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Clinical Investigation

Root Cause Analysis and Subsequent Intervention to Improve First Dose Antibiotic Turnaround Time for Hospitalized Pediatric Patients

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OBJECTIVE Antibiotic timing is used as a quality standard for hospital accreditation and is an important quality measure. The study aim was to identify barriers in the process of first dose antibiotic administration on the pediatric floors at a tertiary healthcare center and carry out and test an intervention to improve turnaround time to less than one hour.

METHODS We conducted a quasi-experimental pre-post study of hospitalized pediatric patients up to 18 years of age initiated on intravenous antibiotics. Every order for a first dose intravenous antibiotic was assessed on all pediatric floors (10/2008). Orders that did not meet the overall turnaround time goal of ≤ 1 hour were identified. A root cause analysis (RCA) was performed to identify reasons for delayed antibiotic administration. Barriers identified in the RCA were used to develop interventions (03/2009) to improve compliance, and the proportion of orders that met the goal was compared pre- (10/2008-02/2009) and post-intervention (04/2009-05/2009).

RESULTS During the pre-intervention assessment period, 32 out of 46 total physician orders for a first dose intravenous antibiotic did not meet the one-hour overall turnaround goal. A main reason for delay was failure to label antibiotic orders as first dose. We designed an intervention that included antibiotic audits and individualized feedback to prescribers. The mean ± SD time from the written physician order to drug administration was 228 ± 58 minutes; timing improved to 55 ± 4 minutes after the intervention. The proportion of antibiotics administered within one hour improved from 42.2% to 63% (p=0.0015).

CONCLUSIONS We identified system barriers associated with delayed antibiotic administration. Antibiotic timing was improved after continued surveillance and individualized feedback to providers.

KEYWORDS antibiotic, first dose, pediatrics, turnaround

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INTRODUCTION

Antibiotic timing is used as a quality standard for hospital accreditation and is an important quality measure.[1] Increased morbidity and mortality, longer length of hospital stay, and development of bacterial resistance have been important considerations for improving antibiotic timing.[2] In addition, earlier initiation of antibiotic treatment decreases the risk of further complications, therefore leading to a shorter duration of stay.[3]

Evidence-based medicine has mainly focused on the optimal choice of antibiotics for a specific infection; however, other steps of the process such as timely administration of the first dose of antibiotic have not received much attention. The Joint Commission and Centers for Medicare and Medicaid Services have each recognized the significance of antibiotic timing in adult patients with pneumonia, making it a quality standard

ABBREVIATIONS IV, Intravenous; MAR, medication administration record; NICU, Neonatal Intensive Care Unit; PICU, Pediatric Intensive Care Unit; RCA, root cause analysis

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for hospital accreditation.[1] However, at this time, there is no national standard measuring antibiotic timing in pediatric patients.

Initially, interest in this issue by the pharmacy department at Shands Hospital at the University of Florida was prompted when physicians and nurses voiced concerns about delayed antibiotic administration times. In 2005, the pharmacy department initiated a quality assurance project, with a total antibiotic turnaround time goal of one hour or less from the time of physician order to medication administration. The institution's Pharmacy and Therapeutics Committee agreed on a total antibiotic turnaround goal of 1 hour or less. Although consensus for a general evidence-based guideline for antibiotic turnaround is lacking and may not be possible due to multiple factors, sufficient evidence does support the importance of antibiotic timing. When the project initially started, the average turnaround time was 3.5 hours and only approximately 25% of first dose antibiotics were meeting the 1 hour goal.

This project subsequently evolved into an ongoing quality measure for the pharmacy department. Over the next 3 years, the median turnaround time decreased to approximately 1 hour; however, the compliance rate of meeting the 1-hour goal was met by only 48% of all first dose antibiotics in the pediatric population. Noncompliance with previously established turnaround goals resulted in further analysis to better meet the needs of our patients. The first aim of this study was to identify barriers to timely antibiotic administration. Subsequently, we designed, implemented and tested an intervention to further increase the proportion of first dose antibiotics that meet the 1-hour goal. The study protocol was approved by the University of Florida Health Science Center's Institutional Review Board.

