Medication errors in pediatric nursing: Assessment of nurses' knowledge and analysis of the consequences of errors

Ya-Hui Lan [a], Kai-Wei K. Wang [b], Shu Yu [b], I-Ju Chen [b], Hsiang-Feng Wu [c], Fu-In Tang [b,*]

[a] Tri-service General Hospital, Taipei, Taiwan
[b] School of Nursing, National Yang-Ming University, Taipei, Taiwan
[c] Taipei Veterans General Hospital, Taipei, Taiwan

ARTICLE INFO

SUMMARY

Aim: The purposes of this study were (i) to evaluate pediatric nurses' knowledge of pharmacology, and (ii) to analyze known pediatric administration errors.

Background: Medication errors occur frequently and ubiquitously, but medication errors involving pediatric patients attract special attention for their high incidence and injury rates.

Methods: A cross-sectional study was conducted. A questionnaire with 20 true–false questions regarding pharmacology was used to evaluate nurses' knowledge, and the known pediatric administration errors were reported by nurses.

Findings: The overall correct answer rate on the knowledge of pharmacology was 72.9% (n = 262). Insufficient knowledge (61.5%) was the leading obstacle nurses encountered when administering medications. Of 141 pediatric medication errors, more than 60% (61.0%) of which were wrong doses, 9.2% of the children involved suffered serious consequences.

Conclusions: Evidence-based results demonstrate that pediatric nurses have insufficient knowledge of pharmacology. Such strategies as providing continuing education and double-checking dosages are suggested.

© 2013 Elsevier Ltd. All rights reserved.

Introduction

Medication errors occur frequently and ubiquitously, but medication errors involving pediatric patients attract special attention for their high incidence and injury rates (Kaushal et al., 2001; Koren, 2002). A study whose findings were computed from the administrative data on occurrence of medication errors indicated that medication error rates per 1000 patient-days were higher in pediatric units (14.8) than in adult units (5.7) (Stratton et al., 2004). The injury rate for adult patients is around 1–3% (Leape et al., 2000), while that for pediatric patients is three times higher (Fortescue et al., 2003; Kaushal et al., 2001).

Children are particularly vulnerable to medication errors because of their immature and unique state of physiological development, which results in a high sensitivity to drugs and low tolerance of errors. Kaushal et al. (2001) reviewed 10,778 medication orders and found 616 medication errors, 115 potential adverse drug events (ADEs) and 26 ADEs. The rate of potential ADEs was significantly higher in neonates than in other age groups. The authors summarized four factors contributing to ADEs involving children specifically. These were: the need for weight-based drug dosing involving multiple calculations, dilution of stock solutions, immature physiological buffering systems, and limited communication skills when experiencing side effects. Most drugs manufactured for adults, moreover, are not suitable for children. Also, many drugs used in pediatric units are either unlicensed (not specifically licensed for use in children) or used off-label (outside the terms of the product license, such as without approved indications, approved age groups, approved doses or approved methods of administration) (Turner et al., 1998).

In pediatric settings, medication errors occurring at the administration stage constitute the most common type of preventable drug event, accounting for 59% (Ross et al., 2000) and 41% (Miller et al., 2006) of all errors, with nurses responsible for most of the errors. Some of the research in this area has focused on nurses' calculation skills (Wong et al., 2009); other studies have tried to identify system or human factors contributing to medication errors (Stratton et al., 2004; Tang et al., 2007). In this study, however, we wanted to know whether pediatric nurses possess sufficient knowledge of pharmacology as several studies have indicated that insufficient pharmacology knowledge is one of the most significant factors contributing to drug administration errors on the part of nurses (Lu et al., 2013; Tang et al., 2007). Previous research by the authors of the current study also demonstrated that insufficient knowledge was the leading obstacle among 14 obstacles that nurses encounter when administering high-alert medications (Hsiao et al., 2010). The first objective of the study, therefore, was to evaluate pediatric nurses' knowledge of pharmacology. The second

* Corresponding author at: School of Nursing, National Yang-Ming University, 155, Section 2, Li-Nong Street, Shih-Pai, Taipei 112, Taiwan. Tel.: +886 2 28267297; fax: +886 2 28229973.
E-mail address: fitang@ym.edu.tw (F.-I. Tang).

was to analyze known pediatric medication errors since the collection of data on known errors and the identification and analysis of such help to establish the factors contributing thereto, which in turn can facilitate the development of prevention strategies.

Literature Review

Medication safety is a major concern and a global issue as regards the quality and safety of patient care. The US Institute of Medicine (IOM) and the UK Department of Health (DOH) have both published books (IOM/US: *To Err is Human: Building a Safer Health System*; DOH/UK: *An Organization with a Memory*) concerning medication errors (DOH, 2000; Kohn et al., 1999). In Taiwan, the Taiwan Joint Commission on Hospital Accreditation (TJCHA) has set the "avoidance of medication errors" as its first priority among ten goals for hospital safety, as medication errors are the leading cause among 13 types of medical negligence (TJCHA, 2011). Errors affecting children, however, raise special concerns.

