç dozlama hatalarının yaygınlığını ve ilişkili faktörleri, ayrıca sağlık hizmeti sağlayıcıları tarafından sağlanan ilaçla ilgili bilgilerden ebeveynlerin memnuniyetini araştırmaktır.

Tasarım: 8 yaş altı çocuklara sıvı ilaç uygulayan 18 yaş üstü ebeveynleri veya yasal vasileri içeren kesitsel bir çalışma gerçekleştirildi. Minimum örneklem büyüklüğü 397 katılımcı olarak belirlendi. Ebeveynlerin danışmanlık bilgilerinden memnuniyeti SIMS anketi kullanılarak değerlendirildi. Dozajın doğruluğu, ebeveynden 2,5 ml, 5 ml ve 7 ml sıvı parasetamol ölçüsü istenerek ve kalibre edilmiş silindirler kullanılarak standart dozla karşılaştırılarak değerlendirildi. Dozlama hataları, reçete edilen dozlardan ≥%20 sapma olarak tanımlandı. Verilerin toplanmasından önce etik onay ve yazılı onam alınmıştır. İstatistiksel analiz SPSS versiyon 25 kullanılarak yapıldı.

Bulgular: Toplam 397 hasta ailesi yanıt verdi. Genel olarak %49'u kadındı ve bu kadınların %93'ü çocuğun annesiydi. Ankete katılanların %90'ından fazlası çocuklarına yönelik ilaçların endikasyonları, dozaj teknikleri ve süreleri hakkında bilgi sahibi olduklarını bildirdi. Ebeveynler kendilerini eğitmek için hem eczacıların hem de doktorların (%31) olduğunu bildiriyor

hastalıkları veya ilaçları ile ilgili. Sıvı ilaçların uygulanması sırasında toplam %46'sı kaşık veya doz kap kullandığını bildirdi. Ebeveynlerin 2,5 ml, 5 ml ve 7 ml'lik doz ölçümü değerlendirmesinin ardından sırasıyla aşağıdaki okumalar (ortalama±SS, (aralık)) elde edildi: 3,64±1,067 (2-7); 5,57±1,24 (3-12); 8,49±1,846 (4-17).

Sonuç: Türkiye'de ebeveynler arasında yanlış dozlama uygulamalarının yaygınlığı, pediatrik ilaç uygulamasını iyileştirmek için ileri danışmanlık stratejileri ve standartlaştırılmış dozlama araçlarını gerektirmektedir. Sağlık hizmeti sağlayıcılarının ebeveyn bilgisini artırma ve oral şırıngalar gibi standartlaştırılmış araçları teşvik etmedeki rolü, güvenli ve etkili dozlama için hayati öneme sahiptir.

Anahtar kelimeler: Sıvı ilaç, doz hatası, pediatrik, bakıcı, İlaç bilgisinden memnuniyet (SIMS).

1. INTRODUCTION

Pediatric patient is unique in their reliance on liquid formulations. With the administration of oral liquid medicines, parents must choose an appropriate tool with which it is accurate enough to measure and administer the medicine to their children, while using the range of measurement units (e.g., milliliter, teaspoon, and tablespoon) [1].

The most common cause of diseases in pediatrics mainly are infection and inflammation [58]. However, antibiotics and analgesics are mainly used in the treatment of infections and inflammation. To promote further dosing accuracy, both the American Academy of Pediatrics (AAP) and the US Food and Drug Administration (FDA) recommend that parents use dosing tools with standard markings (e.g., oral syringes, droppers, dosing cups), rather than nonstandard kitchen spoons; which vary vastly in size and shape. However, no national guidelines exist regarding the type of tool that should be necessarily provided to families [1,3].

Studies have documented that more than half of parents make errors when dosing liquid medication for their children [4]. As found by the study the most significant reduction in errors occurred when the dosing tool closely matched the prescribed dose volume, minimizing the risk of overdosing and eliminating the need for multiple measurements [1]. This highlights the importance of using appropriate dosing tools to ensure accurate and safe medication administration.

To fill in the gaps regarding best practices for the labeling and dosing of pediatric liquid medications. As specified by the study, it is necessary to investigate strategies for labeling and dosing pediatric liquid medications. The study explores the potential impact of factors such as including text only or text and pictogram dosing instructions, utilizing milliliter-only or milliliter/teaspoon unit-concordant labels and tools, and ensuring appropriate matching of dosing-tool capacity to dose volume. Moreover, the study emphasizes the importance of considering parental health literacy and language, as low health literacy and limited English proficiency significantly contribute to the risk of errors among parents [2,5,6].

The aim of the study is to determine the prevalence of liquid dosing errors in pediatric patients and to determine the accuracy of the parent preferred dosing tools compared to standard measurements in the studied population. The second objective is to describe parent's satisfaction with information provided by the healthcare providers.

2. LITERATURE REVIEW

2.1. Medication use in pediatric

Pediatrics is a branch of medical science that focuses on the health and medical treatment of newborns, children, and adolescents. The term pediatrics means "healer of children" and is derived from two Greek words: pais (child) and iatros (doctor or healer). It includes the identification, treatment, and prevention of diseases and injuries unique to various age groups. Dr. Abraham Jacobi, known as the "Father of American Pediatrics," ascended through the ranks of pediatrics and medicine in the United States from humble origins in Germany [7-8]. When he said, "Pediatrics does not deal with miniature men and women, with reduced doses and the same class of disease in smaller bodies [9], he recognized the importance and need for age-appropriate pharmacotherapy."

Table 1: Classification of pediatric ages range [10].

Pediatric Subpopulation	**Approximate Age Range**
Newborn	Birth to 1 month of age
Infant	1 Month to 2 years of age
Child	2 to 12 Years of age
Adolescent	12-21 Years of age

Although experts differ on the maximum age limit for defining the pediatric population (table1), adding teenagers up to the age of 21 is compatible with the definition found in numerous well-known sources [13-15].

Medication use in pediatric focuses on the health and medical treatment of children and adolescents, requiring age-appropriate pharmacotherapy; pharmacokinetic responses to medication differ between children and adults due to factors such as immature liver function and variations in drug absorption and distribution, necessitating individualized dosing; preconception care is crucial to

reduce maternal and child mortality and morbidity, addressing various health conditions, behaviors, and risk factors through evidence-based interventions; medication errors and dosing mistakes, including measurement problems and misinterpretation of instructions, can occur in pediatric care, emphasizing the need for effective communication, standardized dosing instruments, and caregiver education [16 23,24].

Both pediatric parents and healthcare providers play critical roles in ensuring safe and effective medication therapy for children. Parents should communicate with healthcare practitioners about their child's medical history, administer medications correctly, monitor for adverse effects, and ensure compliance with the prescribed regimen. Healthcare providers, including clinical pharmacists, should effectively communicate, calculate accurate dosages, provide drug education, monitor patients, and ensure adherence to the prescribed regimen [36]. Clinical pharmacists can significantly contribute to reducing medication errors through activities such as medication reconciliation, dosage calculations, patient education, collaboration with healthcare professionals, and monitoring for adverse drug responses. By addressing these aspects, including age-appropriate pharmacotherapy, standardized dosing units, and proper communication and education, efforts can be made to enhance medication safety and optimize healthcare outcomes in pediatric populations, ultimately reducing morbidity and mortality rates associated with childhood illnesses [59].

As cited in studies conducted, the most common diseases in childhood have been identified [11]. Research indicates that a significant proportion of deaths among children under the age of five are attributed to preventable and treatable illnesses such as acute respiratory infections, diarrheal disorders, and malaria [11]. Furthermore, neonatal disorders and infectious diseases like pneumonia, diarrhea, malaria, measles, and meningitis account for more than 80% of under-five mortality, often exacerbated by malnutrition [11]. It is worth noting that the implementation of effective treatments, even in resource-limited conditions, holds the potential to prevent the majority of childhood fatalities [12].

2.1.1 Maternal and childhood mortality and morbidty

To address maternal and childhood mortality and morbidity, a comprehensive continuum of care spanning from pre-pregnancy to adolescence is crucial. Pre-pregnancy interventions play a vital role in improving the health outcomes of adolescents, adult women, and men, as well as subsequent pregnancy and child health. A collaborative effort led by the Maternal, Newborn, Child, and Adolescent Health Department (MCA) and other WHO departments resulted in a global consensus on preconception care. This agreement includes a menu of treatments, outlining health issues, problem behaviors, and risk factors contributing to maternal and child mortality and morbidity across thirteen areas. The identified interventions encompass health education, immunization, nutritional supplements, contraceptive services, screening, counseling, and medical and social administration. WHO aims to provide evidence-based interventions, tailored to local epidemiology and available resources, to reduce maternal and childhood mortality and morbidity [16].

A menu of effective therapies exists to address various preconception health conditions, behaviors, and risk factors associated with maternal and childhood death and morbidity. These encompass deficits in nutrition, vaccine-preventable infections, tobacco use, environmental dangers, genetic problems, early and unwanted pregnancies, sexually transmitted illnesses, and mental health issues. Interventions can be delivered through health education, promotion, immunization, nutritional supplementation, food fortification, contraceptive services, and comprehensive screening and counseling. Recognizing the importance of universal accessibility, WHO plans to recommend a package of preconception care interventions that can be implemented globally, even in resource-constrained settings. Alongside these recommendations, governments are encouraged to consider additional actions to further improve maternal and childhood health outcomes. By implementing evidence-based interventions and providing necessary guidance, efforts can be made to minimize maternal and childhood mortality and morbidity worldwide [16].