METHODS

Study Settings

Our study was conducted on the 164 pediatric beds of a 660-bed university affiliated tertiary health care center. The hospital has six decentralized satellite pharmacies, which receive faxed routine orders and faxed STAT orders from patient care floors. One satellite pharmacy processes orders for the general pediatric floors and Neonatal Intensive Care Unit (NICU) and another satellite pharmacy processes orders for the Pediatric Intensive Care Unit (PICU). Both pharmacies have laminar airflow hoods. Satellite pharmacists enter physician orders into the pharmacy computer system after receiving physician orders faxed by the unit clerks. These orders are typically sent to the Intravenous (IV) Center located in the Central Pharmacy on the ground floor. Once customized antibiotics are compounded, the antibiotics are sent back to the patient care floors once every hour. For medications that are needed immediately (i.e., STAT orders), IV medications can be prepared in the laminar airflow hoods located in the satellite pharmacies. The STAT orders, including physician orders labeled 'first dose now' and 'now' are expected to have a turnaround time of less than one hour after the physician order is written.

The decentralized pharmacy that serves the PICU is open 24 hours a day and the pharmacy that serves the NICU and the general pediatric floors is open for 16 hours. Once this decentralized pharmacy closes, the orders are faxed to the Cardiothoracic ICU/Surgical ICU decentralized pharmacy which is located 2 floors below. This pharmacy is also equipped with oral medications and a laminar airflow hood.

Patients

Hospitalized pediatric patients (aged 0-18 years) with an order for a first dose IV antibiotic prescribed on the pediatric floors (PICU, NICU, and general pediatric floors) were eligible for inclusion. All pediatric patients who received second or third supplementary antibiotics and/or streamlining of an antibiotic treatment regimen were also included, specifically for patients who received a supplemental antibiotic with a broader coverage to treat recent microbiologic culture findings that were not being covered by the active antibiotic regimen. Seventeen patients were excluded from the study based on incomplete time documentation in patient charts, first dose antibiotic given in the operating room or emergency department, or first dose antibiotics intentionally prescribed for administration at a later time.

Data Collection

The following time measurements were recorded: time from prescriber order to fax (goal 10 minutes or less), time from pharmacy order

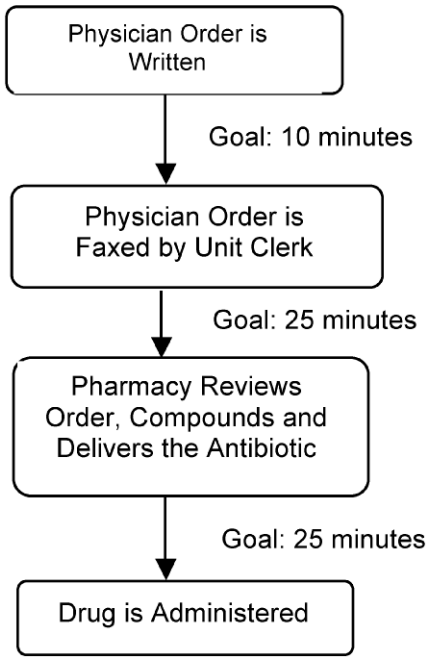

Figure 1. Flowchart of processes and time goals from physician order to drug administration.

receipt to drug delivery to the floor (goal 25 minutes or less), and time from delivery to the floor to drug administration (goal 25 minutes or less). These time measurement goals were decided by the Pharmacy and Therapeutics Committee (Figure 1). The different time measurements were obtained through the physician order form as recorded by the provider, the time stamp from the fax machine, the pharmacy computer system when the pharmacist reviewed and entered the order into the pharmacy computer system, the time stamp when the medication was delivered to the floor as recorded by the pharmacy technician, and lastly, the medication administration record (MAR) reported by the nurse.

Pre-Intervention

The pharmacy department enlisted pharmacy students on clinical rotations to perform daily data collection for the quality assurance project. This data collection occurred between October 2008 and February 2009. Students were based in the pediatric satellite pharmacies and collected the time measurements for all first dose antibiotics retrospectively to capture antibiotics dispensed during all times of the day. Every month an average of 50 first dose antibiotics were collected and analyzed. These data were presented to the Pediatrics Operations Committee quarterly to report progress.

Root Cause Analysis

Root cause analysis (RCA) was performed to identify barriers that resulted in delays in first dose antibiotic turnaround time in October 2008. The RCA was not communicated to any department and was solely performed by the primary investigator. When the satellite pharmacist entered an antibiotic order for a pediatric patient into the prescription system, an alert (via paging system) was sent to the primary investigator. Within 60 minutes, the primary investigator went to the patient care floor to see if the dose was given. If the medication was not given within the goal of 60 minutes, the primary investigator determined possible origins for the delay. The nurse and/or physicians in the patient care unit were interviewed to clarify reasons for delay. Not all parties were interviewed in every case. The interviews were not scripted, and the information gathered was later presented in vignettes.

