Summer 2023

Using Education to Improve Timeliness and Efficiency of Medication Administration in an Inpatient Hospital Setting: A Quality Improvement Project

Kevin Christopher Lane
University of New Hampshire, Durham, kl1275@unh.edu

Using Education to Improve Timeliness and Efficiency of Medication Administration in an

Inpatient Hospital Setting: A Quality Improvement Project

Kevin C. Lane

Department of Graduate Nursing, University of New Hampshire

Faculty Mentor: Pamela Kallmerten, PhD, DNP, RN, CNL
Practice Mentor: Natalie Hansel, MSN, RN, CNL
Date of Submission: July 28th, 2023

Table of Contents

Abstract

Background: Timeliness of medication administration is important for optimal patient care. Technology, interdepartmental communication, and nursing workflow influence on-time delivery of medications. Improving knowledge through PowerPoint™ education and visual aids such as medication alert placards improves interdepartmental communication and positively influences nursing workflow leading to improved medication delivery times.

Local Problem: Nurses spend considerable time looking for and administering medications to patients on the unit. A goal was established to reduce the amount of time nurses spent looking for medications by 5% after implementing PowerPoint™ education to improve workflow.

Methods: This project used the Plan-Do-Study-Act (PDSA) strategy for implementation. Surveys, observational data of nurses attempting medication retrievals, and missing medication data provided by pharmacy were analyzed prior to and after the intervention and compared.

Interventions: Virtual PowerPoint™ education and Medication Alert Placards were introduced at the June 2023 staff meeting. Medication Alert placards were placed in nursing pods on the unit for a two-week period and workflow patterns were observed.

Results: Mean resolution times for missing medications increased (M =30-90%) during the post-interventional period. Survey results revealed nurses somewhat agreed (M = 4.1) the intervention improved their knowledge of medication delivery but did not improve resolution times.

Conclusion: Continued follow-up and investigation into nursing workflow processes and pharmacy inventory management are important to improve medication delivery times.

Key words: *automated dispensing cabinets, nursing, workflow, delays, medications, quality improvement.*

Introduction

The administration of medications is a fundamental component of patient care in the hospital setting. Due to higher safety standards, healthcare facilities are implementing technology to make patient medication administration more efficient, such as the use of Automated Dispensing Cabinets (ADCs). ADCs have been shown to reduce errors in medication delivery, which are a major cause of patient harm and are estimated to occur in 5-10% of in-hospital medication administrations worldwide (Debono et al., 2017). Despite the benefits and improvements to patient safety, ADCs can make medication delivery more complicated for the following reasons. ADCs are often integrated with other software applications, including patient management systems (Epic™, Cerner™, Meditech™), and patient medication administration records (MAR) allowing multiple departments in the hospital to interact with and participate in the process of reviewing, ordering, fulfilling and delivering the medications. Relatedly, many organizations have created complex steps for the processing and fulfilling of medication orders within their pharmacies, increasing the risk of those orders not being fulfilled and delivered in a timely manner (Nance et al., 2020). This increases the time registered nurses spend looking for the medication, prolonging medication delivery, decreasing the effectiveness of therapy and increasing the risk of adverse patient outcomes.

Problem Description

Local Problem

The microsystem was a busy, 37-bed medical surgical unit on the first floor of a large medical center in New England. The microsystem used both patient management software and electronic health records (eHR, Epic™) and ADCs (Omnicell™) for processing, ordering, delivering and storing medications. Orders placed by the provider in eHR were received by the

pharmacy, processed, fulfilled and delivered to the microsystem through PevcoLink™, a tube system using pneumatic technology for deliveries. Authorized personnel on the unit took the medications to be placed in the Omnicell™ or within locked patient bins throughout the unit. Registered Nurses reviewed each patient's MAR, and traveled to one of the two Omnicell™ on the unit or secured patient bins throughout the unit, removed the medications and administered them to assigned patients. RN's or Licensed Practical Nurses (LPN's) often spent considerable time locating medications prior to preparing and administering them to patients. RN's and LPN's expressed frustration with medications not being accessible in the Omnicell™, often because they were missing and had not been delivered to the unit. Informal inquiry reveals this happened at least once per dayshift, and required the nurse to contact pharmacy either by phone or through an automated message in Epic™ to inquire about the missing medication. Nursing staff then waited for the medication to be delivered, which on observation ranged from 30-120 minutes from the time the pharmacy was notified to the time the medication was administered to the patient. This resulted in delays in care, delays in associated lab results, and suboptimal use of nursing time.

Available Knowledge

Medication administration is a fundamental component of the nursing job function in the inpatient hospital system. On patient floors, medications are typically administered by both RN's and LPN's. Shifting trends in global healthcare include improving patient safety, maximizing efficiency, and streamlining workflows to improve care delivery and maximize favorable patient outcomes. An important component of medication administration is timely delivery of medications, which is important for maintaining therapeutic concentrations and is associated with improved patient outcomes (Craswell et al., 2020). In order to administer medications on

time, nursing workflow must be efficient. To make the process of medication administration more efficient, hospitals across the globe have turned to the use of technology, such as electronic medical prescribing (ePMA), and ADCs to improve workflow, reduce errors and maximize efficiency and patient safety. The implementation of technology in hospital environments has been suggested to improve medication administration in several areas. First, ADC's may reduce the risk of medication errors, which has been estimated to occur in 5-10% of in-hospital medication administrations worldwide (Van Wilder et al., 2016). Relatedly, findings of ADC and ePMA administration in hospitals have been suggested to improve workflow by reducing the amount of time needed to prepare medications, largely due to improved efficiency through automation (Van Wilder et al., 2016). Additional benefits include possible improvements in nursing workflow, such as improved timeliness of medication administration (Nance et al., 2020). Additionally, Douglas et al. (2017) found that use of ADCs reduced the time spent looking for and locating medications, while Keers et al. (2013) found improvements in job satisfaction among nursing staff. Many hospital floors have a mix of highly acute and moderately acute patients, which requires systems and processes to improve nursing workflow that encourage safe and efficient care, and elicits good results.

Despite the documented benefits of technology in the literature in improving patient safety and nursing workflow, other studies have shown little to no change in error rates after implementation (Ahtiainen et al., 2020). This may be related to a possible reduction in some forms of error and the creation of new ones, such as missed or late doses, which can be further classified as medication errors (Harkanen et al., 2016). Since the addition of new technology often creates challenges and new potential problems unforeseen at the time of implementation, the impact of ADC's on nursing workflow has been variable in the literature. For example, Van

Wilder et al. (2016) found that the time nurses spent on administering medications decreased, whereas the time spent on documentation increased. Additionally, a systematic review of 55 studies by Keers et al. (2013) found no significant improvements in the availability of medications, whereas increased issues with facility-based equipment and missing inventory items were found. Craswell et al. (2020) found that staff satisfaction with new ADC's was positive, but there was increased workflow due to the inability to access medications and time to prepare them.

The implementation of technology has created other challenges for health care organizations and the ability to improve in several key areas. ADC's are often integrated with other technologies, including patient management software (EPIC, Cerner) and patient medication records, allowing multiple departments in the organization to interact with and participate in the process of reviewing, ordering, fulfilling and delivering medications. Several studies on medication administration and workflow have cited challenges with interdepartmental communication between nursing and pharmacy (Abdelaziz et al., 2016; Alomar et al., 2020; Keers et al., 2013) and increased workflow time for pharmacy staff due to complexities and added steps in fulfilling medication orders and timely delivery (Abdelaziz et al., 2016; Alomar et al., 2020).

Limited evidence and suggested interventions to improve timely delivery of medications and improve interdepartmental communication include education for nursing and pharmacy staff, which helps with the creation of organizational best practices for identifying issues surrounding medication delivery (Nance et al., 2020). Education for improving workflow and timely medication delivery for nursing staff can take many forms, such as in-service education through PowerPoint presentations, visual aids at nursing stations, posters alerting staff of time-critical

medications, and simulation training (Corrado et al., 2020; Harkanen et al., 2016; Nance et al., 2020).

Search Criteria

Specific articles were found utilizing the online library search tool at the University of New Hampshire. Utilizing the health sciences subject (Nursing) search tool, three databases were chosen, the Cumulated Index to Nursing and Allied Health Literature (CINAHL), PubMed, and Medline (EBSCO). Search results were refined to filter and gather articles specific to the topic. Utilizing Boolean search methodology, keywords used included "Electronic Medication Systems" OR "Electronic Medication Dispensing Systems" OR "Automated Dispensing Cabinets" OR "ADC" AND nurse* OR "nursing" AND "work" OR "workflow" were selected. Additional search terms included "medications" AND "missing" OR "delayed" OR error. To capture articles discussing educational interventions, keywords such as "education" OR "nursing education" were also included. In CINAHL and Medline (EBSCO), advanced search criteria were applied to more effectively coincide with the topic which included additional filters for credibility (academic journals, Systematic Reviews, Randomized Controlled Trials, cohort and case-control studies). Opinion pieces and editorials were excluded.

Seven hundred and fifty-three articles were reviewed from the three databases, and another five were hand-selected from the Web of Science database for a total of seven hundred fifty-eight. Each article was screened and reviewed for relevance and alignment with the topic, using the Preferred Reporting Items for Systematic Review and Meta Analyses (PRISMA). Required criteria for eligible articles included keywords and results relevant to the project topic, and had been conducted within the predetermined time range (last ten years) and be of the designated level of evidence.

Additional exclusion criteria used to filter irrelevant articles included interventional strategies not performed in hospital settings, such as skilled nursing facilities, community clinics and schools, and keywords not pertaining to the project topic.

Twenty-eight were identified for further review and ultimately excluded, and consisted of duplicate articles (1), studies examining effects on patient populations (7), qualitative studies not pertaining to the project topic (8), and non-evidence-based studies (2). Ten articles met the criteria and were selected for analysis in this inquiry (See Appendix A for PRISMA flowsheet).

Abdelaziz et al. (2016)

Evidence suggests that systems supporting medication administration can both improve and complicate workflow for nursing and pharmacy staff. Abdelaziz et al. (2016) evaluated time to process medication orders at a large medical center in order to identify sources of delay, and identify interventions to correct procedural errors. This was an observational study conducted at 350-bed, acute care hospital on the east coast. 502 medication orders were studied and 389 were used for analysis. Total medication orders were studied to evaluate time to process, which were classified by entry orders from the physician and orders from non-physicians (Abdelaziz et al., 2016). The type of data collected consisted of the specific medication, the indication, time of order, time confirmed by pharmacy, time sent from the pharmacy and time charted as given to the patient. Processing times and standard times were calculated using the Mann Whitney test. Results showed a median overall time of 29 minutes (IQR 16-63; $p < 0.0001$), and that the time needed to process NPE orders was significantly less than needed for PE orders (mean 27 vs. 34 min, $p = 0.0026$), (Abdelaziz et al., 2016). The median total time required to process STAT orders for medications available in the ADC's was within 30 minutes, and to process non-STAT orders for medications available in the ADC's was significantly greater than 30 minutes (Median

time = 34 minutes, $p < 0.0001$), (Abdelaziz et al., 2016). Possible reasons for the reduced time

for NPE orders include the involvement of nurses in order entry, which improved

communication between the floor and the pharmacy staff. Improved communication between PE

orders and the pharmacy staff is an important component of interdisciplinary care and can

improve medication delivery times. Additionally, in-service education may help improve

communication between departments and improve workflow. Further results reveal that

approximately 20% of STAT orders were not documented as delivered to patients, which

requires further investigation and can be seen as a limitation in this study which questions the

reported evidence.

Systematic Review by Ahthiainen et al. (2020)

A systematic review conducted by Ahthiainen et al., (2020) looked at automated and

semi-automated drug distribution systems in hospitals to examine medication safety, workflow,

and costs. Over 3,136 articles were reviewed between 2005-2016, and 30 were selected for

inclusion using PRISMA methodology. Effects of drug dispensing systems on staff time and

work process were mixed (n=24/30) (Ahthiainen et al., 2020). Specifically, nurses reported

improved workflow, when compared with pharmacy staff, who reported additional workloads

and the need for increased staffing levels ($n = 5$). Minimal reductions in error rates were

reported. There were no listed strengths in this study. A major limitation of this study was the

lower quality of the reviewed evidence. Many of the studies included in the review employed

observational methodologies, which can create inherent bias when interpreting the findings. This

may be due to a lack of available research employing randomized control methodology, a finding

which warrants the need for further research.