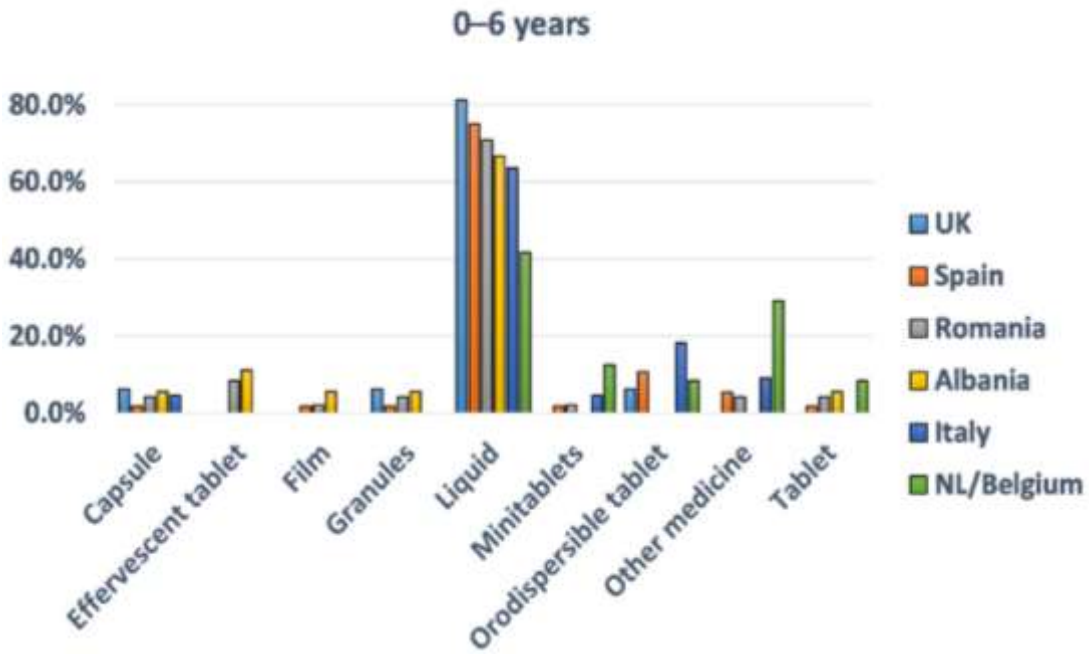
According to the polls evaluated, only a few nations (the United States, Canada, Denmark, Sweden, the Netherlands, the United Kingdom, Germany, and Italy) were

represented. Italy and Canada had the highest rates of pediatric antibiotic prescriptions among the nations surveyed, whereas northern European countries (the Netherlands and the United Kingdom) had much lower rates. For example, the incidence of antibiotic prescription appears to be fourfold greater in Italy than in the UK and sixfold higher than in the Netherlands. This disparity may be much higher when one considers that the Italian research was based on prescription records, and hence the prevalence rate may be understated. Preschool children were found to be the most exposed age class in studies reporting antibiotic usage by age, with an average frequency that is 1.5- to 2.5- fold greater than that of school-age children and adolescents. This discovery is most likely the result of children entering the communal context. Penicillins are typically used as first-line treatment for the majority of frequent pediatric respiratory infections [17-20].

2.1.2 Pediatric physiological and pharmacokinetic challenges of drug therapy

In pediatrics, the patient might be a preterm newborn weighing 500 g or a fully developed teenager weighing up to 100 kg. Doses for children are frequently calculated by scaling adult doses after correcting for body weight. However, it is widely recognized that pharmacokinetic responses to a medicine, such as drug absorption, distribution, metabolism, and excretion, differ significantly between children and adults and that these responses alter as children grow and mature. Drug elimination is poor in newborns, particularly preterm neonates, due to the limited drug metabolizing ability of the liver and immature kidney function. As a result, these newborns require even lower dosages than the predicted weight-adjusted amounts [21]. Toddlers and preschool children, on the other hand, have a higher metabolic capacity and may require higher dosages than weight-adjusted doses [22]. Furthermore, the surface area-to-body weight ratio in children can be up to three times that of adults, resulting in a greater proportion of topically applied medications being absorbed in children. As a result, it is obvious that simply scaling from adult doses does not always provide adequate estimates of appropriate dosages for children [23, 24].

A research study on pediatric medication prescription found that after interviewing the parents of 343 pediatric inpatients following hospital discharge, they discovered that opioid consumption was related in part to surgical procedures and pain at the time of discharge; however, more than half of all doses dispensed were left unconsumed when opioids were no longer needed to treat pain, and only 4% of families disposed of this leftover medication [25].



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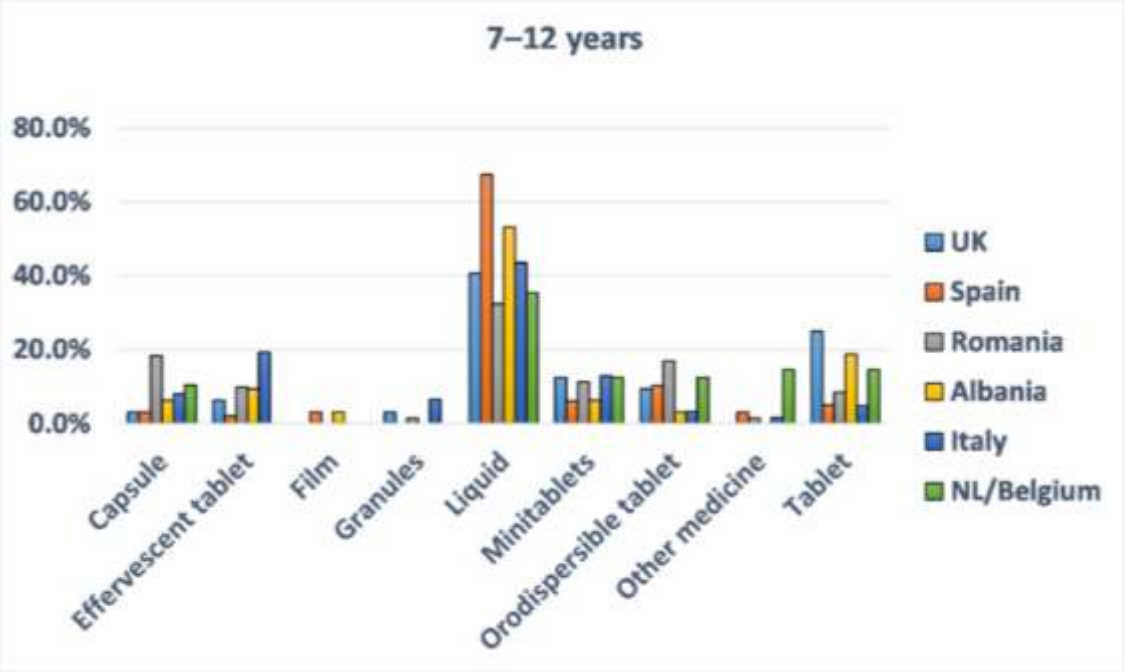

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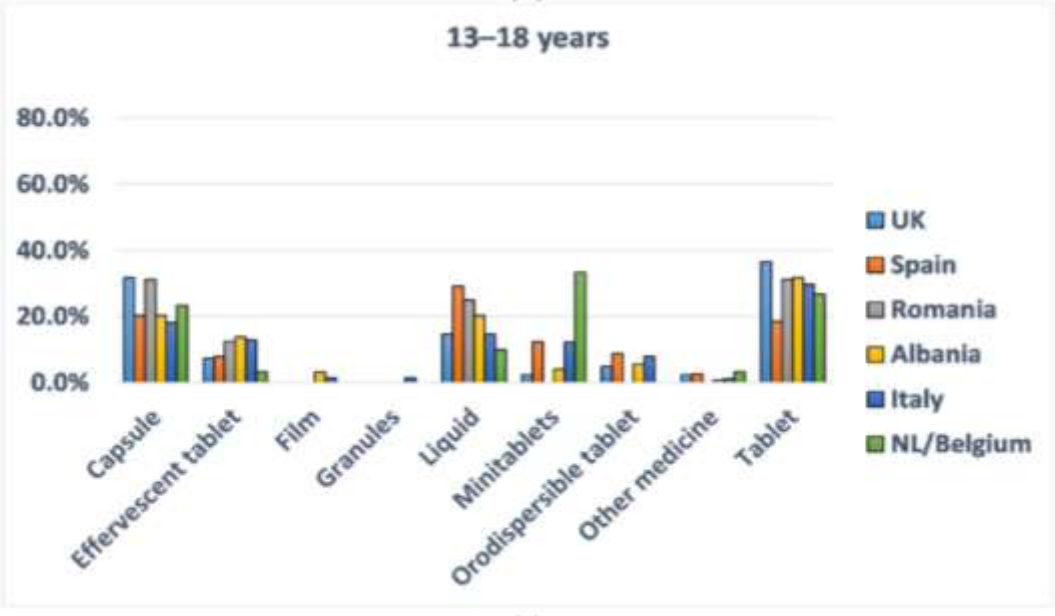

(c)

Figure 1. Percentage of respondents by country and type of dosage forms preferred; for (a) 0–6 years, (b) 7–12 years, and (c) 13–18 years. Different colours of the columns indicate different countries, as reported in the legend.[26]

As stated by the results of a study, children generally preferred liquid dosage forms as their favorite medication (93%). Healthy children aged 0-6 years (76.8%) and 7-12 years (54%) showed a significant preference for liquid. This preference decreased with age but remained at 21% among teenagers. However, children with chronic conditions had a lower preference for liquid (less than 40% for younger age groups, 5% for the oldest). Tablets were chosen by less than 10% of healthy children aged 7-12, while twice as many chronically ill children preferred them. Capsules were more popular among children aged 0-6 years and 7-12 years compared to healthy children. Children with chronic conditions had a broader range of dosage form preferences. Their preference for solid dosage forms may be due to the convenience and potential palatability challenges. Factors like ease of administration and quick intake were more important to children with chronic conditions. Capsules and tablets were least favored, while granules, liquid, and effervescent pills were preferred by older children [26]. (Figure 1)

2.2. Irrational use of medicine in pediatric and dosing error

Rational use of medicine is defined as patients receiving medications appropriate to their clinical needs, in doses that meet their own individual requirements, for an adequate period of time, and at the lowest cost to them and their community [27]. Common examples of irrational drug use include use of antimicrobials for viral infections and over-prescribing of injections. Such practices result in waste of resources, inappropriate patient demand, antimicrobial resistance and increased drug-related morbidity and mortality [28].

2.2.1 Drug related problem can be classified into several parts:

Drug-related problems (DRPs) are defined as "an event or circumstance involving drug therapy that actually or potentially interferes with desired health outcomes" [29,31]. For a case to be considered a DRP, two conditions must be met: the presence of symptoms in a patient and the association of these symptoms with drug therapy [33,34]. It is important to note that most DRPs are preventable once the

underlying medication errors and contributing factors are identified [30]. The causes of DRPs include drug selection, dose selection, and medication procedural errors [29].