Intervention Strategy

Upon completion of the RCA, barriers were categorized according to their origins: providers, clerks, pharmacy personnel, nursing staff, or other. These data were then presented to an interdisciplinary group consisting of the various departments. The group discussed and designed strategies to address issues that resulted in delayed administration. The intervention selected by the group was to perform an audit of prescriber orders and was started in March of 2009 to identify those prescribers who did not identify the antibiotic order as a first dose antibiotic with either "STAT," "Now" or "First Dose Antibiotic." Prescribers who failed to identify the order with one of the aforementioned descriptors were provided with weekly individualized feedback in the form of a typed letter from the vice-chair for clinical affairs reminding the prescriber to denote orders as first dose antibiotics.

Post-Intervention

The last phase of the study was the post-intervention stage with data collected from April 2009 to May 2009. Although the intervention was initiated in March, the individualized feedback letters did not reach the providers until the end

Table 1. Potential Causes of Delay for 32 Instances of Delayed First Dose Antibiotic Turnaround Time

Source	Potential cause	Number of occurrences	Total per source
Prescriber	Did not specify medication was a first dose antibiotic	26	26
Clerk	Prolonged time to fax the order (>10 minutes)	20	20
Pharmacy	Antibiotic remained in IV room (i.e., antibiotic was not picked up for delivery)	2	15
	Pharmacy technician delivered another medication first	2	
	Antibiotic made in central pharmacy	11	
Nursing	Nurse assumed antibiotic had already been administered	1	16
	Nurse did not find antibiotic immediately	6	
	Nurse waited for administration of another medication first	6	
	Nurse did not actively wait (i.e., Nurse was off the floor)	3	
Other	Medication hidden under charts	1	8
	Patient underwent a procedure	1	
	IV access obtained late	5	
	Order never reached pharmacy	1	

of the month; therefore, the data from the month of March were not included in the analysis. Once the intervention was implemented and applied to practice, the time measurements were continuously collected and re-examined to determine if antibiotic timing had improved on the pediatric units. There was no investigation performed if the antibiotic was not administered within the 60-minute goal during this phase of the study.

Statistics

Differences in proportions between the pre-intervention and post-intervention periods were determined using the chi squared test. The Wilcoxon rank sum test was used to analyze differences in medians. A p-value less than 0.05 was considered statistically significant.

RESULTS

Of the 46 patients identified during the RCA period, 32 received delayed first dose antibiotics. The investigation was not continued for the other 14 alerts as the antibiotic was administered within 60 minutes. The mean (± SD) time from the written physician order to drug administration was 3.8 ± 0.96 hours.

The RCA identified barriers causing late antibiotic administration. Causes were placed into five categories: provider, clerk, pharmacy personnel, nursing staff, and other (Table 1). The providers' failure to indicate that the antibiotic was a first dose antibiotic was most commonly associated with delay and was found in 72% of delayed antibiotics. To address this barrier, providers who omitted the first dose indicator in the order were identified in the audit. Providers received weekly direct mailings regarding how to improve antibiotic timing. Improvement in antibiotic administration was achieved after implementation of this individualized feedback.

We analyzed 211 antibiotic prescriptions in the pre-intervention phase and 81 post-intervention. The proportion of antibiotic orders written as "First Dose Antibiotic," "STAT" or "Now" increased from 58.3% to 74.1% (p=0.0037). Additionally, the fax machine dedicated to STAT orders was utilized more after the intervention: 48.3% vs. 67.9% (p=0.0027).

The compliance rates of the clerks and pharmacy personnel were not statistically different (p=0.76 and 0.67, respectively). The nursing staff demonstrated significant improvement in the process of administering first dose antibiotics after the medication was delivered (p=0.0065) (Table 2).

Table 2. Compliance Rates Pre- and Post-Intervention

	Pre-Intervention (%) N=211	Post-Intervention (%) N=81	p-value
Orders labeled as a first dose antibiotic	58.3	74.1	0.0037
Orders sent through the STAT fax	48.3	67.9	0.0027
Physician order to fax time less than 10 minutes	47.4	49.4	0.7606
Pharmacy review to medication delivery less than 25 minutes	72.9	69.1	0.5386
Orders delivered and administered in less than 25 minutes	45.8	64.2	0.0065
Pharmacy time to delivery less than 15 minutes	70.5	67.9	0.6788
First dose antibiotics administered within 60 minutes after physician order	42.2	63	0.0015

Each of these improvements contributed toward attaining the study's primary objective: the number of first dose antibiotics administered within 1 hour increased from 42.2% to 63% (p=0.0015, Figure 2). The median time from the written physician order to drug administration decreased from 72 ± 6 minutes to 57 ± 3 minutes (p=0.0015; Figure 2 and Figure 3).

