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## Measuring non-administration of ordered medications in the pediatric inpatient setting



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### ABSTRACT

**Objective:** Medication compliance in inpatient settings shows some significant gaps for adult patients. In pediatric settings prescribing and other administration errors have been studied but missed doses have not been specifically studied in the pediatric inpatient setting. We intended to apply health information technology and data processing methods to study the medication compliance for pediatric patients at our institution.

**Study design:** We collected medication ordering, dispensing, and administration data spanning 42 months (7/1/2010 through 12/31/2013) for pediatric inpatients admitted to a major tertiary pediatric hospital. We analyzed the orders for which either the corresponding administration record was missing or the records indicated non-administration.

**Results:** There were only 596 medication orders without corresponding administration records, accounting for less than 0.05% of 1.6 Million orders for 56,000 patients. There were 40,999 orders with corresponding administration records indicating non-administration (or less than 3% of all orders). Overall order compliance of the nursing staff was 97.35%, with another 2.6% of orders having a documented reason for non-administration. The top two medication classes comprising the missed and non-administered orders were “Alimentary tract and metabolism drugs” and “Nervous system drugs”.

**Conclusion:** Measurement of medication compliance is an important quality measure of patient safety and quality of care. Our study found a small proportion of non-administered medication orders and discovered corresponding reasons illustrating how health information technology can help to measure the quality of the medication process from ordering and dispensing to administration at a major healthcare institution.

### 1. Introduction

Medication errors can occur at any step in the medication process from ordering, dispensing, administration, and documentation [1]. In this paper we focus on the administration process and specifically on the aspect of missed doses. The term ‘adherence’, frequently used in outpatient settings, indicates a patient following providers’ advice (on medication or health-behavior) and signifies the patient’s active role in achieving a common goal of disease treatment. ‘Compliance’, more often used in inpatient settings, indicates a passive role by patient and

an active role of the medical staff (e.g., nurses and pharmacists) [2]. For the purpose of this study, we define compliance as the proportion of medication orders that culminate in actual administration to the patient in an inpatient setting and focus on the ‘missed’ administrations – either due to non-documentation or an indicated reason; while the adherence is the proportion of ordered medications that are actually taken by the patient in the ambulatory setting. Though the medication compliance rates in an inpatient setting are expected to be higher than adherence rates observed in outpatient environments, the inpatient compliance is influenced by the complexities of patient care as well as hospital

**Abbreviations:** ATC, Anatomical Therapeutic Chemical; EDW, Enterprise Data Warehouse; EHR, Electronic health record; eMAR, electronic medication administration records; ETL, extract-transform-load; IRB, Institutional Review Board; IV, intra-venous; MAR, Medication Administration Records; NPO, nil per os (nothing by mouth); PRN, pro re nata (as in PRN orders); Prop., proportion; TPN, total parenteral (or peripheral) nutrition; VPH, Vanderbilt Pediatric Hospital; VUMC, Vanderbilt University Medical Center

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policies, procedures, and staffing states [3]. Much of the inpatient medication compliance literature concentrates on patient factors [4,5]. However, a qualitative study by Elder et al. indicates that the compliance by the nursing staff plays an important role in the medication process that culminates in administration of the ordered doses [6], and reveals the impact of a previously unrecognized nursing staff's assessment of individual patient risks and benefits of the medication to the patients. This study by Elder et al., of inpatient venous thromboembolism prophylaxis orders for subcutaneous heparin, found a compliance rate of only 80% in certain nursing units at a major academic medical center, with a significant variation between nursing units. Other recent studies have also indicated significant compliance gaps in the inpatient medication process [7,8].

Potential communication barriers with caregivers are of particular concern in pediatrics since children depend on others for appropriate medication administration [9]. Parents in most cases act as proxy for the pediatric patient and may often need guidance about the medication treatment from the nursing staff at the hospital [10]. Given the observed gap for medication administration in adults [6], we considered it worthwhile to examine the medication process for similar inconsistencies and gaps in a pediatric population.

In pediatric inpatient settings, medication is generally administered by nursing staff and occasionally by parents [10]. Compliance for pediatric inpatient settings is therefore more dependent on the integrity of the medication dispensing and administration process [11]. Medication management for pediatric patients is more complex and poses higher safety risks due to the developmental gradient of children and their inability to buffer errors due to limited internal reserves [10,12]. It is therefore important that every medication ordered for a pediatric patient is delivered and administered as intended by the provider. Further, it is in the interest of a healthcare institution to periodically assess the robustness of medication compliance to ensure quality of care. Some limited work was done in examining the medication process in general, after relocation of a children's hospital at an academic medical center [11]. This paper focuses on the analysis of missed doses for pediatric inpatient population of a major tertiary pediatric hospital and describes 'Medication Compliance' as the proportion of medication orders that culminate in actual administration to the patient. Additional studies were spawned to analyze administration-times and other detailed aspects of the deviations.