Furthermore, findings from a study conducted in Türkiye indicated that patients who had renal impairment, inflammation, polypharmacy, or an extended duration of hospitalization were more susceptible to experiencing drug-related problems (DRPs). Inappropriate drug choices, errors in dose selection, and medication procedure mishaps were identified as the primary factors contributing to DRPs in this study [40].

A study also highlights that the participation of clinical pharmacists in pediatric departments plays a crucial role in identifying and resolving drug-related problems (DRPs), resulting in improved therapeutic outcomes. The implementation of clinical pharmacy services encourages collaboration among healthcare professionals, reducing medication errors and enhancing patient well-being [41].

Table 2: Influential factors contributing to drug related problems. [29,35-39].

Factors associated with health care professionals	**Factors associated with patients**
Inadequate therapeutic training	Characteristics of the patient (for example, personality, literacy, and language problems).
Insufficient drug knowledge and expertise	Clinical case complexity, encompassing various health issues, polypharmacy, c-reactive protein and high-risk drugs.
Inadequate understanding of the patient	Administering or taking the medicine incorrectly—wrong dose, improper route, incorrect frequency, incorrect duration;
Inadequate risk perception	
Health-care workers that are overworked or exhausted	
Problems with physical and emotional	

health	
Inadequate communication between health care professionals and patients.	

Medication error: A medication error is described as an avoidable mistake in prescribing or administering medication to a patient that results in an incorrect use of medicine or injury to the patient [35,42,43].

Dosing mistakes are the administration of an inaccurate dose of medication owing to a variety of circumstances, such as dosage misunderstanding, measurement problems, or misreading of drug instructions. Dosing mistakes can have major effects, such as adverse drug reactions, medicine overdoses, or underdoses. Errors may occur at different levels in the treatment cascade, whether on prescriber level, administer level and/or patient level. According to studies, parents frequently misunderstand instructions on how to correctly administer medication to their children, with over 40% of caregivers making errors in dosing liquid medications. People with low health literacy [44,45] and limited English proficiency are especially vulnerable to medication administration errors [5,6,47]. A health literacy-informed strategy to improve provider communication of prescription instructions to parents through the use of advanced counseling tactics, as well as the use of standardized dosage tools, are potential solutions to decrease mistakes [48,49]. Drug-drug interactions can therefore be considered as medication errors, representing risk factors for adverse drug reactions [50].

Adverse drug reaction: An adverse drug reaction (ADR) is defined by the World Health Organization (WHO) as a harmful and unintended response to a drug, occurring at normal therapeutic doses. It can be associated with the prevention, diagnosis, or treatment of a disease, or with the modification of normal bodily functions [51]. Understanding the origin and risk factors of medication errors is crucial for the prevention of ADRs, as medication errors can serve as a precursor to adverse drug reactions [29].

A study conducted in a respiratory care unit in China revealed a notable prevalence of drug-related problems (DRPs) among hospitalized patients, with a rate of

34.6% and an average of 2.5 DRPs per patient. The findings emphasize the importance of clinical pharmacists in identifying and resolving these DRPs through clinical interventions [52].

The concept of drug-related problems can be visualized through the overlapping circles of medication errors, adverse drug events, and adverse drug reactions. Medication errors encompass mistakes in any step of the medication process, including prescribing, dispensing, and administering drugs. While medication errors are common, only a small proportion of them lead to adverse drug reactions or adverse drug events. Adverse drug events encompass any harm or injury associated with drug use, regardless of the proven causality. Adverse drug reactions, on the other hand, refer to unintended noxious responses to a drug that occur at normal therapeutic doses [29].

Adverse drug event: An adverse drug event (ADE) is defined by the World Health Organization (WHO) as an untoward medical occurrence that may occur during treatment with a medication, but does not necessarily have a causal relationship with the treatment. Simplified, an ADE can be described as an injury resulting from the use of a drug [53-55]. Since a significant portion of ADEs can be prevented, it is crucial to focus on their prevention after detection. Identifying patients at the highest risk for ADEs is a challenging task in hospital practice. To address this, we have reviewed the literature to provide an overview of various effective methods for preventing ADEs. These tools for detecting high-risk patients show promise in improving drug safety [56].

Adverse drug events (ADEs) are a considerable cause of morbidity and mortality in hospital practice. The precise frequency is unknown, but studies give an incidence number ranging from 2 until 52 ADEs per 100 patients. There are many different methods for definition, causality assessment, severity classification and detection of ADEs which make it difficult to compare the different studies. A substantial part (in some studies up to 70%) of ADEs can be prevented and it is important to, besides their detection, focus on the prevention of these ADEs. In this literature review we give an overview of methods for preventing ADEs. There are many different tools with different impact on a particular part of the distribution system which has the potential to prevent ADEs. A multifaceted approach is needed. Two interesting strategies of

prevention, pharmacist participation on ward rounds and computerized physician order entry with clinical decision support systems (CDSS), are highlighted. Moreover, two promising CDSS are discussed in more detail, namely computer-based monitoring systems and information systems which link laboratory and pharmacy data. [56].

A study demonstrates that relying solely on spontaneous reporting for adverse event detection is inadequate. Computerized techniques offer more accurate and cost-effective methods, particularly in identifying adverse drug events and nosocomial infections. Leveraging electronic medical records and advanced tools like natural language processing can further enhance adverse event detection and pave the way for effective prevention strategies [57].

2.3. Liquid medication uses in pediatric

In general, liquid medications are the most common dosage form used by pediatrics [119]. According to a 2021 survey, liquid dosage forms were the most popular (35%), followed by tablets (19%), capsules (14%), effervescent tablets (9%), minitablets (9%), orodispersible tablets (8%), other medications (3%), orodispersible films, and granules (1% each). Given the wide age range in the population investigated, an analysis by age group was done to identify similarities and differences among pediatric subgroups. For the younger children (67.9% age groups 0–6 years), liquid proved to be the preferred oral dose type. Its trend significantly decreased as age rose (47.5% in the 7–12 age group and 18.3% in the 13–18 age group) [26]. The liquid dosage form is particularly beneficial for individuals who struggle to swallow solid medications, such as children and the elderly.

The formulations offer an attractive appearance and can be sweetened, colored, and flavored to make them more palatable, especially for bitter or unpleasant medicines. The flexibility of liquid dosage forms allows for convenient adjustment of dosage by measuring different volumes, making it easier to administer the appropriate dose. Moreover, liquid medications are generally absorbed more rapidly than solid forms, and they are suitable for delivering hydrophobic or deliquescent drugs. The effects of adsorbents and antacids can be more pronounced in liquid dosage forms compared to

tablets. Overall, liquid dosage forms offer greater flexibility, improved palatability, easier administration, and enhanced absorption, making them a favorable option in various therapeutic contexts [60].

Table 3: Types of liquid dosage forms:[72]

Types of liquid	Definitions
Syrups	Medications that are dissolved in a sweet, syrupy liquid. Coughs and colds are frequently treated with syrups
Solution	A drug that has been completely dissolved in a liquid. A range of diseases, including allergies and digestive issues, can be treated with solutions.
Suspensions	Medications that are scattered in a liquid but do not completely dissolve. Suspensions are frequently used to treat infections and inflammation.
Elixirs	Medications that are dissolved in a combination of alcohol and water and are used to treat illnesses such as nausea and vomiting.
Drops	Liquid drugs can also be administered in drop form, which is dispensed with the use of a dropper. Drops can be used to treat a wide range of ailments, including ear infections and eye problems

Measuring mistakes in medicine dosage refers to errors that can occur as a result of using the incorrect dosing instrument or misinterpreting the marks on the tool. This can result in the administration of too much or too little medicine, potentially leading to negative health results. This can happen between healthcare practitioners and parents or caregivers or between healthcare providers and can result in dosage mistakes and adverse outcomes [1,61].

Discordance in units of measurement has been an issue for both prescription and over-the-counter (OTC) drugs [62,63]. Some liquid drugs, for example, may be given in milligrams (mg), yet the dosage instrument that comes with the prescription may be labeled in milliliters (mL), causing confusion and dosing mistakes [1,64].

Researchers discovered unit of measurement discordance among parents delivering liquid medicine to their children in a study conducted by Yin et al. (2014). They discovered that 41% of parents who used dosing equipment with mL markers thought mL and cc (cubic centimeters) were similar units of measurement, and 43% didn't recognize the difference between mL and teaspoons (tsp). Discordance in units of measurement refers to instances in which different units of measurement are utilized to indicate the same pharmaceutical dosage. This too can happen between healthcare practitioners and parents or caregivers, or between healthcare providers, and can result in dosage mistakes and adverse outcomes [64].

Dosing designations that are prone to inaccuracy contribute to drug errors and patient damage. The usage of several volumetric units (e.g., teaspoons, tablespoons, dropperful) as well as multiple abbreviations for the same volumetric unit (e.g., mL, cc, mls; tsp, TSP) increases the possibility of dosage mistakes by healthcare professionals, patients, and caregivers. One of the most common dosage mistakes is a patient or caregiver mistaking teaspoons for tablespoons, resulting in three-fold dose errors. Furthermore, the inclusion of teaspoons and tablespoons as units of measure on labels may lead the public to assume that they may dose pharmaceuticals using non-calibrated household spoons [65].

Many healthcare professional organizations, safety advocates, standard-setting groups, and regulatory agencies now recommend using metric units alone (i.e., milliliters [mL]) on dosing instructions and devices and avoiding spoon-based units (e.g., teaspoons [tsp], tablespoons [TBSP]) for oral liquid medications to prevent medication errors [66,67]. Voluntary industry recommendations also urge that all over-the-counter pediatric oral liquid drugs be dosed using mL alone [68]. When prescribing, dispensing, labeling, and communicating about drug dosages, utilizing a single

consistent measuring unit helps avoid mistakes caused by mistaking multiple scales (for example, mixing up mL and tsp). Furthermore, the inclusion of spoon-based units on prescription labeling encourages the use of non-standard home spoons, which increases the chance of inaccuracy [69,70].

In 2018, clinicians participating in the Centers for Medicaid and Medicare Services Quality Payment Program participants will be motivated to utilize electronic health records and other health information technology (IT) systems that use mL alone when prescribing oral liquid pharmaceuticals [71]. To guide the shift to mL-only dosage, we assessed primary care professionals' (PCPs') opinions and behaviors about dosing units for oral liquid drugs [68].