DISCUSSION

The present study shows that reducing the time from the written physician order to the administration of the first dose antibiotic is attainable in a hospital setting. The most common barrier identified at our institution was the failure to indicate in the original order that the antibiotic was a first dose. This prescribing practice became the target of improving turnaround time for our study.

A study by Vogtlander et al. improved first dose antibiotic turnaround time in a hospitalized adult population.[4] The study had similar methods, including identifying barriers that caused a delay in antibiotic administration, implementing interventions, and performing a post-intervention analysis. The interventions included auditing and providing feedback for physicians and nurses and placing more commonly ordered antibiotics on the patient care floors. The antibiotic timing improved from 4.1 hours to 2.6 hours (p=0.003).

For our study, Departments of Pediatric Medicine, Nursing and Pharmacy were involved in the development of potential interventions to improve antibiotic timing. We wanted to address the most common barriers that were identified, such as the prescribers' failure to indicate that the order represents a first dose antibiotic and to help clerks identify which orders are more urgent. Some interventions discussed were: (1) creating separate physician order sheets for first dose antibiotics, (2) labeling antibiotics with bright-colored first dose antibiotic stickers, (3) pharmacy communication notes to inform nurses that the antibiotic has been delivered to the floor, (4) first dose antibiotic audit with individualized feedback letters to prescribers, and (5) all antibiotics to be compounded in the satellite pharmacies. Audit with individualized feedback was chosen because this method has been shown to be very effective in other hospital issues at our institution, including banned abbreviations and weight-based dosing for pediatrics. We chose a single isolated intervention over a multi-faceted design to be able to study the effectiveness of the chosen intervention.

The combination of audit and feedback was associated with a reduced first dose antibiotic turnaround time in pediatric patients. The compliance rate of meeting the 1-hour turnaround time goal was increased by 20.8%. A secondary analysis showed that physician orders labeled with "First Dose Antibiotic" or "STAT" were treated differently by clerks, pharmacy personnel, and nursing staff.

One limitation of the study is a potential Haw-

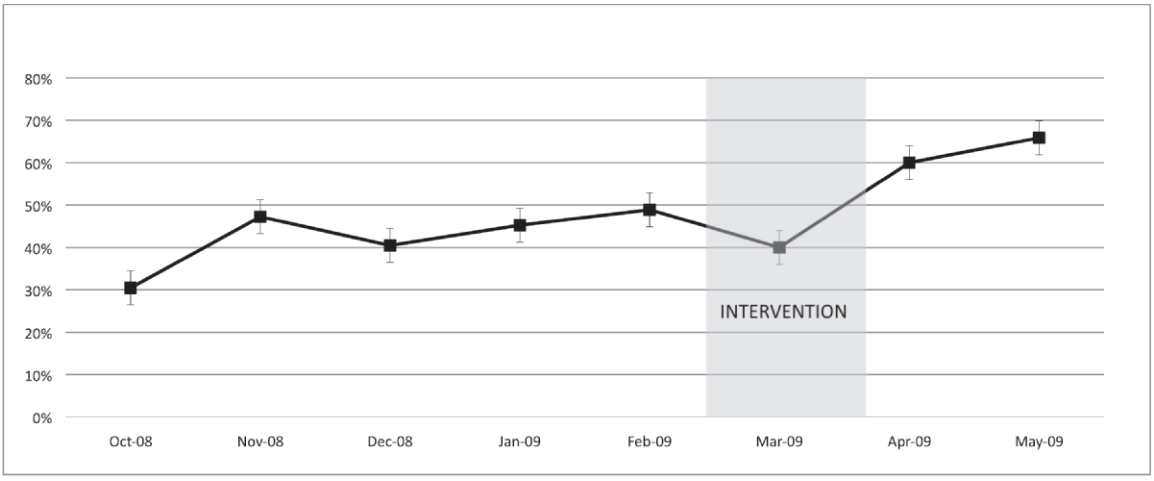

Figure 2. Percentage of pediatric patients who received antibiotics within 60 minutes of physician order. –■– = percent of time < 60 minutes with SEM. Mean 5 months pre-intervention time was 42.2% compared to mean 2 month post-intervention time of 63.0%. The absolute difference was 20.8% (p=0.0015).