Alomar et al. (2020)

A study conducted by Alomar et al. (2020) investigated the frequency and reasons of missing doses and the impact of a pharmacist-led intervention to reduce the number of missing doses in King Farah Medical Center in Saudi Arabia. This was a case-control study where 1400 patient records were retrospectively audited to quantify the problem of missed doses from the EHR/ADC. Missing doses were identified manually and written on a sheet and analyzed using inferential statistics and multinomial regression analysis. Results revealed a statistically significant decrease ($p = 0.00$, $p < 0.05$) from 190 missing medications to 11 over a two-month period. This study was successful as it improved communication among team members and improved medication delivery but also increased the amount of work the nurses needed to perform, such as increased documentation. Limitations in this study include a short interventional period, which may not be sustainable over a long-term period given the increase in workflow required for the nursing staff. Future research focused on improving communication and developing systems for long-term sustainability is recommended.

Corrado et al. (2020)

Corrado et al. (2020) created a case control study which aimed to improve on-time medication delivery to patients with Parkinson's Disease (PD) in the Leeds Teaching Hospitals Trust (LTHT). LTHT comprises over 90 adult medical units with between 35 and 50 patients with PD admitted on average. The study was conducted over a 4-year period from August 2016-June 2020. A collaborative driver team was assembled, which created primary drivers for the study, such as identifying and prompt delivery of medications, improved culture, including improvements in teamwork and accountability. Data collection involved collecting information on PD patients admitted each week, as well as the time when medications were given (expressed

as a percentage) within 30 minutes of due time, the time of the first dose of medication after admission was scheduled, and time it was administered. Data was analyzed using statistical analysis in the form of a control chart. Collaborative meetings between the research team and the staff allowed for the creation of interventions to achieve the aims, which included reminders at the bedside, magnets alerting personnel to time-sensitive medications, and small alarm clocks worn by nursing staff set to alert when medications were due, and twice-yearly educational masterclasses for hospital and volunteer staff on PD management (Corrado et al., 2020). Later interventions included "get it on time" stickers in the ED prompting timely medication administration. Between the period of January 2016 and June 2020, the average delay for the initial dose administration of medication dropped from 7 hours to 1 hour, and the average percentage of PD medications given within 30 minutes of the prescription time increased from 56% in March 2017 to 74.4% in April 2018 (Corrado et al., 2020). Feedback from the staff on the floors revealed that the interventions were simple to use and could be easily transferred between clinical environments. A significant strength of this article was the collaborative approach used to design the aim and interventions of the study. Possible limitations include a smaller sample of study participants over the study period, which may limit generalizability to the greater population.

Craswell et al. (2020)

A case-controlled study conducted by Craswell et al. (2020) studied the result of automated medicine dispensing cabinet units on nursing work process in a single tertiary hospital in Australia. The aim of the study was to evaluate the impact of the ADC on nursing and pharmacy assistant workflow during the hospital's opening. Data on workflow was collected using a combination of surveys (for nurses using ADC's) and non-participant observation of

personnel engaging with ADC's across four clinical areas. 260 surveys were distributed, and non-participant observation was performed on nursing staff delivering medications. Data analysis for survey responses consisted of placing nurses into groups for between-group analysis. Non-parametric statistical tests, such as Chi-Square and Mann-Whitney were used to examine differences between groups ($p = 0.05$), (Craswell et al, 2020). Observational data was analyzed using frequency and percentage. Data measurements from the medical and surgical floors were compared using Chi-Square and Mann Whitney analyses. Survey results reveal that medications were generally available when needed, but the process of filling the ADS often caused delays, which was more of an issue for nurses than pharmacy assistants ($p = 0.02$), and that the use of the ADC's creates additional delays in delivery and in the preparation and administration of a medication dose ($p = 0.037$) (Craswell et al., 2020). Observational results suggest that staff required 0-2 minutes to complete an ADC medicine cabinet transaction 74% of the time; 3-5 minutes 20% of the time and six or more minutes 6% of the time, "however, there was a difference between clinical areas with the median transaction time on the medical ward being double that on the surgical ward ($p = 0.001$)" (Craswell et al., 2020, p. 8). Strengths of this study include the rollout of a new ADC in a brand-new hospital, and a building of the current knowledge base. Limitations include the use of self-report surveys and non-participant observation which increase the potential for bias. Future research suggestions may be directed toward improving communication between pharmacy and nursing floors to reduce delays in medication delivery.

Douglas et al. (2017)

Research conducted by Douglas et al. (2017) used a case control study methodology to study Automated Dispensing Cabinets (ADC) on medication administration workflow and

nursing satisfaction. The primary objective of this study was to review the use of a new ADC on medication administration workflow and nursing satisfaction using the Medication Administration System Nurses Assessment of Satisfaction (MAS-NAS), which assesses nurse satisfaction in three key areas, efficacy, safety and access (Douglas et al., 2017). A total of 25,238 medication administrations (12,619 from both the new and old ADC) were compared to assess medication administration processes. 120 registered nurses completed the MAS-NAS questionnaire at month 1 and month 6. Survey results were collected and analyzed using inferential statistics (Douglas et al., 2017). Comparison of the median time difference between scheduled and actual administration in the previous and new ADC showed a 40% reduction from 14 to 11 minutes $(p = .0001)$. Statistically significant improvements in the new ADC were found in areas of reducing medication errors ($p = .0225$), and efficiency of medication administration ($p = .0005$) (Douglas et al., 2017). Strengths of this study include improved nursing workflow in the areas of medication administration and potential error reduction. Limitations include lack of randomization and increased probability of researcher bias in results interpretation, which ultimately limits the generalizability of the findings.

Harkanen et al. (2016)

Harkanen et al. (2016), completed a systematic review on the quality and effectiveness of educational interventions implemented to increase medication administration abilities and safety of registered nurses working in the hospital environment. Using PRISMA methodology and inclusion/exclusion criteria, 755 references were presented for review, of which 726 were excluded. 14 articles were kept and accepted for further review, which were independently assessed by two researchers using the EHPP Quality Assessment Tool for Quantitative Studies to verify credibility. The majority of the studies in the review aimed to evaluate the role of nursing

education in reducing medication preparation and administration errors, and to compare pre-and post-intervention learning outcomes. In the present study, a missed dose or delayed dose is also considered a med error. Types of learning interventions include e-learning (modules), wall posters, information pamphlets, flip charts, slide show presentations and simulated learning. Results showed a statistically significant difference between the mean pre- and immediate post-intervention results for the wall poster and informative pamphlets interventions ($p < 0.001$), and 3 month- educational intervention and flip chart and slide show presentation ($p < 0.001$), (Harkanen et al., 2016). Changes also remained statistically significant when measured at six-month and 18 month-follow up ($p < 0.05$). Strengths in this study include the methodology used to validate the credibility of the studies. Limitations in this study include a small number of interventional studies conducted in the research area, which necessitates the need for further research in this area.

Keers et al. (2013)

A systematic review conducted by Keers et al. (2013), evaluated the empirical evidence available on the causes of medication administration errors (MAE's) in hospital settings. Fifty-five publications were selected using PRISMA methodology and Reasons for Accident Causation analysis. Several of the studies reviewed reported challenges with communication ($n = 19$), in areas of failed prescription entry, possibly delaying administration time, and medication supply problems ($n = 27$), either due to misplaced medications or delayed deliveries from the pharmacy (Keers et al., 2013). Findings from this study highlight the need for possible future research on nursing workflow and improved timeliness of medication administration. A major strength of this study was it used a critical approach to analyze different contributors to medication safety and workflow, which encompasses a vast array of research. Limitations

include the lack of consistency in methods used in the studies reviewed, which may limit

generalizability in the findings. Future research should be directed toward improving

communication among team members, and developing systems to improve workflow.

Nance et al. (2020)

An interventional cohort study conducted by Nance et al. (2020) designed a quality

improvement initiative to enhance the safety and timeliness of medication administration to

inpatients with Parkinson's Disease (PD) in a local hospital. This study tracked 30,909

administrations of Carbidopa/Levodopa (C/L) over a 6-year period (between 2012-2018).

Primary outcomes were to record the frequencies with which C/L products were administered

within 60, 30, and 15 minutes of scheduled times (Nance et al., 2020). Patients were assigned

unique identifiers and recorded in an EMR-based data set. Based on this data collection, several

interventions were performed in 2015, which included 3 types of alerts in the EMR, staff in-

service education, and prioritization of stocking C/L in automated medication machines on

patient floors. 15-, 30-, and 60-minute administration times were calculated using the two-sided

Cochran-Armitage test for each time interval. Results from 5,939 C/L administrations during

2018 revealed significant improvements in on-time medication delivery, ranging from 89.3% in

2012 to 96.5% in 2018 (within 60 minutes of the scheduled time) 65.5% to 86.4% (30 minutes)

and 42.3% to 71.1% (15 minutes) (all $p < 0.0001$), (Nance et al., 2020). Registered Nurses taking

part in the study intervention stated that the alerts in the EMR were helpful for improving

timeliness of delivery. Strengths of this study include a longitudinal design and a well-funded

program to supply resources to fund the study. Limitations include the lack of a control group,

and a focus on the C/L "given" doses and lack of analysis on the "ungiven" doses.

Van Wilder et al. (2016)

Van Wilder et al. (2016) explored how electronic medical prescribing (ePMA) affected different aspects of nurse workflow, specifically workload and patient safety. This was a case control study that started one month before and continued until one month after the introduction of ePMA on a medical floor in a teaching hospital. Observation of nursing staff and patterns of workflow were observed in 20 scheduled drug round pre-ePMA and 14 after. 20 nurses were followed at scheduled drug rounds (8am, 12pm, 2pm, 6pm and 10pm) and spaghetti diagrams were created. Observers recorded interruptions to workflow, which were defined as a break in the performance of human activity initiated by a source internal or external to the recipient (Van Wilder et al., 2016). Time was measured from the time when each of dose was due to the time it was administered. Two-dimensional random interval sampling was performed, 1.) Activity, 2.) and who the activity was with. (Van Wilder et al., 2016). Data was analyzed using inferential statistics. Results discovered that the time spent on documentation was significantly higher (increasing from 9.5% (95% CI 6.9% - 12.0%) to 20.3% (95 % CI 16.6 % - 24.1%) of nursing time post ePMA when compared to pre-ePMA. Additionally, administration of medications given within one-hour of the scheduled time post ePMA (481 of 649 doses 74.1% 95% CI 70.1% 77.9%), were considerably more timely than pre-ePMA (120 of 198 doses, 60.6%, 95% CI 54.2%, 67.8%), (Van Wilder et al., 2016). The introduction of ePMA was seen as a valuable intervention on improving medication times because it reduced the amount of time nurses spend looking for drug charts. Strengths of the study include the first to study the effects of ePMA on nurses work. Limitations include a relatively small sample size, and limiting observations to staff on a single floor, which may reduce generalizability in the findings. Additionally, the relatively

short data collection period may not be sufficient to capture additional challenges with nursing workflow over a longer period of time.

Evidence Synthesis

Findings from the selected articles were generated and organized according to common themes, such as the importance of education, the use of alerts and disruptions in nursing workflow due to delayed and missing medications. Limited findings suggest that education improved proactivity and timeliness of RN's and LPN's delivering medications. Out of ten studies reviewed, three studies listed education as an intervention to improve timeliness of medication administration (Corrado et al., 2020; Harkanen et al., 2016; Nance et al., 2020). The type of education provided varied between the three studies. When examining improved timeliness of medication administration with PD patients, successful interventions used included in-service masterclass training to staff members on PD management, bedside posters, and magnets to alert staff to time-critical medications ($p < 0.0001$), (Corrado et al., 2020).