These survey results indicate a number of activities that can help ease the looming transition to mL-only e-prescribing. All practitioners (including nurses, doctors, and pharmacists) should utilize mL in written and verbal contacts with patients and caregivers to ensure that mL-dosing instructions are repeated and reinforced across contexts. Clinician education initiatives can help raise awareness among both the future generation of providers (through the medical school curriculum) and those who are presently practicing (through professional society policy or other communications). Clinician dosing demonstrations with suitable instruments (e.g., oral syringes, dosing cups) and units of measurement that match those in the dosage instructions, as well as having patients or caregivers display back dose measurement, can help assure precise delivery [73]. Increasing the availability of dosage devices with mL-only markings will also help patients and caregivers translate mL-only instructions for administration [68].

2.4. Role of healthcare providers counselling in attenuating drug related problems

Pediatric parents and healthcare providers play an important role in ensuring that children receive safe and effective drug therapy. The following are some of the critical responsibilities that pediatric parents and healthcare providers play in pediatric pharmaceutical therapy:

2.4.1 Healthcare Providers

Effective communication between healthcare providers and parents is crucial for ensuring safe medication use in children [36]. Accurate dosage calculation based on the child's weight, age, and medical history is essential to avoid medication errors [74]. Comprehensive drug education provided by healthcare practitioners helps parents understand proper drug administration techniques [75]. Regular monitoring by healthcare providers enables the early detection of adverse drug reactions and the necessary adjustments in treatment [59]. Promoting medication adherence is an important responsibility of healthcare professionals to ensure optimal treatment outcomes [76].

2.4.2 The contribution of the hospital pharmacist

Hospital pharmacists can considerably assist with ADR reporting. The most serious adverse drug reactions occur in hospitals. Furthermore, according to some research, adverse reactions to drugs account for a large fraction of total hospital admissions. The percentages that vary owing to variations in adverse medication events are operationally defined and differ significantly by country, ranging from 3.2% in France to 6.7% in the United States to 12% in Sweden [77,79]. A recent prospective study of ADRs as the cause of hospital admissions in the United Kingdom discovered that 6.5% of hospital admissions were ADR-related. Previous studies highlight the necessity of avoiding and recording adverse events in hospitals in order to decrease both the negative impacts and the costs associated with these events. This method would be best controlled by hospital pharmacists, particularly if they are involved in patient care [81]. The literature also shows that pharmacists can significantly reduce the incidence of adverse events [59, 78, 82].

Furthermore, clinical pharmacists are critical in assessing and optimizing patients' pharmaceutical treatment. They assess the appropriateness and efficacy of drugs, discover untreated health conditions, monitor progress, collaborate with healthcare providers, give pharmaceutical counseling, support holistic health practices, and make appropriate referrals when necessary [83].

2.4.3 Role of pharmacist in community pharmacy

The role of the pharmacist in the health care system has been the subject of much debate and change. The pharmacist's principal goal has typically been to administer pharmaceuticals as recommended by a physician and to guarantee that these drugs fulfill the requisite criteria. Nowadays, pharmacists regularly serve as pharmacological consultants [59,84,85]. A review of a large number of countries participating in the World Health Organization's International Drug Monitoring Program indicates that the quantitative contribution of community pharmacists to the national system is limited [86]. Community pharmacists play an important role in reporting adverse events in some countries, such as the Netherlands [87]. In the Netherlands, adverse reaction reports generated by pharmacists, mainly community pharmacists, have unique characteristics that make them a desirable addition to physician-generated reports. Community pharmacists are more likely to report eye and skin problems because these conditions are easier to notice by patients. In addition, they are in a unique position to report adverse reaction of the over-the-counter drugs (OTC). Once we look at how pharmacists see how they participate in ADR reporting, we find that they are not only highly motivated but also consider it as an important part of their professional responsibilities [59, 88, 89].

Currently, there is no information on the status or involvement of pharmacists in other countries because this has only been described in Cuba, where community pharmacists in health centers play an active role in reporting adverse events [90]. Their possible function relative to nonprescription drugs (OTC) has been discussed in the literature [91,92]. This includes not only OTC medicines but also alternative therapies; pharmacists are the ideal place to know and report adverse drug reactions [59,93].

The role that pharmacists play or are assigned to play is also determined by the conditions in which they practice their profession [84]. Nonetheless, the pharmacist's primary responsibility will always be to ensure that drugs are used safely [59,101].

The role that pharmacists play or are assigned to play is also influenced by the environment in which they practice [84]. Yet, the fundamental role of the pharmacist is going to remain to ensure that medications are administered safely [59,101]. Several more strategies for pharmacists to assist in ensuring pharmaceutical safety are listed in

the literature. Pharmacists can play an important role in record-keeping, training, and monitoring OTC medications and alternative therapies, in addition to prescription delivery and compliance [93,94]. In addition, as computerized medicine distribution systems grow more ubiquitous, the pharmacist's role as both a user and a system manager becomes increasingly important. ADR reporting is one of the responsibilities that pharmacists may be assigned [59].

Studies have found that 3% to 9.7% of outpatient pediatric prescriptions lead to preventable medication errors [95,96]. These errors pose a greater risk to pediatric patients due to complex factors like weight- and age-based dosing, various concentrations and dosage forms, and the need to modify adult medications [97]. Caregivers struggle to accurately measure oral liquid doses [98], with accuracy ranging from 15% to 84% [99]. However, community pharmacists can minimize errors in pediatric medication use by implementing interventions like labeling doses in milliliters, providing oral syringes, and offering counseling with measurement demonstrations [100].

According to an article, a survey highlights that pharmacists failed to appropriately identify errors or interventions to reduce the likelihood of errors in 15% to 59% of scenario-based questions. Correct identification of doses was found to be associated with total prescription volume in one scenario and pediatric prescription volume in another. Additionally, the survey highlighted inconsistent practices among pharmacists, such as not consistently labeling prescriptions for oral liquids in milliliters or dispensing oral syringes. Several barriers to pharmacist involvement were identified, including caregiver availability and interest, the ability to contact the prescriber, and staffing constraints in pharmacies [100].

An examination of a large number of nations participating in the World Health Organization International Drug Monitoring Program indicated that the quantitative contribution of community pharmacists to national systems is limited [86]. Community pharmacists play an important role in ADR reporting in several countries, such as the Netherlands [87]. Pharmacist-generated ADR reports in the Netherlands, primarily from

community pharmacists, have unique qualities that make them a desirable supplement to physician-generated reports. Community pharmacists report more on eye and skin problems since these conditions are more likely to be noticed by patients. They also hold a unique position in the reporting of ADRs for over-the-counter drugs. When we examine how pharmacists see their involvement in ADR reporting, we discover that they are not only highly motivated but also see it as an essential part of their professional duties [59,88,89].

To date, nothing is known regarding the status or participation of pharmacists in other countries because this has only been detailed for Cuba, where community pharmacists in health centers play a systematic role in ADR reporting [90]. Their possible function with regard to nonprescription medications (over-the-counter pharmaceuticals) has been discussed in the literature [91,92]. This includes not just nonprescription medications but also alternative therapy; pharmacists are ideally situated to learn about and report ADRs. [59,93].

2.4.4 Role of clinical pharmacist in paediatric liquid medication dosing error

Clinical pharmacists can detect and prevent pharmaceutical mistakes by reviewing doses to guarantee prescription correctness. Clinical pharmacists can assist caregivers with medication counseling about the medicine's usage, correct administration, probable side effects, and adverse effects, as well as basic medication safety advice [6,102].

Medication-related issues are prevalent, with medication mistakes occurring in 1.5–35% of all doses administered to hospitalized patients [103]. These errors cost a lot of money, and pharmaceutical errors account for around 6.5% of hospital morbidity and death, despite the fact that two-thirds of these occurrences are avoidable [104,105].

Clinical pharmacists provide numerous layers of patient protection in the hospital context, which helps limit the potential dangers of these mistakes [105-107]. According to the study, medication error is an important variable in determining patient safety services, so it is critical to identify health care members' medication error weaknesses and provide an educational program to address them. Medication mishaps are common on hospital wards. The actions of clinical pharmacists can successfully avoid these mistakes. These types of mistakes imply the necessity for ongoing education and clinical pharmacist interventions [105].

Several studies have demonstrated that pharmacists may improve patient outcomes by participating in health care team rounds, interviewing patients, reconciling prescriptions, and giving patient discharge counseling and follow-up [108,109]. Medication mishaps are common on hospital wards. The actions of clinical pharmacists can successfully avoid these mistakes. These types of mistakes imply the necessity for ongoing education and clinical pharmacist interventions [105].

Here are some ways clinical pharmacists may assist in the prevention and correction of dosage mistakes in pediatric liquid medication:

- Medication reconciliation is a process of acquiring an accurate medication history that is normally created by asking for the name, dose, frequency, and route of administration of all drugs [110-112].
- Dosage calculations: Based on a patient's weight, age, and medical history, clinical pharmacists may determine the proper dosage of medicine, ensuring that the patient receives the correct amount of medication [113].
- Patient education: To help reduce dosage mistakes, clinical pharmacists can educate patients and caregivers on how to appropriately administer medicine, including the use of dosing devices and proper dose practices [76,114,].
- Collaboration with healthcare professionals: Clinical pharmacists can collaborate closely with healthcare providers, such as physician and nurses, to ensure that prescription orders are right and that dose problems are corrected as soon as possible [36].
- Clinical pharmacists can monitor patients for adverse drug responses and offer appropriate measures, such as dose modifications or medication changes, to prevent additional damage [59].

3. MATERIALS AND METHODS

3.1. Study design

This study is conducted as an observational cross-sectional study from March to June 2023, data was collected from both hospital and community pharmacy settings. This study is an in-depth examination through a comprehensive survey of parents' practices regarding giving liquid medications to their children. It also examined how satisfied these parents were with the information they received about the medication. Data collection commenced with participants completing a comprehensive form, including demographic and Satisfaction with Information about Medicines Scale (SIMS) questions.

Inclusion criteria:

Parent/legal guardian >18 years of age, who routinely administers medicine to children ≤8 years of age who previously used liquid medicine for their children [70].

Exclusion criteria:

Parents who do not complete study questionnaires fully.