thorne effect. During the data collection in the pre-intervention phase, we were as discrete as possible to avoid this phenomenon. However, after the intervention was implemented, the providers, pharmacy personnel, and nursing staff were aware of the data collection, which may have improved turnaround time in itself. Another potential limitation is inaccuracy of the time stamp recording, especially the time stamp for antibiotic delivery to patient care floors. This data was obtained solely based on the pharmacy technicians' writing in a logbook. The level of training of the staff from the different departments may have been varied as well. Our study design did not allow causality to be established. Alternative causes for delays or reductions in delays could theoretically have influenced our results, yet, we are unaware of co-interventions at that time that may have affected time to first dose antibiotic administration. Lastly, because of time limitations, the pre-intervention phase (5 month duration) is not equal to the post-intervention phase (3 month duration). The results may not fully represent the improvement in compliance after the implementation of the intervention.

This study showed that an antibiotic audit and individualized feedback has the potential to improve and reduce the first dose antibiotic turnaround timing, but there is still room for improvement. Though first dose turnaround

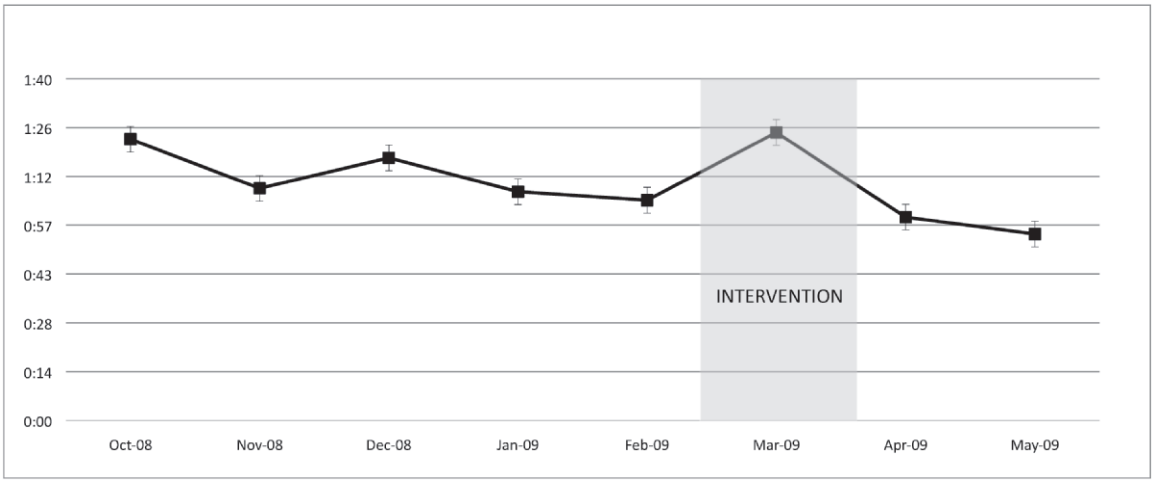

Figure 3. Median total time from physician order to antibiotics administration. –■– = median total time (hr:min) with SEM. Median 5 months pre-intervention time was 1:15 hrs compared to2 month median post-intervention time of 1:00 hr. The absolute difference was 15 min (p<0.0046).

timing improved, it may be a short-lived effect as demonstrated in previous studies.[4] The educational campaigns and efforts in changing clinical behavior have a tendency to have brief effects unless the interventions are continuously applied. Continued measurements are needed to monitor compliance rates and adherence to turnaround time goals.[5]

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REFERENCES

1. Mitka M. JCAHO tweaks emergency departments' pneumonia treatment standards. JAMA 2007;297:1758-1760.
2. Wachter RM, Flanders SA, Fee C, Pronovost PJ. Public reporting of antibiotic timing in patients with pneumonia: lessons from a flawed performance measure. Ann Intern Med 2008;149:29-32.
3. Houck PM, Bratzler DW, Nsa W, et al. Timing of antibiotic administration and outcomes for medicare patients hospitalized with community-acquired pneumonia. Arch Intern Med 2004;164:637-644.
4. Vogtlander NPJ, van Kasteren MEE, Natsch S, et al. Improving the process of antibiotic therapy in daily practice. Arch Intern Med 2004;164:1206-12
5. Madridejos-Mora R, Amado-Guirado E, Perez-Rodriguez MT. Effectiveness of the combination of feedback and educational recommendations for improving drug prescription in general practice. Med Care 2004;42:643-648.