A second key finding was the use of electronic alerts for improving medication delivery times. Interestingly, Nance et al. (2020) concluded that alerts in the patient EMR were the most impactful in improving medication delivery times. A possible explanation for this finding included the frequency with which nurses log into the EMR to locate patient medication records. An EMR alert that pops up on the screen increases proactivity and reminds the nurse of due or near due medications. Additional details and the effects of the in-person educational seminar for staff were not expanded upon in the study. Further educational interventions as mentioned by Harkanen et al. (2016) include e-learning (modules), posters, informational pamphlets and slide show presentations, of which, wall posters, informative pamphlets and slide-show presentations were the most significant and effective ($p < 0.001$). Possible explanations for this finding

include the frequency with which wall posters can be viewed as a visual aid which enhances subsequent reinforcement of relevant material. Additional supplemental materials, such as slide shows and informative pamphlets may provide additional reinforcement and teaching that helped improve performance and results. While education was shown to be effective in the present study, the majority of the articles reviewed examined the effects of education in reducing medication errors and were less focused on improving timeliness of delivery. While this may be viewed as a detriment, the interventions from this study may be replicable and used to improve timeliness of medication delivery in future improvement efforts.

A third key finding was the disruption in nursing workflow due to medication delays and missing medications. Medication delays and workflow challenges were mentioned in four of the ten studies (Abdelaziz et al., 2016; Alomar et al., 2020; Craswell et al., 2020; Keers et al., 2013). The reasons for the delays and missing medications varied across studies. Challenges with orders and slower processing times with pharmacy staff featured strongly in one study, suggesting ineffective communication and possible broken links in interdepartmental workflow (Abdelaziz et al., 2016), and slower ADC filling times affecting medication availability for nursing staff (Craswell et al., 2020). Medication supply challenges were also a theme in the review conducted by Keers et al. (2013) mostly attributable to supply challenges and pharmacy delays. Explanations for these findings included logistical challenges in pharmacy verification, authorization, and delayed deliveries due to staffing issues. These findings created an opportunity for organizations to identify areas of weakness and to use educational interventions to create organizational best practices to improve proactivity and timeliness of medication administration.

Improved Medication Delivery Time

Improved medication delivery times were noted in five of the ten studies reviewed (Ahthiainen et al., 2020; Douglas et al., 2017; Nance et al., 2020; Van Wilder et al., 2017). Four of the five had used either ADC's or ePMA in their studies. Statistically significant decreases in medication administration times were noted with ADC use (Alomar et al., 2020; Douglas et al., 2017, $p = .0001$; Nance et al., 2020), or ePMA use (Van Wilder et al., 2016). These findings suggest that the use of technology appears to improve nursing workflow and timeliness of medication administration. Interestingly, two of the same 5 studies also noticed increases in required documentation times in the EMR after instituting ePMA and ADC use. Possible explanations for these findings include a temporary increase in workload during the new interventional period (Alomar et al., 2020) and the lack of familiarity with new ePMA system use (Van Wilder et al., 2016). While these results give credibility to the use of technology to improve workflow, they also highlight potential inefficiencies that may have occurred in workflow patterns that could be improved with targeted education and training.

Timely medication administration is influenced by several factors, such as the efficiency of nursing workflow, technology, interdepartmental communication, and availability of medication. Educational interventions, such as power point presentations and placards at nursing stations, were simple, cost-effective ways to educate nursing staff and potentially improve timeliness of medication administration. An important aim for future research efforts is the assessment of nursing satisfaction with medication administration in their current environment, as this may help identify problems with interdepartmental communication, medication delivery and other systems issues contributing to nursing workflow and the timeliness of medication delivery (Douglas et al., 2017). This would allow for targeted educational interventions to be

introduced that address workflow challenges, improve on time medication delivery and improve

patient outcomes. This quality improvement project investigated whether nursing staff who

completed education on timely medication administration compared with those who did not

complete education were at risk for delayed medication delivery due to medication retrieval

challenges, such as poor interdepartmental communication with pharmacy and missing

medications.

Rationale

The measures used to study timeliness of medication administration included direct

observation and examination of nursing workflow using staff surveys. Studies incorporating

direct observation were well documented in the literature and served as an effective means of

measuring nursing workflow and medication administration (Craswell et al., 2020; Van Wilder et

al., 2016). To effectively understand nursing workflow processes and determine variables

affecting on-time delivery of medications, the physical definition of time was used as an

operational definition in this project, which was defined in physics as "what a clock reads"

(USTC, 2019). To be classified as "on-time", medications must have been delivered one hour

before or one hour after the posted time, and anything over was considered late. The time that

nurses spent looking for missing medications was measured using a clock, from the time the

medication was determined to be missing from stock (Omnicell™) to the time it was delivered to

the unit. Time used as a measurement in that capacity created a consistent parameter from which

timeliness of medication delivery was evaluated both pre-and-post intervention.

Questionnaires were consistently used in studies conducted on nursing workflow and

medication administration and were particularly useful in gaining insight into ease of use and

overall satisfaction with the medication administration system (Craswell et al., 2020; Douglas et

al., 2016). They have also been used to identify potential issues with nursing workflow, such as availability of medications and interdepartmental communication challenges with pharmacy. Response results may be analyzed and used to determine disruptions in nursing workflow, which was defined as a break in the performance of human activity initiated by a source internal or external to the recipient (Van Wilder et al., 2016). Observational data was combined with staff surveys to identify which medications were consistently missing, and specific nursing workflow challenges and other components of the workflow process were used to direct the content of the educational curriculum.

QI Model

This quality improvement project utilized Plan-Do-Study-Act (PDSA) methodology for testing changes in timeliness of medication delivery within the microsystem. PDSA provided a structured experimental learning approach for testing proposed changes, and evaluated if making adjustments increased the chances of delivering and sustaining the desired improvement. PDSA methodology is an evidence-based approach and is central in many quality improvement approaches, such as lean and six sigma (Reed & Card, 2016).

Specific Aim

The intended theme for improvement with this project was improving the timeliness of medication administration. The global aim of the project was to reduce the amount of time registered nurses (RN's) and licensed practical nurses (LPN's) spent looking for missing medications. This process began from the time of the attempted medication retrieval to the time of delivery. By working on this project it was expected that time spent identifying and delivering medications would be reduced, and that targeted education would improve interdepartmental communication between the microsystem and the pharmacy team, making nursing workflow

more efficient. It was imperative to begin this improvement project because prolonged medication delivery times cause delays in care, causing increases in departmental costs such as higher nursing salaries and increased hospital length of stay. The specific aim of the proposed project was to reduce the amount of time RN's and LPN's spent looking for medications by 5% post-intervention after implementing an in-person PowerPoint™ presentation and informational placards for 50% of the unit-based day shift nursing staff within the microsystem by July 28th, 2023.

Methods

Context

This quality improvement project was created after completing a 5P assessment of the microsystem. A 5P assessment provided an opportunity to look at the intricacies of the microsystem, its purpose, patients, professionals, processes and patterns and identify areas for improvement (Reed & Card, 2016).

Purpose

A well-defined purpose is an important foundational attribute for any microsystem, as it provides a framework for how decisions and policies will be designed and implemented. The microsystem was a 37-bed medical specialty unit located on the 1st floor of a busy medical center in western New Hampshire. The purpose of the microsystem was to provide a compassionate and safe environment that supported and delivered quality care to treat acute and chronically ill patient populations. Important care deliverables such as timely medication administration, was an important focus for the microsystem to help improve patient outcomes.

Patients

Understanding the patients of a microsystem is also an important part of identifying areas for quality improvement. Most of the patient population within the microsystem came from hospital medicine, in addition to departments such as neurology and pulmonology. Top diagnoses for admitted patients include Sepsis, Acute Kidney Failure, Heart Failure and Chronic Kidney Disease. Patients ranged in age from 18-85 years, and were comprised of both male and females (57% male, 43% female). The average length of stay for patients in 2022 was 11.6 days, which is above the national average of 5.4 days (American Hospital Association, 2019). Length of stay was an important performance indicator, which may be affected by the efficiency and timely delivery of medications to patients.

The majority of the unit's patients come from nearby Vermont and New Hampshire, including surrounding states such as New York, Massachusetts and Maine. Many patients had preexisting conditions and chronic illnesses that necessitated a longer stay and may have affected their ability to manage the acute medical condition for which they sought treatment for.

Professionals

The microsystem unit leadership was composed of a unit nurse manager, an associate nurse manager, 3 clinical nurse supervisors (one position is currently vacant), a nurse educator, a clinical nurse leader and an administrative assistant. The unit team also included Registered Nurses (RN), Licensed Practical Nurses (LPN), Licensed Nursing Assistants (LNA), and Unit Support Personnel (USA). A report from March 2023 indicated a vacancy rate of 28.7% for the unit. Microsystem permanent staff included 25 RN's, 3 LPN's, and 14 LNA's. The unit also interacted with interdisciplinary staff from other departments such as registered dietitians (RD), speech language therapists (SLP), physical therapists (PT), pharmacists, social workers,

housekeepers, mobility technicians (MT) engineering, housekeeping, transportation, volunteers

and chaplaincy. Provider care consisted of 45 hospitalists (of varying specialty and experience)

and 10 Advanced Practice Providers (Nurse Practitioners and Physician Assistants). There were

four patient pods on the unit, each consisting of 6 patient rooms. Two RNs were scheduled per

pod, along with one licensed nursing assistant and an LPN. RN's and LPN's had many

responsibilities, such as the management and delivery of medications to patients on the unit.

Processes

Understanding the processes within a microsystem are important for identifying areas for

potential quality improvement. An absence in knowledge of specific working processes can lead

to ineffective workflow, reduced care effectiveness and increased risk for error. The microsystem

had many processes, including patient rounding, new patient admissions and transfers, and

medication administration. Medications were administered by RNs and LPNs through interaction

with an Automated Dispensing Cabinet (ADC) called Omnicell™ which released medications

electronically. The medications in the ADC's were stocked by pharmacy staff, who made

deliveries periodically throughout the shift, which resulted in fluctuating inventory levels for

certain medications.

Patterns

Patterns in microsystems are important to understand, as they serve to support how

professionals interact, communicate and accomplish tasks. The microsystem had many patterns

that allowed for daily operations. The process of identifying and analyzing patterns was an

important step to take before beginning the quality improvement project. Interdepartmental

communication between the pharmacy and the microsystem was important for medication

administration. Medications ordered by physicians were approved by the pharmacy who brought

them to the microsystem to be stocked in the ADC's. The nurse was responsible for communicating with the pharmacy in the event of an error or missing medication, which may delay administration to the patient. Informal inquiry revealed that delays happened at least once per shift, and required the nurse to contact pharmacy either by phone or through an automated message to inquire about the missing medication. Staff waited for the medication to be delivered, which on observation had ranged from 30-120 minutes from the time the pharmacy was notified to the time the medication was delivered to the unit.

Cost/Benefit Analysis

This quality improvement project took information from the 5 P assessment and involved implementing education for 50% of the day-shift nursing staff to improve workflow and timeliness of medication delivery. To implement this quality improvement project successfully, a thorough evaluation of related environmental, human, and material resources was considered and analyzed prior to implementation.

Environmental Factors

The timely delivery of medications were important components of nursing workflow and patient safety within the microsystem. Certain medications administered on the unit, such as vancomycin, carbidopa/levodopa (C/L), and anti-seizure medications like phenytoin, required on-time administration to maintain therapeutic levels and prevent further exacerbation of conditions such sepsis, epilepsy and bradykinesia. The microsystem was a busy unit with a daily full census. Each nurse was assigned 5 patients per shift, and each patient had multiple medications that were delivered throughout the day. Delays in medication administration had the potential to delay patient discharge dates and increase costs for the unit. The average daily cost for an inpatient hospital stay on a medical floor in New Hampshire in 2022 was $2,937, or

$122.38 per hour (Kaiser Family Foundation, 2023). Improving interdepartmental communication between the microsystem and the pharmacy through targeted education had the potential to improve workflow and timeliness of medication administration while simultaneously reducing costs.