3.2. Study tools

The study involved a self-reported questionnaire and a face-to-face dosing technique evaluation activity employed to assess the accuracy of parents in measuring liquid medicine before administering it to their child. The questionnaire had three sections. The first section focused on gathering demographic information about the parents and the child (8 question). The second section involved the Satisfaction with Information about Medicines Scale (SIMS) questionnaire which consists of two parts [125]. First part of SIMS evaluates knowledge of action and usage of medication, while the second part evaluate the knowledge of adverse effect of medicine. The questions are all answered either yes/no. The original version contained totally 17 items. Following the expert panel revision of items based on the context of the study, the questions were reduced from 17 to 10.

The third section of the study's questionnaire involved 4 items, one reporting commonly used dosing apparatus, confidence on their dosing technique accuracy, confidence on accuracy of their commonly used dosing apparatus, and finally healthcare provider that educate them most on information about medication and dosing.

In the dosing technique evaluation, participants were asked to measure three different volumes of (liquid medicine syrup, Calpol) paracetamol: 2.5mL, 5mL, and 7mL. Following their measurements, the accuracy of their dosing was verified by comparing it with the measurements obtained using a calibrated measurement cylinder. Of the medication measuring devices used in the experiment, 4 types (the regular dosing cup, the printed dosing cup, the dosing spoon, and the oral syringe) (see figure 3) were provided. An ISOLAB graduated cylinder (Germany, blue grad, 10 mL) was used to measure the amount of syrup dispensed by the study participants (see supplements) [61,117]. This experimental approach allowed for an objective assessment of parents' ability to accurately measure and administer liquid medication to their children.

A dosing error was considered upon parents measuring 20% deviation of the prescribed dosage whether less or more. A dose deviated less than 20% of the total prescribed dose were considered within an acceptable range and were not classified as medication dosing error [1, 48, 5,]. A large dosing error was considered when parents measure a dose larger or equal to twice as much as the prescribed dose.

Figure 2. Different oral liquid medicine administration aids.[116}

3.3. Data collection and sample size determination

This survey was conducted through face-to-face interactions using an electronic data collection form (Google Forms). Following the end of evaluation parents were provided an educational presentation by the clinical pharmacist to educate on proper measurement and evidence supported tools. Counseling on their current medication was provided to participants.

Parents were counseled and provided with feedback based on the guidelines recommended by the American Academy of Pediatrics (AAP) and the US Food and Drug Administration (FDA) regarding the proper administration of liquid medications for the utilization of dosing instruments featuring standardized markings, such as (oral syringes, droppers, and dosing cups) [1, 62,124] .

The minimum sample size (n=397) for this observational study is calculated by using the following equation:

$SS = Z2 \times p \times (1 - p)/c2$, where Z represents the confidence level (for example, 1.96 confidence level for 95%), p is the choice of estimated percentage (assigned 50%) and c is the desired level of precision, i.e. 0.05 [118].

3.4. Statistical analysis

The distribution of variables was analyzed for normality using Kolmogorov test. Descriptive statistic was utilized in which continuous variables were be expressed as mean ± standard deviation while categorical variables were presented as percentages. The Chi-square test was used to analyze the association between categorical variables while The Student's t-test, one-way Analysis of variance (ANOVA), Mann-Whitney test; and the Kruskal-Wallis's test were used when relevant to evaluate association between categories and continuous variables. An association will be accepted as significant if it is less than 0.05.

3.5. Ethical considerations

This study involved parents and healthcare providers in tertiary hospital, and community pharmacies in Istanbul Türkiye. All participants were informed about the aim and objective of this study and provided a written consent form upon their acceptance to participate. An ethical approval was attained from Yeditepe University Hospital Institutional Review Board (202203Y0202).

4. RESULTS

4.1. Demographics and Characteristic Participant

Out of 600 parents who received invitations to participate, a total of 397 parents voluntarily engaged in the study, thereby forming the study's sample (66% response rate). The survey encompassed the completion of 10 yes-or-no questions utilizing the Satisfaction with Information about Medicines Scale (SIMS) questionnaire. The completion time for the survey averaged 7 minutes (range 5 to 10 minutes).

These participants were drawn from diverse backgrounds and were geographically disperse across various community pharmacies and hospitals in Istanbul, Türkiye. The demographic profile of the participants' children involved 50.9% girls and 49.1% boys. Furthermore, the age range of the children, spanning from 0 to 8 years old (4.2 ± 2.33). Table1 shows participants demographics.

Table 4: Participant demographoic (n=397)

Demographics		Frequency	Percent%	Mean	Std
Child gender	Male	195	49.0		
	Female	202	50.8		
Child ages	≤2			4.183	2.3356
	>2				
Parents age				33.14	5.260
Relationship to child	Mother	370	93.0		
	Father	27	8.6		
How many childern you have	1-2	362	91.0		
	3-4	35	8.8		
Education Level	Primary School	71	17.8		
	Intermediate School	4	1.0		
	Secondary School	150	37.7		
	University Graduate	170	42.7		
	Postgraduate graduate	3	0.8		

4.2. Participant satisfaction of information about medicine

The analysis of participant responses to the question "Are you satisfied with the information you received?" revealed that considerable majority of respondents, constituting 81.4% of the participants, indicated their satisfaction with the information provided. Conversely, 18.6% expressed dissatisfaction with the received information. Figure 4 shows parents score on each SIMS scale. (figure 4)

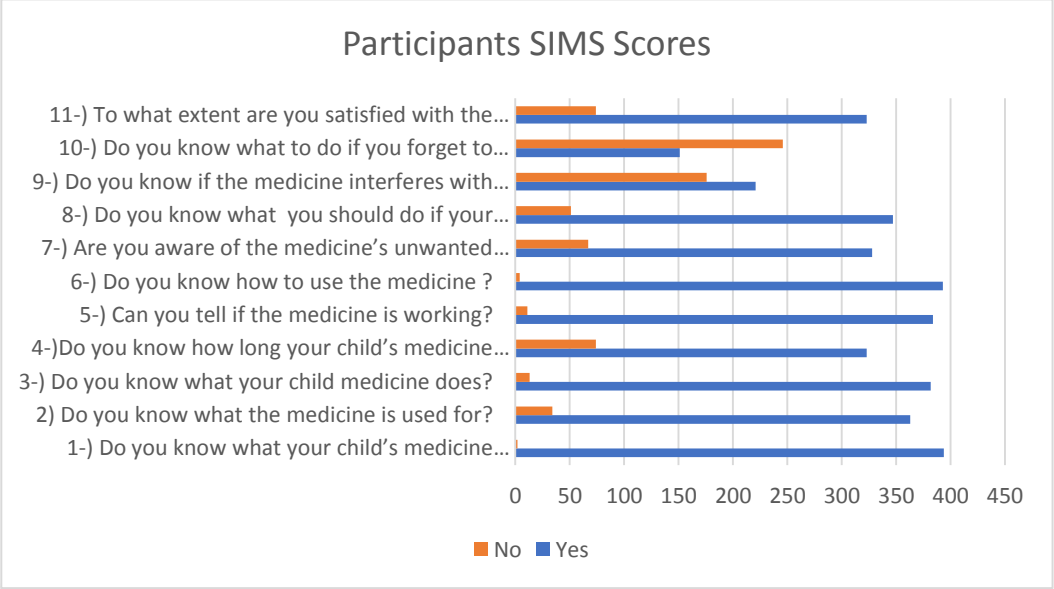

Figure 3. Participant's satisfaction of information about medications

4.3. Participant's confidence and measuring tool utilized commonly

Parents reported that the measuring tool they use to measure the liquid dose is appropriate (93.2%), confirmed their confidence in the suitability of their chosen measuring tools. While 6.8% responded negatively (Figure 5).

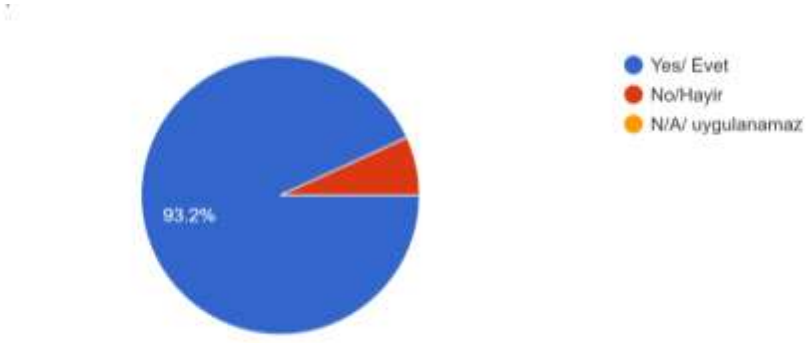

Figure 4 . Accuracy of liquid medication measurement

Among the various apparatus, the regular dosing spoon emerged as the most preferred tool, with a significant percentage of parents (46.3%) reporting its use. In contrast, printed measuring cups were the least common, with only a minimal

percentage (0.8%) of parents reporting its use. Additionally, (23%) of parents chose to use an oral syringe as their preferred dosing tool (Figure 6).

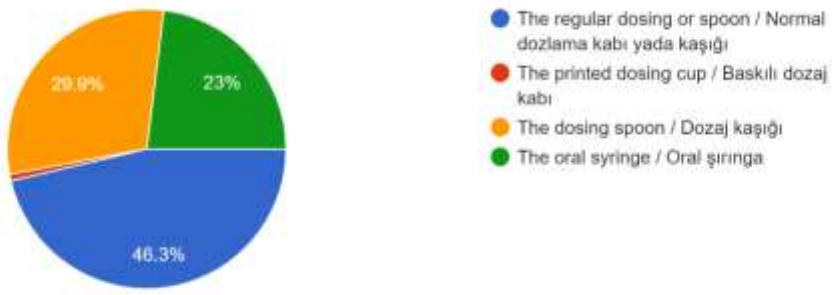

Figure 5. The tool prefered to measure the liquids dosage form.