Pediatric administration errors

Research indicates that taking more than one medication and being younger than five years of age are correlated with risk of a medication administration error (Lemer et al., 2009; Zandieh et al., 2008). In one study pediatric medication errors occurred in 0.15% of admissions, with the highest rate (0.98%) occurring in neonatal intensive care, and with nurses responsible for nearly 60% (59%; 115/195) of the errors (Ross et al., 2000). In the US MEDMARX database (MEDMARX is an internet-accessible anonymous medication error reporting program designed to enable hospitals and health systems to collect, analyze, and report medication errors systematically (Santell et al., 2003)), a total of 1956 pediatric errors were reported (from January 1, 1999, to December 31, 2000) and administration accounted for 51% (1007/1956) of errors (Cowley et al., 2001). One systematic review article reported that the distributional epidemiological estimates of the relative percentages of pediatric error types were: prescribing 3–37%; dispensing 5–58%, administering 72–75%, and documentation 17–21% (Miller et al., 2007). In addition, administration errors involved more "harmful errors" (59%) (a "harmful error" was defined as one reported as harmful or one requiring additional monitoring and intervention) than "non-harmful errors" (32%) (Rinke et al., 2010). These results suggest that most pediatric errors occurred during the administration stage and caused more harm to patients than errors occurring at other stages. Nurses hold great responsibility for patients at this stage.

The high rate of administration errors highlights the importance of developing, testing and implementing effective error-preventing strategies. In a systematic review article, however, 26 unique recommendations for strategies to reduce medication errors were identified. None was based on pediatric evidence (Miller et al., 2007). We therefore consider that improving pediatric nurses' pharmacology knowledge might facilitate reductions in nurses' administration errors. Before educational training programs are implemented, assessment is required. A few studies have assessed competency in pediatric nurses' pharmacology knowledge and no validated tool exists for such assessment.

Methods

Aim

The aims of this study were to evaluate pediatric nurses' pharmacology knowledge and to analyze known pediatric medication administration errors.

Methodology

We adopted a cross-sectional study design. A questionnaire was developed, containing two sections and based on a previous study evaluating nurses' knowledge of high-alert medications (Hsaio et al., 2010). Section 1 comprised 20 true–false questions to evaluate pediatric nurses' pharmacology knowledge. Section 2 was designed to analyze known medication errors reported by participating nurses. Nurses working in pediatric wards in medical centers in Taipei, Taiwan, were recruited to participate in this study. Content, construct and face validity were used to validate the questionnaire. Descriptive statistics were used to analyze responses. The study was conducted in 2009.

A formal invitation letter and research proposal were submitted to eight medical centers in Taipei City, seeking their cooperation and permission to conduct this study. Four agreed and allowed us to contact their nurses. We then distributed the questionnaires to the head nurses of their pediatric wards. The head nurses distributed the questionnaire to the ward nurses.

Instrument Development

Section One (Nurses' Knowledge)

We divided this section into four parts. The first and second parts were intended to elicit information for objective evaluation of nurses' knowledge regarding high-alert medications and common-use medications. The third part was aimed at gaining an understanding of the factors that contributed to the knowledge score. The fourth part invited nurses to provide their subjective evaluation of conditions regarding the use of pediatric medications.

Part 1: High-Alert Medications (10 True/False Questions)

High alert medications are drugs that bear heightened risk of causing significant patient harm when used in error (ISMP/US, 2003). Most medication errors cause no harm to patients. Harmful events are due mainly to the flawed administration of high-alert medications. We had previously validated 20 test questions regarding high-alert medications (Hsaio et al., 2010. *Nurses' knowledge of high-alert medications: Instrument development and validation.* Journal of Advanced Nursing, 66(1), 177–190). Pediatric experts and researchers together selected 10 questions relevant to pediatric use and possessing a high discrimination index (average 0.56), indicating that they are good questions. The questions concern the use of potassium chloride (KCl), insulin, epinephrine, calcium etc. (Table 1).

Part 2: Common-use Medications (10 True/False Questions)

Common-use medications were defined by experts, the researcher's own clinical experiences and literature review as medications that are often administered by pediatric nurses including such drugs as dilantin, aminophylline, acetaminophen, digoxin etc. Given the importance of administering correct doses to children, four questions were designed to test nurses' calculation skills (Table 1).

Part 3: Contributing Factors (Close-ended Questions)

This part aimed to analyze pediatric nurses' personal background and work-related experience, including age, educational levels, working years, and training courses undertaken that have contributed to their knowledge of pharmacology.

Part 4: Self-evaluation

This part was designed to determine nurses' subjective evaluation of the following three factors concerning medications used in pediatric wards.

(1). What are the obstacles that nurses encounter when administering medications to children? (In this study "obstacle" implies anything that makes it difficult for nurses to administer