Human Factors

Registered nurses and Licensed Practical nurses were the predominant staff members delivering medications to patients within the microsystem. Missing medications caused interruptions in workflow, potentially delaying medication delivery. The average salary for an acute-care nurse per hour in New Hampshire in 2022 was $37.68 and for a Licensed Practical nurse was $28.43 per hour (USBLS, 2022). Medication administration delays of 30-120 minutes had the potential to incur additional personnel costs to the unit, potentially adding additional expenses for 30 minutes ($18.84 per RN, $14.22 per LPN) and 120 minutes ($75.36 per RN, $56.86 per LPN). Targeted education provided an opportunity to improve communication between the microsystem nurses and pharmacy staff to improve medication delivery times and reduce personnel costs. Staff required to be involved in this intervention included the day-shift nursing staff, the unit Clinical Nurse Leader, unit support staff, Licensed Practical Nurses, the Associate Nurse Manager, and the Unit Nurse Manager.

Material Costs

This quality improvement project utilized targeted education for missing medications that were identified during the data collection process. Costs associated with the intervention were estimated and consisted of the following materials:

- 1 Ream of Printer Paper (printing surveys, data collection sheet) $6.99
- 1 Ream of Yellow Paper (educational placards) $6.99

- Lamination Cost – Fed Ex (educational placards) $3.99 x 4 pods ($16.00)

- **Total Project Costs: $30.00**

The estimated costs of implementing targeted education provided a reasonable, cost - effective solution to reduce potential expenses that may be incurred from delays in medication administration within the microsystem.

Intervention

Description of the Intervention

Information from the 5 P assessment was used to create the recommended intervention which included implementing education for the nursing staff within the microsystem. The purpose of the educational intervention was to improve interdepartmental communication between the microsystem nursing staff and the pharmacy team, and reduce the amount of time nursing staff spent looking for and administering medications. The method of educational delivery consisted of two components, a PowerPoint™ presentation and visible placards at nursing stations. The nature of the PowerPoint™ education was targeted based on information gathered during the data collection period, and contained the following information:

- Introduction to the problem (missing medications, challenges with workflow and interdepartmental communication).

- Purpose of the intervention.

- Current state of medication administration (as determined by observation and survey).

- Goal state (reduce the amount of time staff spend looking for medications by 5%).

- Current medications that were missing the most (as determined by observation).

- Steps for increasing proactivity and improving on time medication delivery (placards at nursing pods).

The PowerPoint™ presentation was presented at the microsystem June 2023 staff meeting, after the data collection period. Following the presentation, one designated placard was placed at each of the 4 nursing pods (4 total placards) within the microsystem. Each placard was constructed using 8.5" x 11" yellow paper and was laminated and contained the following information:

- A bold header informing nursing staff to proactively check their assigned patients medication administration record (MAR) for medications identified as missing.

- Highlighted medications identified as frequently missing and steps for contacting pharmacy.

- A bold footer reminding nursing staff to proactively check the Omnicell™ prior to administering any above listed medications in advance of their administration time.

Pertinent microsystem staff members who made this intervention successful were the Unit Nurse Manager and Associate Nurse Manager who circulated general information about the intervention with the staff, the Clinical Nurse leader who oversaw and monitored the intervention, and RNs and LPNs that participated in survey responses and consented to direct observation of medication administration.

This intervention was selected based on previous studies reviewed in the literature that reported meaningful outcomes using education to improve timeliness of medication administration. Visual reminders at nursing stations and in-session education had been used to improve timeliness of medication administration in acute care settings (Corrado et al., 2020) and PowerPoint™ presentations have been shown to produce statistically significant decreases in medication administration errors ($p < 0.001$), (Harkenen et al., 2016). Additionally, the use of electronic medical alerts in the hospital EMR had been shown to increase proactivity and

improve timeliness of medication delivery (Nance et al., 2020). While technological upgrades

such as electronic reminders in the EMR were not feasible in the quality improvement project,

their benefits were intended to be replicated using placards as visual reminders to reinforce

educational material and potentially improve workflow. Placards were placed at computer

workstations on each pod for nursing staff to observe when coming on for shift, which was

intended to improve proactivity and reduce the amount of time nurses spent looking for missing

medications.

The success of the intervention was dependent on stakeholder approval. Key stakeholders

in this project included the microsystem nursing education team, composed of a unit educator

and a Clinical Nurse Leader (CNL), the management team, consisting of a Unit Nurse Manager

and Associate Nurse Manager, and the unit nursing staff. Additional requirements for a

successful intervention included nursing staff participation in both pre-and-post observational

activities, questionnaire completion, and attendance at and integration of the educational

concepts presented at the June staff meeting.

Study of the Intervention

This intervention was chosen because no formal process existed for measuring nursing

workflow and medication administration time within the microsystem. The successful

implementation of the PowerPoint™ presentation and nursing placards was expected to increase

interdepartmental communication between the microsystem and pharmacy teams, and decrease

the amount of time nursing staff spent looking for and delivering medications by 5% from

previous state data. Medication administration times were recorded and compared both pre-and

post-intervention. Types of process measures used to determine the success of the intervention

included the use of an observational checklist to measure changes in workflow patterns, such as a

nurse contacting the pharmacy proactively prior to administering a medication to check availability. Types of outcome measures used to evaluate success of the intervention included an observed improvement in MRC time during scheduled observation days.

Measures

Data Collection

Quantitative procedures were used to determine the targeted educational material deployed for the intervention. To accomplish this, the following measures were applied. To determine challenges with specific missing medications, measures to collect data on 20 total medication retrieval challenges were performed through scheduled observation days on-site at the microsystem. The QI project leader was positioned at the ADC from 7am-7pm during scheduled observation times. A medication retrieval challenge (MRC) was described as the time it took for a nurse to locate a medication (once it was determined missing from the Omnicell™) to the time it was delivered to the unit. Time was recorded with a stopwatch and a checklist was used to record pertinent information. The checklist contained the date, type of medication, time determined missing, and the time delivered to the unit. To determine the outcome of the proposed intervention, observation days were conducted both pre-and-post intervention to measure effectiveness.

Survey Distribution

To collect information on medication administration, satisfaction and nursing workflow, nursing staff were provided with a survey containing questions from the Medication Administration System Nurses Assessment of Satisfaction Scale (MAS/NAS) which assessed nursing satisfaction with medication administration in three principal areas, efficacy, safety and access (Douglas et al., 2017). The MAS/NAS consists of 14-items and was designed to evaluate

nursing effectiveness in delivering medications. Responses were recorded using a 5-point Likert scale. The MAS/NAS is a validated tool with a reliability coefficient of 0.86-0.91 and was used in the following studies examining medication administration and nursing workflow (Douglas et al., 2017; Kuusisto et al., 2021). A previous researcher was contacted and permission was granted to use questions from the MAS/NAS in the current project. To determine the effectiveness of the intervention, the survey was distributed to the day-shift nursing staff both pre and post intervention (13 RNs and 2 LPNs) with a goal response rate of 30%.

Analysis

To effectively analyze the data collected from the measures both inferential and descriptive statistics were planned. Descriptive statistical analysis for both pre-and post-aggregate data was conducted while inferential statistical analysis was not.

Observational Data

Numerical data collected from scheduled observational days were analyzed using descriptive statistics both pre-and-post intervention. Time points for MRC's collected at the exact time when medications were retrieved and then delivered were calculated using Excel to determine the mean, standard deviations, and ranges. Data measured as time was summarized using measures of central tendency and distribution. Paired t-testing analysis was planned, comparing pre intervention time to post intervention time, but was not conducted. Specific medications identified during observational sessions as missing were treated as categorical data and analyzed separately. To be considered for analysis and ensure reliability, all observations of nurses retrieving, looking for and delivering medications were direct and did not involve QI project team participation in the delivery process. Additionally, all observed administration processes were written and recorded on the observation sheet. Finally, administration of nursing

staff delivering medications not directly observed by the QI project team were removed from the analysis.

Surveys

Results from the MAS/NAS questionnaires were collected and were planned to be analyzed using non-parametric inferential statistical analysis (Chi Square). Likert-scale responses for each of the 11 statements had planned to be grouped and presented as agree/disagree. All of the above methods suggested for analysis were not conducted in this project. Surveys collected were checked to ensure all questions had been answered appropriately. Each survey was completed fully, and submissions with questions containing unrecorded answers were removed from the analysis.

Ethical Considerations

There were no identified ethical issues with this quality improvement project. The measures and suggested intervention did not involve or require any identifying information or have any ill-effect on the health and well-being of the participants. Microsystem staff that took part in the project received thorough explanation of the survey and observation details, as well as provided verbal consent to participate. The QI project team that conducted the quality improvement project were not compensated or incentivized by the medical center or the microsystem, nor was this project subsidized or funded by any other organizations or groups. The QI project leader accepted a position on the unit as a nurse resident, which may have introduced response bias by the participants.

This project was submitted as a formal proposal to the University of New Hampshire Department of Nursing Quality Review Committee prior to being implemented and was deemed

to be a quality improvement project meeting the criteria as exempt from full Institutional Board review. A copy of the final proposal was sent to the microsystem management team for review and approval. No formal submission process for the medical center was required for this project.

<div align="center">Results</div>

Results

Initial Steps

The intervention was approved by the microsystem management team and was scheduled for implementation during the quarterly June staff meetings. An introductory email was generated and sent to the microsystem supervisory team giving an overview of the project and timeline for data collection prior to and after the intervention. To prepare for the intervention, on-site visits were scheduled to observe nursing staff interacting with the Omnicell™ automated dispensing cabinets, patient medication bins, and storage refrigerators to observe patterns in workflow. Project parameters, including methods of data collection, were introduced to the nursing staff during the morning huddle. To gain clearer understanding into challenges with the current medication system and interdepartmental communication with pharmacy, questionnaires were distributed in person for nursing staff to complete.

Changes to the Intervention

A significant development to the intervention was the acquisition of medication reports from the pharmacy team which was used to create the intervention. After an initial request for data from the pharmacy team, a Webex™ call with the QI project coordinator, the clinical nurse leader of the microsystem and the pharmacy team was scheduled. Project details were provided during the call and within 10 days the pharmacy provided a list of alert messages generated by

nurses requesting delivery of missing medications within the microsystem over a two-month period. An additional development during the interventional period was the inclusion of a presentation from the pharmacy team to readdress proper protocol for communicating missing medications. To facilitate interdepartmental communication, the pharmacy team collaborated with the QI project team and joined the presentation to address the staff and review the messaging protocol. This protocol was added to the interventional placard (See Appendix C) in an effort to improve interdepartmental communication between the microsystem and pharmacy staff. An educational PowerPoint™ which included the medication alert placard was introduced at the beginning of each scheduled meeting, with the review of the messaging protocol introduced by pharmacy staff. No further modifications were made to the data collection process or the distribution of content during the PowerPoint™ educational session.

Timeline of the Intervention

Pre-interventional data, which included observation days and survey collection was conducted for a two-week period beginning 5/30/23 and ending 6/13/23. This data was collected and analyzed for the June staff meetings which were scheduled from 8:30am-10:30am EST 6/19-6/21/23. All staff meetings were conducted virtually via Webex™ to improve staff attendance. Meeting attendance was recorded and calculated to coincide with forecasted goals created in the specific aim. The movement of the meeting to a virtual environment was seen as advantageous because it allowed for a greater percentage of nursing staff to attend the meeting, which was thought to increase the likelihood of improving the effectiveness of the intervention and achieving the specific aim. The schedule of the pre-intervention timeline and staff attendance is available below (Table 1).

Table 1

Timeline of Intervention Project

Pre-Intervention		Intervention		Post Intervention
Data Collection 5/30-6/13/23	6/19/23	6/20/23	6/21/23	Data Collection 6/19-7/3/23
Onsite Observation and MRC's (10)	Webex™	Webex™	Webex™	Onsite Observation and MRC's
Survey Collection (11)	Interventional PowerPoint and Placard	Interventional PowerPoint and Placard	Interventional PowerPoint and Placard	Survey Collection
Pharmacy Data	Pharmacy Messaging Protocol	Pharmacy Messaging Protocol	Pharmacy Messaging Protocol	Pharmacy Data
Staff Data N = 24				
Meeting Attendance Per Session N = 18	4	6	8	
Staff % education goal (50)	17%	25%	33%	
Total %			75%	

Note: Total % attended is calculated off the total (N = 18) participants across the 3-day interventional period.