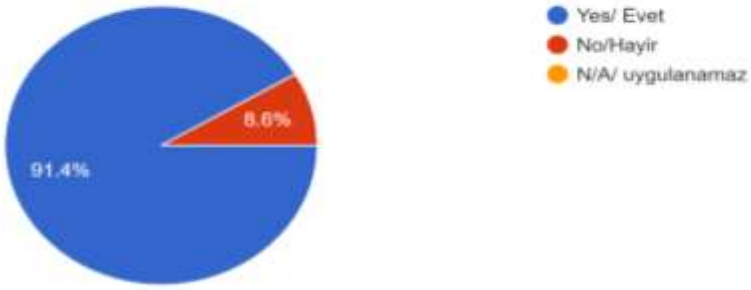

Figure 6. The accuracy of the measurement

An exploration into parents' confidence in their selected liquid medication measurement method unveiled that a significant 91.4% displayed confidence in their strategy, indicating a high level of accuracy in dosing. Conversely, 8.6% responded negatively as shown in figure 7.

4.4. Participant's evaluation of their measuring technique

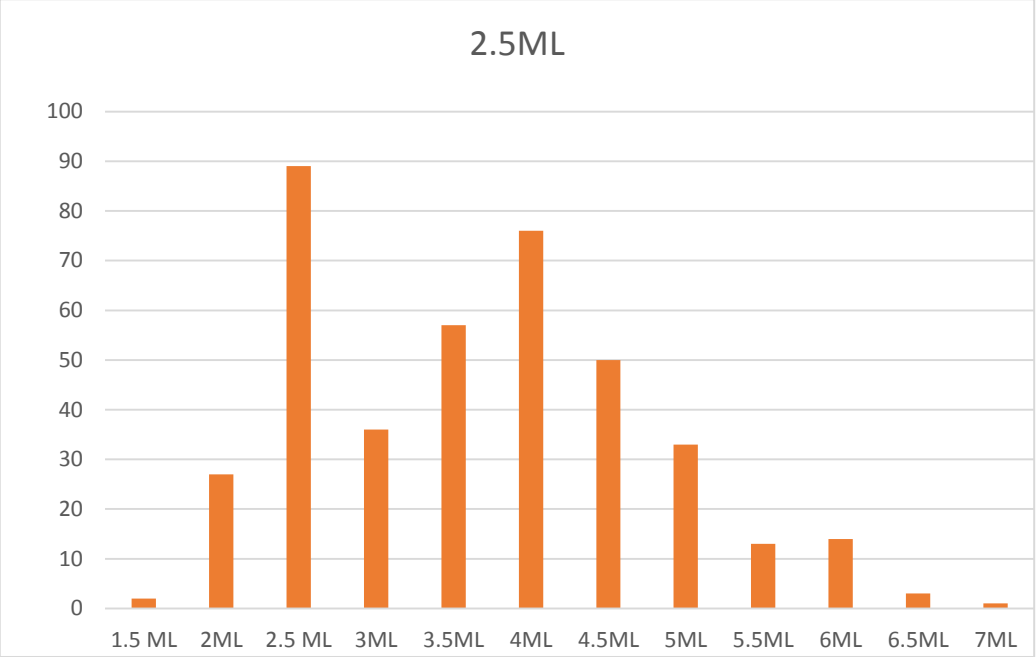

Figure 7. The result of measurement 2.5mL

Among the respondance various measurements were observed when they were asked to measure 2.5ml of liquid medication (1.5-7 mL) the mean value was (3.6mL) the acceptable measurement within 20% were 37.4% and more than 20% were 62.1% Out of the total, only 2 parents (0.5%) used a teaspoon and obtained a measurement of 1.5ml, which is below the intended dosage. The majority of parents, 89 (22.4%), accurately measured 2.5ml. Other measurements reported by parents as it shows on the figure 8.

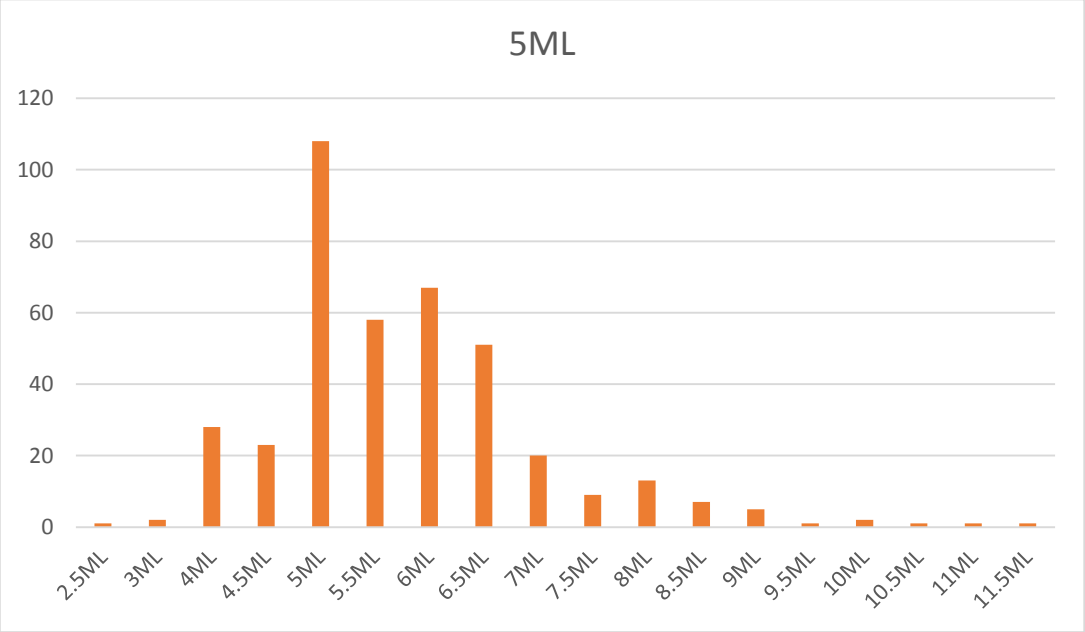

Figure 8. The result of measurement of 5mL.

The investigation into parents' measurement practices for 5mL liquid medicine, as shown in Figure 8, unveiled a range of results spanning from 2.5mL to 11.5mL. Notably, a considerable 71% of parents managed to achieve measurements falling within the acceptable 20% range. Conversely, 27.6% of parents exceeded this range, suggesting room for refinement. It is particularly noteworthy that 27.1% of parents demonstrated an impressive level of precision by accurately measuring the intended 5mL dosage. The mean measurement for 5mL liquid medicine among parents was 5.7mL. (Figure 9)

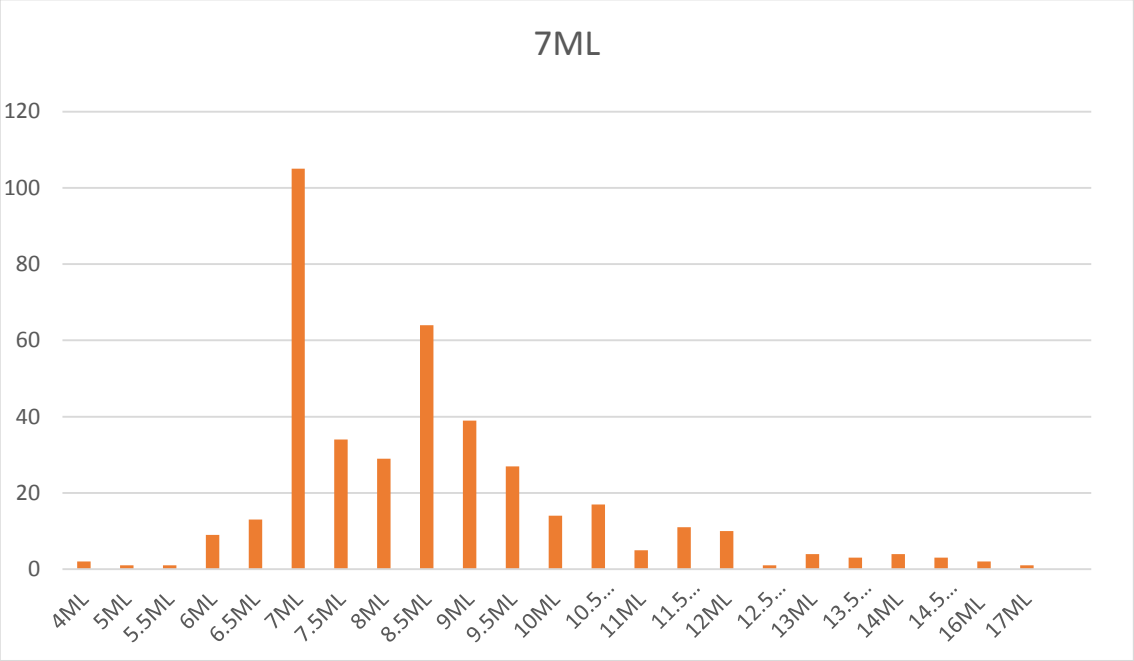

Figure 9. The result of measurement 7mL

Among parents who measured 7mL of liquid medication, the reuslt was from 4-17mL. The acceptable meansurement with 20% were the majority 26.3% achieved an accurate dosage of 7mL, indicating a relatively higher level of accuracy for this volume. The mean is 8.4 .Under-dosing instances were observed, with 2 parents measuring 4ml (0.6% of parents), indicating a potential risk of administering insufficient medication. Over-dosing instances were also observed, with measurements exceeding the intended 7.5 mL. These instances included 15 parents with a result of 10.5 mL (4.6% of parents) and 26 parents with a result of 9.5 mL (8% of parents), indicating a potential risk of administering excessive amounts of medication.(Figure 10)

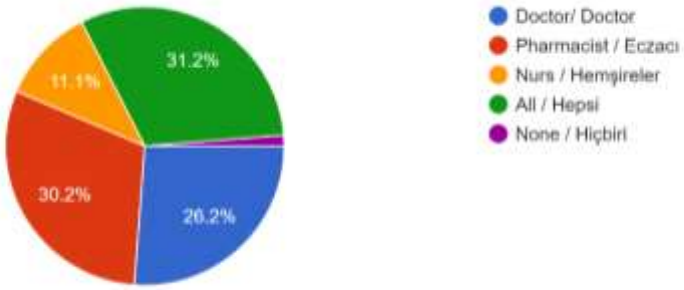

Figure 10. Educations of healthcare providers

Regarding healthcare practitioners advising parents, pharmacists (30.2%) were the most prevalent healthcare providers to provide education. However (26.2%) of parents said that doctors were active in delivering education. The survey findings indicate that both pharmacists and doctors are actively contributing to improving parental understanding and supporting safe drug practices, with pharmacists having a slightly larger representation.(See Figure 11).