## 2. Methods

This retrospective cross-sectional study uses the Enterprise Data Warehouse (EDW) at the Vanderbilt University Medical Center (VUMC) that receives daily feeds from Vanderbilt's operational systems, such as Vanderbilt's order entry system (Horizon Order Entry and WizOrder) [13] and the electronic Medication Administration Record (eMAR) System. We queried datasets that contain data on medication orders, dispensing, administration, patient encounters, and demographics using Structured Query Language.

We isolated pediatric patients (less than 19 years of age on the date of admission) in the EDW based on their inpatient encounters (including admissions and observational stays) and extracted their demographic information. For this pediatric patient dataset, we collected all orders from July 01, 2010 through December 31, 2013 (42 months). To identify the medication orders, we included only orders serviced by pharmacy, and applied filters to exclude orders for pharmacy consultations. We also excluded orders where the administration was not mandatory (e.g., PRN orders) or was not routinely recorded in the medication administration record (e.g., TPN orders were recorded by nurses as fluids and not medications). For the medication orders collected, we isolated the corresponding pharmacy dispensing data, medication administration data, and the patients' unit location at the time of the order (Fig. 1).

In the next step, we identified medication orders that did not have a

corresponding matching administration record – we labeled this set of order records the "missed-admin" subset. Orders not explicitly for a medication (e.g., orders named 'PHARMACY MESSAGE') or for discontinuation of medications were also excluded. We further excluded the orders for patients, who were not in a pediatric unit, and all orders from the pediatric emergency department since it used a paper-based MAR process.

At VUMC, nurses may select a REASON (from a predefined list) to indicate why a medication was not administered or delayed. The presence of a (non-zero) REASON-CODE indicates a deviation from the order. Some non-zero REASON-CODES indicate that medication was 'not administered' – others refer to deviation in timing or route. We labeled the set of orders with the corresponding administration records indicating 'not administered' REASON-CODEs as 'non-admin' subset. Fig. 2 shows the schematic view of separating the *missed-admin* and *non-admin* subsets.

We further analyzed the orders in the *missed-admin* or *non-admin* subsets with respect to the medication class. Because of the nature of the data stored, the medication details (name, dose, frequency, etc.) are contained in a free-text attribute. We used MedEx [14] to extract the medication details from the text attribute, and Anatomical Therapeutic Chemical (ATC) Classification [15] to classify the medications.

Since the orders in the 'missed-admin' subset did not have corresponding administration records, the proportions are with respect to the # of orders, while those for the 'non-admin' are with respect to the # of administration records. Administration records are related to the corresponding order by respective order number (order-identifier). Each order may have multiple administration records. Wherever appropriate, we have used number of distinct orders.  $\chi^2$  test was used to check the association between respective categories of administration records. We used statistical package R [64-bit version 2.15.2 (2012-10-26)] [16] for statistical analyses.

The EDW uses Oracle 11 g database engine and is behind a firewall. This data collection and analysis effort was part of a larger effort to study medication compliance for pediatric inpatients at VUMC. We obtained the Vanderbilt IRB approval for this Medication Compliance Study.

## 3. Results

We isolated the demographic data for 56,428 distinct pediatric patients (26,006 Females), who were inpatients or observation patients, with 110,435 encounters. Over half of the patients (30,442 or ~54%) were less than 3 years old (18,360 or ~33% neonates) with 51,443 (~47%) encounters. There were 1,570,994 medication order records for these patients, with 3,742,013 matching administration records. Only 596 distinct medication order records did not have a valid matching administration record (the *missed-admin set*). Table 1 summarizes these results.

### 3.1. Medication class distribution

Of the 596 "missed-admin" orders, half (50%) were for the "Alimentary Tract and Metabolism Drugs" (e.g., antiemetic medications like Ondansetron, steroids like Prednisolone, etc.), 14.4% were for the "Nervous system Drugs" (e.g., pain medications like Morphine), and 10.9% were for the "Antiinfectives for Systemic Use" (Influenza Virus Vaccine, Ampicillin, etc.). Table 2 shows the distribution of the "missed-admin" orders by (ATC) drug-class.

The distribution of administration records with non-zero REASON-CODEs is shown in Table 3. We grouped the non-zero REASON-CODEs into three categories: "Administered per Protocol", "Permitted Deviations", and "Not Administered". "Administered per Protocol" indicates that the medication was given in a modified manner, for example, delayed when the patient was off the unit; and "Permitted Deviations" indicates that the medication was not administered for valid

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