Process Measures

To evaluate the efficiency and timeliness of medication administration, several methods were introduced to identify gaps and challenges with the current workflow and system. These methods include observation days, pharmacy data, and staff surveys.

Problematic Medications: Observation Days

Medication retrieval challenges were observed and recorded during scheduled medication pass times. Missing medications were recorded on a sheet which included the specific medication, medication pass time, time the medication was determined missing and the time pharmacy fulfilled the order. Calculations for mean, standard deviation and range were performed to determine the amount of time that was required to resolve each medication retrieval challenge. Mean values were then compared pre and post intervention, and percentage differences in resolution times between the two groups were calculated and have been displayed in Table 2.

Eighteen medication challenges were recorded over the eight observation days. Time to resolve medication messages ranged from 2 minutes in the pre-interventional period (5/30/23, Multivitamin) and 210 minutes in the post-interventional period (6/21/23, Phenol 1% oral spray). Both Multivitamins and Memantine were identified as missing medications in both the pre-interventional and post interventional periods, and longer resolution times were observed in both medications during the post-interventional period when compared with the pre-interventional period. Additionally, mean resolution times for medications increased during the post-interventional period (M=01:47:37) when compared with pre-intervention values (M =00:53:12).

Table 2

Observational Data – Medication Retrieval Challenges

Pre-Intervention:			Post-Intervention:		
Date:	Medication:	Resolution Time:	Date:	Medication:	Resolution Time:
5/30/23	Multivitamin (oral)	00:2:00	6/21/23	Phenol 1% spray	03:30:00
5/30/23	Aricept (oral)	01:03:00	6/27/23	Memantine	02:00:00
5/30/23	Zosin (oral)	01:15:00	6/29/23	Multivitamin (oral)	01:25:00
6/4/23	Sodium Chloride (nebulizer)	01:100	6/29/23	Multivitamin (oral)	01:25:00
6/6/23	Levodopa/Carbidopa	00:3:00	6/29/23	Timolol 0.5% ophthalmic drops	00:57:00
6/6/23	Memantine (oral)	01:01:00	7/3/23	Potassium (oral)	00:30:00
6/6/23	Amlodipine (oral)	00:30:00	7/3/23	Memantine (oral)	01:16:00
6/6/23	Eliquis (oral)	01:16:00	7/3/23	Multivitamin (oral)	02:30:00
6/8/23	Doxycycline (oral)	01:16:00			
6/8/23	Senna (oral)	01:16:00			
Mean:		00:53:12		01:41:37	
Standard Deviation:		00:30:06		00:57:01	
Range:		2-76		2-210	
Mean Change Resolution Time:				+ 00:48:26	
% Change Resolution Time:				+ 91.02%	

Note: Mean resolution times were compared both pre- and post-intervention. The % change in resolution time reflects an increase in time as a percentage, and the Mean Change in Resolution time reflects an increase in time in hours, minutes and seconds.

Problematic Medications – Pharmacy Data

Pharmacy data was collected and analyzed during two time periods (pre-intervention 3/1-4/30/23, post-intervention 6/19-7/3/23) to measure the timeliness of medication administration. This data consisted of 835 alert messages (689 pre-intervention, 146 post intervention), sent to pharmacy pertaining to medications that nurses were unable to retrieve from the Omnicell™ automated dispensing cabinets, patient medication bins, and cold storage refrigerators during scheduled medication pass times. Messages with the most frequent number of alert messages (n = 86) generated in the pre-interventional period were selected and grouped by medication type for analysis. Alert messages for the same medications were analyzed during the post-interventional period (n = 4) for accuracy. Mean, standard deviation and ranges were calculated for the message alerts with results placed in Table 3.

Calculation times have been displayed in hours, minutes, and seconds to accurately represent time duration between when missing medication messages were sent by the nurse (time missing) to when the pharmacy resolved the message and the medication was delivered to the unit (time resolved). All med pass times are displayed using a 24-hour clock.

Table 3

Messaging Alerts by Medication Type

Pre Intervention			Post Intervention	
Medication	N:		Medication	N:
Acetylcysteine (200 mg/dL) oral solution 1,200 mg	10		Acetylcysteine (200 mg/dL) oral solution 1,200 mg	0
Albumin 25% 50 ml IV	10		Albumin 25% 50 ml IV	0

Cholecalciferol (Vitamin D3) tablet 1,000 units oral	10		Cholecalciferol (Vitamin D3) tablet 2,000 units oral	1
Lactulose (0.67 gram/mL) oral	12		Lactulose (0.67 gram/mL) oral	0
Miconazole 2% powder	10		Miconazole 2% powder	3
Omeprazole (2 mg/mL) oral	15		Omeprazole (2 mg/mL) oral	0
Verapamil (tablet 40 mg)	18		Verapamil (tablet 40 mg)	0
N: Total	86		N: Total	4
Mean Resolution Time Pre-Intervention:	0:09:15		Mean Resolution Time Post-Intervention	0:12:49
Mean Resolution Time	+ 0:03:34			
Mean % Change Resolution Time	+ 38.62%			

Note: Mean, Standard Deviation and Range calculations are expressed in hours, minutes and seconds to coincide with the passage of time as a clock reads. Medications marked with a "0" in the post-interventional columns indicate no messages for that medication were sent during the period

Of the seven most frequently alerted medication types in the pre-interventional period, 71% were oral medications and 21% were topical (Miconazole) or intravenous (Albumin). The most frequently messaged medication types were Verapamil (18), and Omeprazole (15). Additionally, Omeprazole and Lactulose had the longest resolution periods (M = 0:13:20, 0:12:50), and Cholecalciferol (Vitamin D3) and Albumin had the shortest resolution periods (M =0:06:35, 0:06:58). During the post-interventional period, only Miconazole (3) and Cholecalciferol (1) had alerts generated indicating the medications were missing from unit stock. The mean resolution times for Miconazole powder in the pre-interventional (M = 0:09:07) and post-interventional (M = 0:09:19) periods were roughly equal. Mean resolution time increases (M =0:03:34) were observed between the pre intervention and post intervention periods, with a

Mean percentage increase (38.62) in medication resolution time post-intervention when compared with pre-intervention values.

Surveys

Surveys were distributed to nursing staff during the morning huddle. A total of 20 surveys were distributed and collected between May 30, 2023, and July 3, 2023. Surveys were entered in Qualtrics™ for analysis. Likert-scaled responses for each of the fourteen statements were grouped and calculated for Mean, Standard Deviation and Ranges and populated in Table 4.

A response rate of 45% (11 responses pre-intervention, 9 responses post-intervention) was achieved when computed against the current microsystem nursing staff roster (N = 24). Survey responses show nursing staff somewhat agree that the current medication administration system is effective at both preventing and reducing the risk for medication errors pre-intervention (M= 4.27) and post intervention (M= 4.2). Additionally, nurses somewhat agree the current medication system provides them with sufficient information to know that a pharmacist has verified the medication before they administer both pre-intervention (M= 4.64), and post-intervention (M=4.44). While nursing staff disagreed that medications were readily available when needed pre-intervention (M = 2.36), post intervention data reveals that nurses feel medications were more readily available (M=3.88). Similar findings were reported that the current system makes it easy to check active medication orders before the medication is administered pre-intervention (M = 2.73), and post-intervention (M= 4.3). Nursing staff somewhat agreed that the PowerPoint™ education (M= 4.11) and informational placards were valuable in improving their knowledge to deliver medications (M=4).

Table 4

Survey Responses

Question	Pre-Mean	Standard Deviation	Range	Post-Mean	Standard Deviation	Range
The current medication administration system helps me be efficient at medication administration	3.73	1.42	1-5	3.89	0.6	1-5
The current medication administration system is user-friendly for the nurses who administer medications	3.64	1.03	1-5	4.11	0.6	1-5
The current medication administration system is effective in reducing medication errors	4.27	0.65	1-5	4.22	0.44	1-5
The current medication administration system is effective in preventing medication errors	4.27	0.79	1-5	4.11	0.92	1-5
I have access to the systems that support medication administration (physician orders, pharmacy verification, drug information) when I need them	4.27	1.01	1-5	4	0.86	1-5
I know where all the medications are stored (either in the unit or if they need to be procured from pharmacy)	3.91	0.94	1-5	3.77	1.09	1-5
The equipment and/or supplies needed to administer medications are readily available to me	4	1.00	1-5	4	1.00	1-5
The turnaround time for receiving medications needed for "stat" or for patients newly admitted to the unit is adequate	3	1.18	1-5	3.44	1.3	1-5
The current medication administration session provides me with information to know that a medication order has been checked by a pharmacist before I administer the medication	4.64	0.67	1-5	4.44	0.52	1-5

I have to keep stashes of medications to be sure I have medications for when I need them	2.36	0.67	1-5	2.67	1.11	1-5
The medications I need are readily available to me when I need them	2.36	0.67	1-5	3.88	0.6	1-5
The current medication administration system makes it easy to check active medication orders before administering medications	2.73	1.27	1-5	4.3	0.7	1-5
The PowerPoint™ Education provided during the staff meeting helped improve my knowledge to deliver medications in a more efficient manner				4.1	0.92	1-5
The Medication Alert Placards placed at nursing stations helped improve my knowledge to deliver the medications in a more efficient manner.				4	1	1-5

Note: Likert-Scaled responses range from 1, = "Somewhat Disagree" to 5, = "Strongly Agree". A response of 3 "Neither Agree nor Disagree" is considered neutral.

Contextual Elements

Contextual elements supporting the intervention include nursing leadership, staff communication, and interdepartmental teamwork. Nursing leadership was instrumental in providing necessary resources for the implementation of the project, and providing access to key stakeholders within the pharmacy team. Additionally, the nursing staff helped integrate the medication alert placards into the workflow process, which helped improve interdepartmental communication with the pharmacy team.

Nursing Leadership

The involvement of key stakeholders within the microsystem helped shape and support the process and the implementation of the intervention. The clinical nurse leader was an

important stakeholder in providing much of the background for the initial 5 P's assessment, as well as facilitating communication with key leadership positions in the pharmacy department for the acquisition of data used to create the intervention. Additionally, support from the Unit Nurse Manager and the Associate Nurse Manager were instrumental in securing availability for the presentation of the intervention during the June staff meeting.

Staff Communication

To help build awareness of the intervention with the nursing staff, microsystem supervisors were contacted via an introductory email, highlighting the key elements of the project. Nursing staff were introduced to the purpose of the project and the data collection methods during morning huddles. Medication alert placards were placed at each pod with the intent of improving communication between nursing staff and the pharmacy team, and changing behavior that would ultimately affect workflow patterns. Microsystem nursing staff were largely in support of an intervention to reduce the frequency of missing medications from the Omnicell™ automated dispensing cabinets.

Interdepartmental Communication

The intervention was an important first step to improve interdepartmental communication between the microsystem nursing staff and the pharmacy department. Initial contact with the pharmacy department began with a request for data pertaining to alert messages generated by nursing staff regarding missing medications. A Webex™ call was facilitated by the Clinical Nurse Leader, and included representatives from the safety, quality and leadership groups of the medical center pharmacy team. At the conclusion of the Webex™, the pharmacy team had agreed to collaborate with the intervention and review proper messaging protocols that would

improve the response time for missing medication messages. In addition, data was provided to assist with the intervention. The inclusion of the pharmacy department in the intervention was an important element which may improve interdepartmental communication and improve timeliness of medication administration.