Table 5, briefly presents a series of participant characteristics along with their corresponding measurements. This comprehensive table describes the relationship between a participant demographics and the accuracy of their medication practices.

Table 5: Participant's characteristics and dosing errors using different measures

		7mL Measurement			2.5mL Measurement			5mL Measurement			Error Or Not		
		<20% difference	>20% difference	p value	<20% difference	>20% difference	p value	<20% difference	>20% difference	p value	No dosing Error	A significant dosing Error	p value
		Row N %	RowN %		RowN %	Row N %		RowN %	Row N %		RowN %	Row N %	
Child Gender	Male	47.70 %	52.30 %	**0.027**	34.40%	65.60 %	4.929	66.20%	33.80 %	4.929	28.20%	71.80%	0.423
	Female	48.50 %	51.50 %		40.60%	59.40 %		76.20%	23.80 %		31.20%	68.80%	
Relationship to child	Mother	48.40 %	51.60 %	1.675	36.20%	63.80 %	4.302	71.10%	28.90 %	0.513	28.90%	71.10%	31.74
	Father	40.70 %	59.30 %		51.90%	48.10 %		74.10%	25.90 %		37.00%	63.00%	
	38	100.00%	0.00%		100.00 %	0.00%		100.00 %	0.00%		100.00 %	0.00 %	
How many children you have (you have cared for?)	1-2	48.90 %	51.10 %	1.011	36.50%	63.50 %	1.995	72.10%	27.90 %	1.332	29.00%	71.00%	1.012

	3-4	40.00 %	60.00 %		48.60%	51.40 %		62.90%	37.10 %		37.10%	62.90%	
Education Level:	Read & write	0.00 %	0.00%		0.00%	0.00%		0.00%	0.00%		0.00%	0.00 %	
	Primary School	29.60 %	70.40 %		19.70%	80.30 %		57.70%	42.30 %		9.90%	90.10%	
	Intermediate School	50.00 %	50.00 %		50.00%	50.00 %		50.00%	50.00 %		50.00%	50.00%	
	Secondary School	39.30 %	60.70 %		30.00%	70.00 %		71.30%	28.70 %		20.70%	79.30%	
	Secondary School	0.00 %	0.00%		0.00%	0.00%		0.00%	0.00%		0.00%	0.00 %	
	University Graduate	62.90 %	37.10 %	29.798	50.00%	50.00 %	29.798	77.10%	22.90 %	11.236	44.70%	55.30%	40.376
	Postgraduate program graduate	66.70 %	33.30 %		100.00 %	0.00%		100.00 %	0.00%		66.70%	33.30%	
	University Graduate	0.00 %	0.00%		0.00%	0.00%		0.00%	0.00%		0.00%	0.00 %	
Which healthcare provider educated you regarding this medication?	None	80.00 %	20.00 %		80.00%	20.00 %	13.424	100.00 %	0.00%		80.00%	20.00%	
	Physician	63.50 %	36.50 %	22.71	41.30%	58.70 %		77.90%	22.10 %	15.305	38.50%	61.50%	

	Pharmacist	47.50%	52.50%	7	45.00%	55.00%		76.70%	23.30%		39.20%	60.80%	**29.966**
	Nurse	25.00%	75.00%		25.00%	75.00%		52.30%	47.70%		15.90%	84.10%	
	All	42.70%	57.30%		29.80%	70.20%		66.10%	33.90%		16.10%	83.90%	
1-) Do you believe the measuring tool you use to measure the liquid dose appropriate?	No	29.60%	70.40%	**3.964**	44.40%	55.60%	**0.591**	74.10%	25.90%	**0.110**	25.90%	74.10%	**0.200**
	Yes	49.50%	50.50%		37.00%	63.00%		71.10%	28.90%		30.00%	70.00%	
2-) Do you believe your method of measurement is accurate?	No	32.40%	67.60%	3.699	41.20%	58.80%	0.211	67.60%	32.40%	0.240	29.40%	70.60%	**0.02**
	Yes	49.60%	50.40%		37.20%	62.80%		71.60%	28.40%		29.80%	70.20%	
3-) Which tool you prefer to measure the liquids dosage form?	Regular spoon	30.30%	69.70%		20.20%	79.80%		67.00%	33.00%		8.50%	91.50%	
	Missing	**0.00%**	0.00%	113.848	0.00%	0.00%	157.316	0.00%	0.00%	36.212	0.00%	**0.00%**	222.960

	Dosing spoon	39.00 %	61.00 %		22.00%	78.00 %		59.30%	40.70 %		15.30%	84.70%	
	Oral syringe	96.70 %	3.30%		93.40%	6.60%		95.60%	4.40%		92.30%	7.70 %	

Table 6: The double dose evluations

Evaluation	Measurement	Frequency	Percent %
2.5mL	<2X	337	84.7
	>2X	61	15.3
5mL	<2X	394	99.0
	>2X	4	1.0
7mL	<2X	387	97.2
	>2X	8	2.0
Total		397	100.0

The study examined the occurrence of double dose errors in relation to different measurement scenarios. Notably, for the measurement of 2.5ml, approximately 15% of participants made double dose error. This percentage was notably lower for the 5ml measurement, with only 1% of participants committing a double dosing error. Similarly, for the 7ml measurement, the proportion of participants making a double dose error remained at 1% (Table 6).

A Mann Whitney test revealed significant differences in dosing errors and SIMS action and usage scores between educational groups where higher education was associated with significantly better satisfaction and less dosing errors ($p<0.001$). In group's comparison, a logistic regression of factors affecting occurrence of a significant dosing error showed that parents education level, which healthcare provider educate the caregiver and which tool caregiver prefer to dose for children to be the main factors that affect probability of significant dosing error (Table7). Factors associated with too high dosing error prevalence include child age, parent age and dosing tool preferred by caregivers. (Table 8)

.

Table 7: Logistic Regression of factors contributing to significant dosing errors

Variables in the equation	B	S.E.	Wald	df	Sig.	Exp(B)
Education Level			14.535	4	0.006	
Education Level :(1)	-2.633	1.384	3.618	1	0.057	0.072
Education Level :(2)	-0.900	0.597	2.273	1	0.132	0.406
Education Level :(3)	-1.557	0.577	7.288	1	0.007	0.211
Education Level :(4)	-4.248	1.415	9.015	1	0.003	0.014
Which healthcare provider educated you regarding this medication?			44.061	4	0.000	
Which healthcare provider educated you regarding this medication?(1)	3.326	0.647	26.404	1	0.000	27.816
Which healthcare provider educated you regarding this medication?(2)	3.298	0.638	26.739	1	0.000	27.063
Which healthcare provider educated you regarding this medication?(3)	3.833	0.765	25.136	1	0.000	46.217
Which healthcare provider educated you regarding this medication?(4)	4.285	0.670	40.889	1	0.000	72.603
Which tool you prefer to measure the liquids dosage form?			100.349	2	0.000	
Which tool you prefer to measure the liquids dosage form?(1)	-0.740	0.396	3.488	1	0.062	0.477
Which tool you prefer to measure the liquids dosage form?(2)	-4.910	0.504	94.996	1	0.000	0.007

Table 8: Logistic regression of too high dose critical mistakes

Variables in the equation	B	S.E.	Wald	df	Sig.	Exp(B)
Child Age	0.251	0.100	6.295	1	0.012	1.285
Parent Age	-0.069	0.015	22.419	1	0.000	0.934
Which tool you prefer to measure the liquids dosage form?			10.430	2	0.005	
Which tool you prefer to measure the liquids dosage form?(1)	-0.162	0.291	0.310	1	0.577	0.850
3-) Which tool you prefer to measure the liquids dosage form?(2)	-3.288	1.021	10.373	1	0.001	0.037

5. DISCUSSION

The accurate dosing of liquid medication by parents is crucial for ensuring the safe and effective administration of medications to pediatric patients. In this study, out of 397 parents who were assessd for medication errors 52% made a critical error while 5% made critical error in doeses that were nearly double the requested doses. The finding of the study indicate that dosing errors are prevalent among parents as seen in other countries such as New York and France [1,5,123]. The results indicate a mixed picture, with some parents demonstrating precise dosing for specific volumes while others exhibited deviations from the intended dosage. These findings highlight the need for targeted interventions to improve parents' dosing accuracy and reduce the risk of dosing errors.

Regarding the demographic characteristics of the parents, the study found that the majority of participants were between the ages of 28 and 44, with a high percentage being mothers. This aligns with previous research indicating that mothers often play a primary role in managing their children's medication [1,5]. Additionally, the study highlighted how parents' education and literacy levels significantly impact their ability to administer liquid medication accurately to their children. The results indicated that parents with higher education levels were more knowledgeable about medication use, dosing techniques, and potential side effects. Consenting to previous research emphasizing education's role in improving health literacy and medication understanding [4-5,46]. The link between education and precise dosing emphasizes the need for targeted educational efforts, especially for parents with lower education levels. These findings underline the importance of customized programs to equip parents with skills for accurate medication administration, ultimately enhancing pediatric patient outcomes. These findings reinforce earlier research stressing the significance of addressing proper dosing tools and health literacy to prevent errors [5]. Education has proven effective in reducing dosing errors for both Spanish and English-speaking parents [120], highlighting educational interventions' role in enhancing medication safety for young patients.

The study highlights the critical role of healthcare providers in delivering information to parents about medication administration. A noteworthy finding indicates that a significant majority of parents (81.4%) expressed satisfaction with the information provided by healthcare professionals. This result underlines the importance of effective communication between healthcare providers and parents, fostering a sense of trust and confidence in the information shared. However, it is essential to address the 18.6% of parents who reported dissatisfaction. This subset of parents might require further clarification, additional information, or personalized counseling to address their concerns and enhance their understanding of medication administration. Overall, the study emphasizes the need for healthcare providers to consistently offer accurate and comprehensive information, ensuring that parents feel well-informed and confident in their ability to administer liquid medications to their children accurately. This approach not only supports optimal patient outcomes but also contributes to strengthening the parent-provider relationship within the context of pediatric medication management. Effective communication between healthcare providers and parents is vital for accurate medication administration. Although a significant number of parents demonstrate confidence in dosing, the persistence of errors emphasizes the necessity of focused educational initiatives. Collaborative efforts among healthcare professionals are crucial for accurate information delivery, safe practices, and addressing concerns. A study demonstrated that a plain language, pictogram-based intervention used in medication counseling reduced dosing errors and enhanced adherence among caregivers in an urban pediatric emergency department [48]. This bring out the importance of improving communication and education strategies, guiding policies to enhance pediatric medication education and outcomes.