Associations

The microsystem is a busy unit with a regularly full census. Due to maximized patient acuity and full schedules, nursing staff often struggle with new systems and implementation. The implementation of a medication alert placard was intended to modify nursing workload and increase proactivity, and improve interdepartmental communication with pharmacy. Medication deliveries happen once daily between 0:500-0:700 am for day shift and shortages can occur if frequently used medications (verapamil, omeprazole) are not stocked in accordance with the microsystem census. Identifying alert medications could improve communication and potentially alter pharmacy protocol for stocking frequently used medications as noted on the interventional placard.

Staffing

The microsystem experienced a decline in its nursing staff (25%) due to the opening of a new intermediate care unit. The transfer of more experienced nursing personnel to the new unit resulted in decreased staffing levels, and a greater reliance on new grad nurses (nurse residents) to fill the spaces. When asked about the interventional placards, many of the RN's admitted to not using them, purely because of being overwhelmed and competing work priorities.

Placement of Placards

The intended placement of the interventional placards was in a location where nurses would be able to view them. Current regulations prohibited placing external display items on the computers, and each pod had a bulletin board cluttered with other protocols, which limited the placement of the placard in that location. Additionally, current regulations prohibited items from being taped to walls, requiring the procurement of non-adhesive substances to place the placards in an ideal location. This was an unforeseen event which was addressed.

Intervention Cost

The costs to implement the intervention were as follows and deviated slightly from the projected proposal:

- 1 Ream of Printer Paper (printing surveys, data collection sheet) $6.99
- 1 Ream of Yellow Paper (educational placards) $11.99
- Lamination Cost – Fed Ex (educational placards) $4.40 x 4 pods ($17.65)
- Scotch non-stick adhesive puddy – 1 pack ($3.29)
- **Projected Costs: $30.00**
- **Total Actual Costs: $39.92**

Missing Data

All data for the intervention was collected and no outstanding items remained.

Discussion

Summary

The intended outcome of this project was to improve the timeliness of medication administration. The global aim of the project was to reduce the amount of time nurses spent looking for missing medications, and to improve interdepartmental collaboration and communication between microsystem nursing staff and the pharmacy team. The specific aim of the intended improvement project was to decrease the amount of time nurses spent looking for medications by 5% after implementing a virtual PowerPoint™ presentation and informational placards for 50% of the unit-based day-shift staff. Mean and percentage differences in alert message resolution times were found in both observational data collection activities and reports generated by the pharmacy team, and in the survey results evaluating staff attitudes toward the medication administration system. Key findings included changes in mean resolution times, additional categories of delayed medications, and staff perceptions of workflow and timeliness.

Key Findings – Resolution Times

Mean resolution times for alert messaged medications increased when compared with pre-intervention values. Nursing staff accessing the Omnicell™ ADCs and patient medication bins were observed returning to the computer to generate an alert message following the pharmacy protocol listed on the medication alert placard. Nurses were directly observed following the pharmacy messaging protocol on five different occasions, and reported that the new protocol was helpful and gave them clearer direction when medications were discovered missing. However, nurses often reported feeling rushed and did not check the patient MAR for

the listed alert medications on the interventional placard due to competing priorities. Upon delivery of a missing medication to the unit, the nurses were observed contacting the pharmacy a second time to confirm if the medication had been delivered, subsequently altering workflow patterns. Similar medications including memantine and multivitamins were missing in both the pre-interventional and post-interventional periods, and longer delivery times were observed in both medications in the post-interventional period.

Problematic Medications – Observation and Pharmacy

Mean resolution time differences were observed in three of the seven medications in the pre-interventional period. Five of the pharmacy's medications with the highest message alerts during the pre-interventional period received no messages during the post interventional period. Mean resolution time increases were observed from the pharmacy data calculations, and post intervention results indicated the increase in message resolution time did not fulfill the objective of the specific aim.

Staff Perceptions - Surveys

The survey examined staff attitudes and workflow patterns regarding the medication administration system, which included the Omnicell™ ADCs, patient medication bins, and cold storage refrigerators. A key finding showed that staff surveyed somewhat agreed the medication system helped them be efficient at medication administration, and that the system was somewhat effective for reducing and preventing administration errors. This self-reported data was also observed of nurses when performing medication passes. The Omnicell™ system would not allow a nurse to access the medication if it was not on the patient's MAR, or if the dose or inventory count was entered incorrectly. While reducing medication errors was not a focus of this project,

it was a finding that is important for efficient nursing workflow, potentially reducing the time that nurses spend on medication passes.

Additional key findings include nurses reporting that medications were more readily available in the post-interventional period when compared with the pre-interventional period, and that the medication administration system was more efficient during the post interventional period when checking active medication orders prior to administering medications. Nurses also agreed that the PowerPoint™ educational lecture and the interventional placards were beneficial in improving their knowledge to deliver medications in a more efficient manner. The lecture and medication alert placards included pharmacy messaging protocols intended to alter workflow patterns and reduce the time nurses spend looking for medications and improve interdepartmental communication between the microsystem and the pharmacy team, which was a clear focus of the global aim.

Nursing Workflow

The pharmacy messaging protocol added to the medication alert placards was intended to streamline workflow and ultimately reduce the time nurses spend looking for medications. The intention was to increase nursing proactivity by adding the most frequently messaged medications to the interventional placard, signaling the nurse to contact pharmacy to verify if the medication was stocked.

Relevance to the Specific Aim

The PowerPoint™ virtual education and medication alert placards were not effective in reducing mean alert message resolution times for medications missing from the Omnicell™ ADCs, patient medication bins or cold storage refrigerators. The increase in message resolution

time recorded during the post-interventional period failed to meet the specific aim of reducing the amount of time nurses spent looking for medications by 5%.

Strengths of the Project

A key strength of this quality improvement project was the collaboration between the microsystem nursing staff and the pharmacy team, which helped drive the focus of the intervention and the PowerPoint™ educational session. The interdepartmental collaboration allowed for the joint presentation of alert messaging protocol and alert medications to the nursing staff during the June staff meetings. An intended improvement measure of the global aim was to increase interdepartmental collaboration with the pharmacy team, which was an important step in helping to reduce the amount of time nurses spend looking for medications. While 5% reduction times were not achieved with this intervention, it was an important first step in building awareness that future Plan Do Study Act (PDSA) cycles can be developed from.

Interpretation

This quality improvement project examined the timeliness of medication administration by nurses who deliver medications within the microsystem. While the implementation of the PowerPoint™ virtual education and medication alert placards were helpful in improving nursing staff knowledge of medication delivery and interdepartmental collaboration with pharmacy, it did not reduce the time nurses spend looking for medications. Inventory control challenges, issues with departmental communication, competing staff priorities and nursing staff shortages are potential causes surrounding the key findings observed during and after the intervention within the microsystem.

Inventory Challenges

The availability of medications in the Omnicell™ automated dispensing cabinets, patient medication bins and storage refrigerators were inconsistent throughout the project period, with no consistent pattern emerging for identifying medications that were the most frequently unavailable. Medications nurses reported missing most frequently in the pre-interventional period such as Verapamil and Lactulose generated no missing messages during or after the intervention. Instead, nurses reported other medications, such as Memantine and Multivitamins were less readily available during the post-interventional period, which was confirmed with observational data of nursing staff attempting to retrieve those medications. Verapamil and Memantine were widely used medications in both the microsystem and the macrosystem, which caused reductions in inventory supply due to high demand areas or problems with the manufacturer. These observations were a likely variable responsible for the increased mean message resolution times observed throughout the project period.

Observations of fluctuating medication inventory in this project were consistent with other studies reviewed on medication administration and nursing workflow. Available literature suggested that inventory control challenges with medications were the most impactful contributors to inefficient nursing workflow and subsequent delays of medication administration. A systematic review of fifty-five studies by Keers et al. (2013), concluded that medication supply problems were the primary causes of inefficient nursing workflow and medication administration delays. Similarly, Nance et al. (2020), found that when inventory control problems were addressed, which involved identifying and pre-stocking highly used medications, significant improvements were observed in nursing workflow and medication delivery.

Staffing Challenges and Competing Priorities

In addition to fluctuating inventory levels, challenges in the working environment created issues for nursing staff implementing the directions on the medication alert placards. A key component of the intervention was to alter nursing workflow by proactively checking availability of medications with the highest alert messages prior to the medication passes, and subsequently notifying pharmacy of any shortages. Staffing changes and movement of more experienced nursing staff to a new intermediate care unit resulted in a smaller percentage of staff available to manage the patient acuity levels on the floor. Relatedly, competing priorities such as new graduate nurse orientation resulted in more senior nursing staff assuming preceptor responsibilities, which limited the ability to take on new tasks.

The use of medication alert placards have proven successful in improving medication delivery times in large teaching hospitals, as the intention is to alter nursing workflow by creating new patterns of behavior (Corrado et al., 2020). With continued reinforcement, the alert placards were shown to improve workflow and significantly improve timeliness of medication administration, but over longer periods of time. Similarly, interventional aids such as wall placards and PowerPoint™ education have been shown to improve timeliness of medication administration, with placards being more effective because of habitual reinforcement (Harkanen et al., 2016).

The increase in mean resolution message time in the current project suggested that the medication alert placards were largely ineffective because they complicated nursing workflow by adding steps to the medication retrieval process. Increased workload was an unintended consequence of this intervention, but was a finding consistent with other literature studies employing similar interventions. Alomar et al. (2020) noted improved medication delivery times

by nursing staff but also increased time spent on nursing documentation. Relatedly, implementation of electronic medical prescribing (ePMA) in a study on nursing workflow improved medication delivery times when compared with pre-ePMA, but also added to nursing workflow by increasing time needed for documentation (Van Wilder et al., 2016).

Departmental Communication

While improved interdepartmental communication between the microsystem and the pharmacy was a strength of this study, communication challenges existed between the hand-off of when a missing medication was delivered to the unit and when it got to the nurse. Missing medications nursing staff generated alerts for were delivered by pharmacy to the unit using one of two methods, the Pevco-Link™ pneumatic tube delivery system, or hand delivered to the unit by pharmacy staff. Unit support assistants (USA's) would take the medication to the pod where the nurse was working and leave it for them to receive and administer to the patient. On several occasions, nursing staff were not readily available to receive the medication because of active engagement in patient care, or due to extremely busy periods USA's would not be able to immediately deliver the medication to the appropriate nursing pod due to competing work priorities.

Findings in the literature report that inefficient communication between the pharmacy department and nursing staff were responsible for delayed administration times due to delivery issues and medications being misplaced. Keers et al. (2013) found that medications were often administered late due to medications being misplaced after delivery to the unit. Relatedly, interdepartmental communication challenges between nursing staff and pharmacy resulted in medication delivery delays which ultimately improved after intervention (Alomar et al., 2020).

While parameters for measuring medication alert message resolution times in the current project ended when the medication was delivered by pharmacy, communication problems within the unit may prolong medication delivery further, and should be a focus for future quality improvement efforts.

Improving Staff Knowledge

The implementation of the PowerPoint™ virtual education and medication alert placards were viewed as beneficial among the nursing staff surveyed. The placement of the medication alert placards on the nursing pods served as a means of reinforcing the proper messaging protocol, and the list of the most frequently alerted medications served as a reminder to check the patient MAR prior to administration. Staff surveyed somewhat agreed that the medication placards were beneficial, although they did not help improve timeliness of medication administration and achievement of the specific aim. Explanations for this finding included competing work priorities, work stress, inconsistent checking of the MAR for alert medication availability, and less available staff to focus on new interventional implementation. Other explanations included a short interventional period, which reduced the time required for positive changes to take place.

Utilizing education to improve staff knowledge was an effective tool to improve interdepartmental communication and ultimately reduce the time nurses spent looking for and retrieving medications. The employment of learning methods such as educational meetings, medication alert placards and electronic medication alerts had been shown to produce significant improvements in nursing workflow, interdepartmental communication and timeliness of medication administration (Corrado et al., 2020; Harkanen et al., 2016; Van Wilder et al., 2016). However, results from these studies differed from the results of the current project. Many of the

studies reviewed in the literature employed multiple interventions over longer time periods, which was key for helping to alter workflow because new protocols needed to be integrated over time to be effective. Additionally, knowledge needs to be continually reassessed through examination and testing for effective evaluation, which was not a focus in the current project.

Impact of the Project

The use of PowerPoint™ education and medication alert placards may be attributed to observed changes in certain aspects of daily operation such as nursing workflow, increased awareness and improved communication.

Nursing Workflow. The pharmacy messaging protocol added to the medication alert placards was intended to streamline workflow and ultimately reduce the time nurses spent looking for medications. The intention was to increase nursing proactivity by adding the most frequently messaged medications to the interventional placard, signaling the nurse to contact pharmacy to verify if the medication was stocked. Nurses reported that while helpful, the addition of extra steps in workflow was challenging to implement during busy periods. The addition of these manual tasks created additional workload for a nursing team already preoccupied with competing priorities.

Increasing Awareness. The current quality improvement project was an important first step for addressing issues with nursing workflow and resolution times for missing medications. The interventional placards and PowerPoint™ presentation were intended to improve the nursing staff's knowledge to administer medications in a more efficient manner. Nurses reported that the pharmacy presentation was helpful, as it clarified more specific details on the pharmacy's operational process, such as scheduled medication delivery times and locations for stocked items.

Improved Communication. The collaboration between the pharmacy team and the nursing staff within the microsystem helped improve interdepartmental communication. The addition of the pharmacy team to the interventional presentation allowed for the disbursement of key information related to messaging protocols, inventory stock and delivery times, and pharmacy department goal turnaround times for medications reported missing. Nurses reported that relearning the proper protocol for messaging pharmacy was helpful as this had been a source of confusion.

Project Costs

The implementation of the PowerPoint™ presentation and medication alert placards required minimal financial resources which was seen as a potential benefit for the microsystem. Total interventional direct costs were $40, and while the specific aim was not achieved through its implementation, the potential benefits observed as a result of the PDSA cycle created numerous opportunities for continued growth, future quality improvement efforts, and improved key performance indicators (KPI's) such as patient length of stay.

Future Quality Improvement. Improving timeliness of medication administration was an important long-term goal and is a recommended focus for future improvement efforts. Improving nursing workflow through continued examination of the current medication administration system, patterns of nursing movement during medication passes, and continued evaluation of the medication hand-off process between departments may be helpful in reducing costs, including nursing salaries. Simple, cost-effective interventions such as education and medication alert placards were inexpensive to implement, but require time to evaluate effectiveness. The intervention helped create a starting point for interdepartmental collaboration

between the microsystem and the pharmacy which can be leveraged for continued growth and success.

Key Performance Indicators. An important area of focus for the microsystem and a key performance indicator was improving patient discharge times. Challenges with medication administration may cause deteriorating patient outcomes, specifically if medications such as antibiotics are not given in a timely manner, which may ultimately lengthen a patient's stay in the hospital, increasing costs and reducing available bed space. Average daily costs for a hospital bed in New Hampshire can be expensive (see 5P's contextual elements) and simple, cost-effective interventions such as education may be used as a focus for continued improvement in this area.

Limitations

The current quality improvement project had several limitations which minimized the ability to generalize the findings to a similar or larger microsystem. Key limitations in this project include the chosen methods of data collection and the period of collection, means of measurement, the short project timeline, rapid interventional period and perceptual bias.

Data Collection

An important limitation to consider in the analysis of this project was the data collection periods used to analyze the problematic medications generated by the pharmacy. A larger timeline was provided to analyze problematic medications during the pre-interventional period when compared with the post-interventional period. Mean resolution result times in the post-interventional period may have been directly impacted by simply having fewer medications to analyze, as a longer post-interventional analysis period may have produced different outcomes.

Additionally, several of the studies reviewed introducing similar data collection methods on improving timeliness of medication administration did so over longer periods of time, which allowed for similar data collection periods over the course of the study timeline. The relatively short period used to collect data in the post-interventional phase of the current project questions the validity of the findings and limits the ability to generalize them to a similar microsystem.

Data Analysis

A second limitation to consider in the current quality improvement project were the methods used to analyze the data. Inferential data analysis, which was originally selected in the proposal phase of the study, was not conducted due to the short study period and the nature of the data collected. Mean, standard deviation and ranges were calculated for all problematic medications generated by the pharmacy, observational days, and survey responses. The decision to abandon inferential statistical analysis was largely due to the small data set generated in the problematic medication data and the unequal participant responses on collected surveys, which would have likely produced statistically insignificant findings not generalizable to a similar microsystem or environment. The decision to employ descriptive statistical analysis provided a simple method to calculate mean responses and observe differences in the pre-and-post data. However, this method of analysis did not allow for interpretation into the relationships between any of the variables, or the causes and effects of the data. Inferential statistical analysis would have been helpful in evaluating relationships between nurse perceptions and missing medications, in addition to other findings that could be used as possible solutions for future quality improvement efforts.

Interventional Period

A third limitation was the short nature of the interventional period and a very limited post interventional period for responding to contextual changes reflective of the outcomes in the work environment in the microsystem. Literature on similar studies on timeliness of medication administration deployed interventions over longer time periods, which allowed for more effective evaluation of the interventional effectiveness in the context of the working environment. The limited interventional period in the current improvement project offered little ability to pivot and respond to changes, which are an important component of evaluating interventional effectiveness. While it is important for PDSA cycles to be efficient and discontinued if progress is not being made, the current project may have produced different outcomes if additional time for knowledge assessment and conceptual reinforcement of the material had been made available to the nursing staff in the microsystem.

Efforts to Address Limitations

The decision to employ both observational and survey data collection methods in the current quality improvement project was reflective of methods used in literature reviewed on timeliness of medication administration and nursing workflow (Craswell et al., 2020; Douglas et al., 2017). This was also done to minimize bias when interpreting the results. The use of non-participant observation may be considered a limitation due to its potential to change the behavior of the staff being observed, and while the additional use of self-reported surveys carries its own potential for biased interpretation, the use of both methods in combination allowed for data comparison, which potentially increased the reliability of the findings (Craswell et al., 2020).

Conclusion

Usefulness of the Work

The current quality improvement project was effective for raising awareness and uncovering contextual variables responsible for increased mean resolution times of missing medications in the microsystem. Nursing staff challenges, such as competing work priorities and fluctuating medication supplies from the pharmacy were important contributors that influenced workflow patterns which affected the efficiency and timeliness of medication administration on the unit. While improvements in nursing workflow weren't observed in this project, the PowerPoint™ virtual education and medication alert placards were beneficial for facilitating communication between the microsystem and the pharmacy team, and improving nursing staff knowledge of the pharmacy's delivery process, which were important outcomes that may be leveraged for the development of future quality improvement efforts, and improving timeliness of medication administration.

Sustainability

Important factors to consider when implementing an interventional protocol include the cost and ease of implementation. The PowerPoint™ virtual education and medication alert placards deployed during the improvement project were cost-effective and required no financial investment from the macro or microsystem, and provided a means to evaluate current workflow patterns on the unit with minimal disruption to current operations or the need for additional nursing staff.

A particular challenge concerning the sustainability of the intervention was the investment in time required to analyze necessary data to develop the intervention to address key

findings in the work environment. Problems with medication inventory required lengthy analysis periods to uncover patterns in missing stock, and the fluctuating nature of medication inventory make targeting and identifying problematic medications a constant area of focus. The fluctuating nature of problematic medications observed in the current project suggested that the alert placards would need to be constantly updated with new alert medications, potentially requiring significant investment in human capital to update and maintain them. Future improvement efforts focused on problematic medications, fluctuating inventory and manufacturing supply problems may require an increased investment in resources from both the microsystem and the pharmacy team, leading to alternative interventional strategies.

Potential for Spread to Other Contexts

While the PowerPoint™ virtual education and medication alert placards were useful for increasing knowledge and improving interdepartmental communication between the microsystem and the pharmacy team, the intervention was not effective in improving efficiency of nursing workflow, or timeliness of medication administration, which limits the potential for spread to other contexts reporting similar challenges. Increasing knowledge through education was a widely used interventional strategy supported in the literature for improving nursing workflow and timeliness of medication administration, and while the intervention was simple to implement and was reported helpful, it did not address challenges with medication inventory and staffing challenges, which were key finding in this project.

Implications for Practice

The implementation of PowerPoint™ virtual education and medication alert placards increased the amount of time nurses spent looking for medications between 30-90%, suggesting

that other factors were potentially responsible for the inability to achieve the outcomes mentioned in the specific aim. Unexpected findings, such as inventory supply problems, intradepartmental challenges with staffing and communication and competing work priorities were important findings that necessitate the need for future projects and quality improvement efforts in these areas.

Implications for Further Study

Future quality improvement efforts and PDSA cycles may focus on improving intradepartmental communication and addressing the hand-off point between when a medication is delivered to the unit and when it gets to the nurse. Recommendations for next steps include creating an interdisciplinary team to address the issue, and implementing possible solutions such as a computerized notification or a phone call to the pod where the nurse works to inform them the medication has been dropped off, ultimately improving medication delivery time.

Suggested Next Steps

Findings from the completed quality improvement project suggest further efforts are required to address nursing workflow and the timeliness of medication administration in the microsystem. Areas of recommended focus include continued collaboration with the pharmacy team to educate and reinforce knowledge of proper messaging protocols for missing medications, and dissemination of key operational protocols relating to medication delivery schedules with aims to improve medication supply and inventory management.

Timeliness of medication administration is influenced by several factors, including nursing workflow, technology and interdepartmental communication. Findings from the current project suggest that challenges such as staffing shortages, competing work priorities, and issues

with medication inventories were likely related to the increases seen in mean resolution times of

medications delivered. While the medication alert placards and PowerPoint™ education were

interpreted as being helpful and beneficial for increasing knowledge of medication delivery and

improving interdepartmental communication, it complicated nursing workflow and added steps

to the medication retrieval process. Future improvement efforts may be directed toward

streamlining interventional strategies to maximize efficiency and improve nursing workflow,

which will help improve timeliness of medication administration.

References

Abdelaziz, H., Richardson, S., Walsh, K., Nodzon, J., & Schwartz, B. (2016). Evaluation of STAT medication ordering process in a community hospital. *Pharmacy Practice*, *14*(2), 647–647. https://doi.org/10.18549/PharmPract.2016.02.647

Ahtiainen, H. K., Kallio, M. M., Airaksinen, M., & Holmström, A.-R. (2020). Safety, time and cost evaluation of automated and semi-automated drug distribution systems in hospitals: A systematic review. *European Journal of Hospital Pharmacy*, *27*(5), 253–262. https://doi.org/10.1136/ejhpharm-2018-001791

Alomar, M., Ahmad, S., Moustafa, Y., & Alharbi, L. (2020). Reducing missed medication doses in intensive care units: A pharmacist-led intervention. *Journal of Research in Pharmacy Practice*, *9*(1), 36. https://doi.org/10.4103/jrpp.JRPP_19_95

American Hospital Association (2012). Fast Facts on U.S. Hospitals, 2022. Retrieved 5/18/2023, https://www.aha.org/statistics/fast-facts-us-hospitals

Burnham, Douglas : Staffordshire University (2006). "Gottfried Wilhelm Leibniz (1646-1716). Metaphysics – 7. Space, time, and indiscernible". *The Internet Encyclopedia of Philosophy. Archived from the original on14 May 2011. Retrieved 9 April 2011.*

Corrado, J., Jackson, O., Baxandall, D., Robson, J., Duggan-Carter, P., Throssell, J., Westgarth, T., Chhokar, G., Alty, J., & Cracknell, A. (2020). Get Parkinson's medications on time: The Leeds QI project. *Age and Ageing*, *49*(5), 865–872. https://doi.org/10.1093/ageing/afaa142.