According to the survey, more than half of parents make mistakes while administering liquid drugs. In a study of 491 therapeutic mistakes among Australian children in a community context, the most prevalent error was the wrong dose, accounting for 56.8% of all errors [115]. When parents are requested to add water to powdered medicine, the likelihood of administration mistakes increases. Medication reconstitution is a technique that is often conducted by the pharmacist prior to medication distribution [5,120,121].

In our study, a noteworthy preference for using household spoons was observed, being approximately twice as common as the selection of more accurate tools like syringes for

measuring liquid medication. More importantly, it identified a significant dosing accuracy discrepancy between regular spoon and syringe users. While 91.5% of regular spoon users made substantial dosing errors, only 8% of syringe users reported errors. This finding underlines the need for standardized dosing tools to mitigate dosing errors and ensure pediatric patient safety. The study revealed that parents often tend to use household spoons, cups, or syringes, with limited preference for more precise tools such as oral syringes. This variation in dosing tools and units can lead to inconsistent practices and potential errors. Encouraging the use of standardized tools, especially oral syringes with clear markings, could enhance dosing accuracy. A comprehensive pediatric labeling and dosing strategy, endorsing oral syringes over cups, could contribute to reducing medication errors [1].

Medication delivery to young children by parents can be difficult. Oral liquid formulations are commonly recommended for young children, and many parents may struggle with proper medication measurement [120,122]. Understanding the significance and proper use of standardized dosing instruments (e.g., oral syringe, dropper, dosing cup), as well as the ability to interpret measurement units (e.g., milliliter, teaspoon, tablespoon), are among the key skills that help parents avoid errors. [5,32,46].

The study underscores the significance of involving a comprehensive range of healthcare professionals in counseling parents about accurate medication administration. Collaborative efforts from pharmacists, doctors, nurses, and other healthcare providers can collectively contribute to a holistic approach to parent education. Such a multifaceted approach can enhance parents' understanding of dosing techniques, potential side effects, and overall medication safety. Integrating the expertise of various healthcare providers ensures a well-rounded education, equipping parents with comprehensive knowledge and guidance to ensure the safe and effective administration of liquid medications to pediatric patients. This study thus emphasizes the importance of inter-professional collaboration in healthcare settings to provide parents with accurate, consistent, and well-rounded education, ultimately contributing to improved medication safety for children.

5.1. Limitation

The study's strength is shown in its diversified demographic representation, which includes people from various educational backgrounds and ages. Real-world situations, such as neighborhood pharmacies and hospitals, are used. Significantly, the study's emphasis on precise medicine administration corresponds to essential areas of pediatric care, providing insights to improve patient safety and treatment success. However, limits must be recognized. It should be highlighted that the study does not include long-term follow-up, which limits knowledge of long-term consequences. When research is conducted in a specific geographic region, generalizability to larger groups may be limited. Furthermore, the questionnaire's lack of validation in the pediatric population raises doubt about its application in such an environment. Whereas the study thoroughly reviews dosage tools, including regular spoons, dosing spoons, and syringes, the lack of other tools may restrict the study's full understanding of tool-related dosing accuracy.

5.2. Recommendation

Several recommendations may be made based on the study's findings to enhance the accuracy and safety of liquid medicine dosage in pediatric populations. Parent education initiatives should be prioritized by healthcare practitioners in order to improve their knowledge and abilities in measuring and giving liquid medication. It is critical to standardize dosage devices with clear and precise measuring marks. Parents should be given clear and simple medication instructions, as well as regular medication reviews. Ongoing monitoring and support systems should be put in place, and further research and development should be done to look at new ways and technologies to increase dosage accuracy. Implementing these suggestions will improve medication safety and results for children who receive liquid medicines.

More study is needed to investigate the underlying variables that contribute to these measurement variations and to create targeted treatments to improve parents' dosage accuracy. Educational programs, clear instructions, and the availability of standardized dosage instruments may be used to increase parents' confidence and competence in precisely measuring liquid medication for their children.

6. CONCLUSION

In summary, this study provides valuable information on parents' dosing practices when giving liquid medicine to their children. The results highlight the need for targeted interventions to improve parental dosing accuracy and reduce the risk of dosing errors. The use of standard dosing devices, such as clearly marked oral syringes, should be encouraged, to ensure consistent and accurate measurements. Besides, educational programs and counseling initiatives need to be developed to increase parents' knowledge and understanding of appropriate medication techniques. Collaborative efforts between the health care provider and the parent are important to facilitate effective communication and ensure that parents receive complete information about the dosage of liquid medication. By addressing these factors, the healthcare system can improve drug safety and reduce the occurrence of dosing errors in children. Further research is needed to evaluate the effectiveness of interventions and explore additional strategies to improve parental medication practices and overall medication adherence in children.

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8. APPENDICES

8.1. Ethical Approval

Ethical approval of the study was accepted by; Yeditepe University Clinical Researches Ethical committee (Report date: 24 June 2022, 202203Y0202).

8.2. Questionnaire

QUESTIONS FOR PARENTS

For child/ Çocuk için:

Yaş / Age : .....

Cinsiyet / Gender : male/erkek ☐ female/kiz ☐

For parents/ Ebeveynler için :

Yaş / Age : .....

Doğduğu ülke/Country of birth: .....

Çocuğa ilişki/ Relationship to child:.....

Irk/ Race: .....

Dil/Language:.....

Eğitim Durumu / Education Level : .....

<u>Etki ve kullanım / (Action and usage)</u>

1) Çocuğunuzun ilacının biliyor musunuz ?

(Do you know what your child's medicine called?) Evet/Yes ☐ Hayir/No ☐ N/A/ uygulanamaz ☐

2) Kullandığınız çocuğunuzun ilacı herbirini ne için kullandığınızı biliyor musunuz ?

(Do you know what the medicine is used for ?) Evet/Yes ☐ Hayir/No ☐ N/A/ uygulanamaz ☐

3) Çocuk ilacınızın ne yaptığını biliyor musunuz?
(Do you know what your child medicine does?)

Evet/Yes ☐ Hayir/No ☐ N/A/ uygulanamaz ☐

4) Çocuğunuzun ilacının etkisini göstermesinin ne kadar sürdüğünü biliyor musunuz?

(Do you know how long your child's medicine take to act ?)

Evet/Yes ☐ Hayir/No ☐ N/A/ uygulanamaz ☐

5) İlacın işe yarayıp yaramadığını söyleyebilir misin?

(Can you tell if the medicine is working?)

Evet/Yes ☐ Hayir/No ☐ N/A/ uygulanamaz ☐

6) hangi sağlık kuruluşu size eğittim verildi biliyor musunuz?

(which healthcare provider educated you regarding this medication?)

- **Doctor/ Doctor**
- **Pharmacist / Eczacı**
- **Nurs / Hemşireler**
- **All / Hepsi**
- **None / Hiçbiri**

7) İlaçlarınızı nasıl kullanmazı gerektiğini biliyor musunuz?

(Do you know how to use the medicine ?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz** ☐

8) Sıvı dozunu ölçmek için kullandığınız ölçü aletinin uygun olduğuna düşünüyor musunuz?

(Do you believe the measuring tool you use to measure the liquid dose appropriate?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz**

9) Ölçüm yönteminizin doğru olduğuna düşünüyor musunuz?

(Do you believe your method of measurement is accurate?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz** ☐

10) likit dozaj formunu ölçmek için hangi aleti hazırlıyorsunuz?

(which tool you prefer to measure the liqiud dosage form?)

- **The regular dosing or spoon / Normal dozlama kabı yada kaşığı**
- **The printed dosing cup / Baskılı dozaj kabı**
- **The dosing spoon / Dozaj kaşığı**
- **The oral syringe / Oral şırınga**

1) Kaç çocuğunuz var (baktınız?)?

How many childern you have (you have cared for?)?)

- **1-2**
- **3-4**
- **>5**

12)Aldığınız bilgilerden ne ölçüde memnunsunuz biliyor musunuz?

(To what extent are you satisfied with the information you received?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz** ☐

Potansiyel problemler / (Potential problems)

13) İlacın istenmeyen etkilerinin (yan etkilerinin) farkında mısınız ?

(Are you aware of the medicine's unwanted effects (side effects)?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz** ☐

14) Herhangi bi istenmeyen etki görüldüğünde ne yapmanız gerektiğini biliyor musunuz?

(Do you know what you should do if your child experiences unwanted effects?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz** ☐

15) İlacın diğer ilaçlarla etkileşime girip girmediğini biliyor musunuz?
(Do you know if the medicine interferes with other medicines?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz** ☐

16) Çocuğa bir doz vermeyi unutursanız ne yapacağınızı biliyor musunuz?
(Do you know what to do if you forget to give a dose for a child?)

Evet/Yes ☐ **Hayir/No** ☐ **N/A/ uygulanamaz** ☐

For the measurement / ölçüm için :

- **2.5mL = ...**
- **5mL = ...**
- **7mL = ...**

9. CURRICULUM VITAE

Personal Informations

Name		**Surname**	
Place of Birth		**Date of Birth**	
Nationality		**TR ID Number**	
E-mail		**Phone number**	

Education

Degree	**Department**	**The name of the Institution Graduated From**	**Graduation year**
Master	Clinical Pharmacy	**Yeditepe University**	2023
University	Clinical Pharmacy	**Altinbas University**	2018
High school	-	**Zhin high school**	2012

Languages	**Reading***	**Speaking***	**Writing***
English	Very good	Very good	Very good
Arabic	Very good	Very good	Very good
Turkish	Good	Very good	Good
Kurdish (Sorani)	Very good	Very good	Very good

Work Experience

Position	**Institute**	**Duration (Year - Year)**
Translator	Memorial Hospital	May - Sep 2019
Pharmacist Intern	Vary pharmacy	Jun - Sep 2017

Pharmacist Intern	Bakirkoy Saadi Konuk Hospital	Oct 2017 -Jan 2018

Computer Skills

Program	**Level**
Microsoft Office Programs (Word, Excel, PowerPoint)	Very good

***Excellent , good, average or basic**