Craswell, A., Bennett, K., Dalgliesh, B., Morris-Smith, B., Hanson, J., Flynn, T., & Wallis, M. (2020). The impact of automated medicine dispensing units on nursing workflow: A cross-sectional study. *International Journal of Nursing Studies*, *111*, 103773. https://doi.org/10.1016/j.ijnurstu.2020.103773

Debono, D., Taylor, N., Lipworth, W., Greenfield, D., Travaglia, J., Black, D., & Braithwaite, J. (2017). Applying the theoretical domains framework to identify barriers and targeted interventions to enhance nurses' use of electronic medication management systems in two Australian hospitals. *Implementation Science*, *12*(1), 42. https://doi.org/10.1186/s13012-017-0572-1

Härkänen, M., Voutilainen, A., Turunen, E., & Vehviläinen-Julkunen, K. (2016). Systematic review and meta-analysis of educational interventions designed to improve medication administration skills and safety of registered nurses. *Nurse Education Today*, *41*, 36–43. https://doi.org/10.1016/j.nedt.2016.03.017

Hurley, A. C., Lancaster, D., Hayes, J., Wilson-Chase, C., Bane, A., Griffin, M., Warden, V., Duffy, M. E., Poon, E. G., & Gandhi, T. K. (2006). The medication administration system—nurses assessment of satisfaction (MAS-NAS) scale. *Journal of Nursing Scholarship*, *38*(3), 298–300. https://doi.org/10.1111/j.1547-5069.2006.00117.x
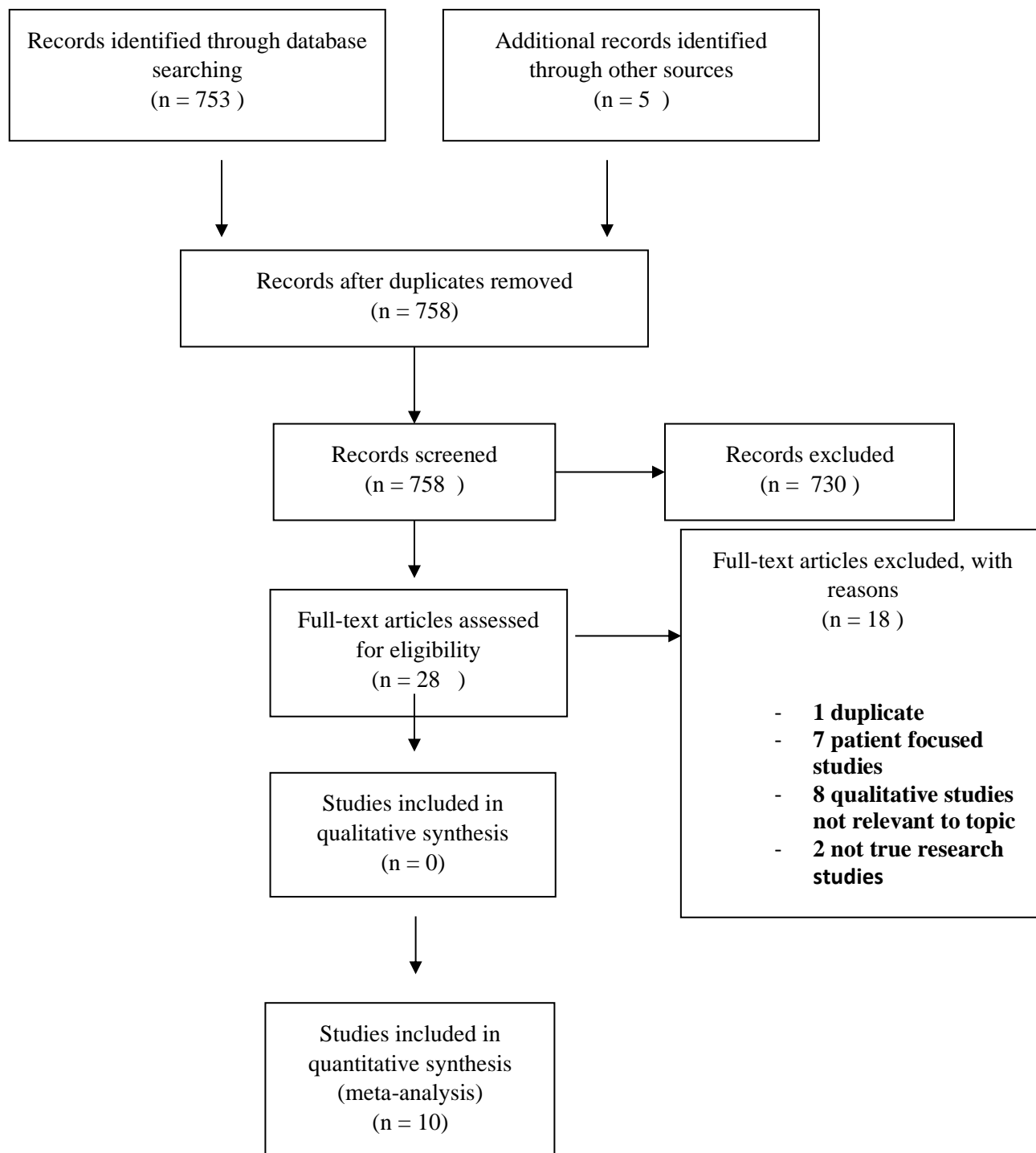
Kaiser Family Foundation (2022). Hospital adjusted expenses per inpatient day. Retrieved 4/16/2023, https://www.kff.org/health-costs/state-indicator/expenses-per-inpatient-day/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D

Keers, R. N., Williams, S. D., Cooke, J., & Ashcroft, D. M. (2013). Causes of Medication Administration Errors in Hospitals: A Systematic Review of Quantitative and Qualitative Evidence. *Drug Safety*, *36*(11), 1045–1067. https://doi.org/10.1007/s40264-013-0090-2

Kuusisto, A., Santavirta, J., Saranto, K., Suominen, T., & Asikainen, P. (2022). Nursing staff's assessments of medication management process in the psychiatric and operative domains: A cross-sectional study after introduction of an electronic medication chart. *Scandinavian Journal of Caring Sciences*, *36*(4), 935–946. https://doi.org/10.1111/scs.12989

Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Nance, M. A., Boettcher, L., Edinger, G., Gardner, J., Kitzmann, R., Erickson, L. O., Wichmann, R., & Wielinski, C. L. (2020). Quality Improvement in Parkinson's Disease: a successful program to enhance timely administration of levodopa in the hospital. *Journal of Parkinson's Disease*, *10*(4), 1551–1559. https://doi.org/10.3233/JPD-202024

Reed, J. E., & Card, A. J. (2016). The problem with Plan-Do-Study-Act cycles. *BMJ Quality & Safety*, *25*(3), 147–152. https://doi.org/10.1136/bmjqs-2015-005076

United States Bureau of Labor Statistics (2022). Occupational wage statistics: registered nursing Retrieved 4/16/2023 https://www.bls.gov/ooh/healthcare/registered-nurses.htm

University of Science and Technology of China (2019). Bridge between quantum mechanics and general relativity still possible. Retrieved 5/18/2023, https://phys.org/news/2019-09-bridge-quantum-mechanics-relativity.html

Van Wilder, A., Bell, H., & Franklin, B. D. (2016). The effect of electronic prescribing and

    medication administration on nurses' workflow and activities: An uncontrolled before

    and after study. *Safety in Health*, *2*(1), 13. https://doi.org/10.1186/s40886-016-0023-8

Appendix A – Prisma Flow Diagram

```
┌─────────────────────────────────┐     ┌─────────────────────────────────┐
│ Records identified through       │     │ Additional records identified    │
│ database searching               │     │ through other sources            │
│ (n = 753 )                       │     │ (n = 5  )                        │
└─────────────────────────────────┘     └─────────────────────────────────┘
```

Records after duplicates removed
(n = 758)

Records screened
(n = 758)

Records excluded
(n = 730)

Full-text articles assessed
for eligibility
(n = 28   )

Full-text articles excluded, with
reasons
(n = 18)

- **1 duplicate**
- **7 patient focused studies**
- **8 qualitative studies not relevant to topic**
- **2 not true research studies**

Studies included in
qualitative synthesis
(n = 0)

Studies included in
quantitative synthesis
(meta-analysis)
(n = 10)

Appendix B - Survey

Dear nursing staff,

My name is Kevin Lane and I am a nursing student at the University of New Hampshire, and I am working on a quality improvement (QI) project to learn about nursing workflow and timeliness of medication administration. By participating in this survey, you are participating in this QI project. This information sheet describes the project and helps you to decide if you want to participate. It provides important information about what you will be asked to do in the project, about the risks and benefits of participating in the project, and about your options as a participant. You should:

• Read the information in this document carefully, and ask me or my faculty advisor any questions, particularly if you do not understand something.
•Not agree to participate until all your questions have been answered, or until you are sure that you want to.
•Understand that your participation in this project involves your completing a survey that will take about 3 minutes.
•Understand that the potential risks of participating in this project are minimal.

You must be at least 18 years old to participate in this project, and you must be a Registered Nurse or Licensed Practical Nurse at Dartmouth Hitchcock Medical Center on Level 1 Wing C (formerly One East) .

If you agree to participate in this project after reading this document, you will be asked to participate in a survey that will take approximately 3 minutes. You will not be paid to participate in this project.

You should complete this survey only once. I may exclude your data if I determine that you did not meet the eligibility criteria for the project. For questions about eligibility, please contact me (information provided at the end of the form).

As a participant in this project, you may benefit from any changes made in the program or process being reviewed. Further, the information may help guide nursing staff to potentially improve nursing workflow and improve timeliness of medication administration.

Taking part in this project is completely voluntary. You may choose not to take part at all. If you agree to participate, you may refuse to answer any question. If you change your mind, you may stop participating at any time. Any data collected as part of your participation will remain part of the project records. If you decide not to participate or if you stop participating at any time, you will not be penalized.

I plan to maintain the confidentiality of all data and records associated with your participation in this project. Due to the low number of respondents, I do not ask for individually identifiable information in this survey in order to protect your identity. Responses are anonymous. As a reminder, any communication via the internet poses minimal risk of a breach of confidentiality.

To help protect the confidentiality of your information, I will store data on the USNH IT secure cloud storage. Only I and my faculty advisor, Dr. Pamela Kallmerten, will have access to the data. Data, even de-identified, will not be used for future projects. I will report the de-identified data in an educational paper that will be available via the UNH Scholar's Repository. I may share the aggregate results with the organization. The results may be used in reports, presentations, and publications for educational purposes only.

If you have any questions about this project or would like more information before, during, or after the project, you may contact me at kl1275@unh.edu If you have questions about your role as a participant, you may contact Dr. Pamela Kallmerten at UNH to discuss them (pamela.kallmerten@unh.edu).

Thank you for your consideration.

Sincerely,

Kevin Lane

UNH Nursing Student

Kl1275@unh.edu
Email contact

Question 1: The current medication administration system helps me to be efficient at medication administration.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 2: The current medication administration system is user-friendly for the nurses who administers medications.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 3: The current medication administration system is effective in reducing medication errors.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 4: The current medication administration system is effective in preventing medication errors.

   ○ Somewhat Disagree (1)

   ○ Strongly Disagree (2)

   ○ Neither Agree nor Disagree (3)

   ○ Somewhat Agree (4)

   ○ Strongly Agree (5)

Question 5: I have access to the systems that support medication administration (physician orders, pharmacy verification, drug information) when I need them.

   ○ Somewhat Disagree (1)

   ○ Strongly Disagree (2)

   ○ Neither Agree nor Disagree (3)

   ○ Somewhat Agree (4)

   ○ Strongly Agree (5)

Question 6: I know where all the medications I need are stored (either on the unit or if they need to be procured from the pharmacy).

- ○ Somewhat Disagree (1)

- ○ Strongly Disagree (2)

- ○ Neither Agree nor Disagree (3)

- ○ Somewhat Agree (4)

- ○ Strongly Agree (5)

Question 7: The equipment and/or supplies needed to administer medications are readily available to me.

- ○ Somewhat Disagree (1)

- ○ Strongly Disagree (2)

- ○ Neither Agree nor Disagree (3)

- ○ Somewhat Agree (4)

- ○ Strongly Agree (5)

Question 8: The turnaround time for receiving medications needed for "stat" or for patients newly admitted to the unit is adequate.

- ○ Somewhat Disagree (1)

- ○ Strongly Disagree (2)

- ○ Neither Agree nor Disagree (3)

- ○ Somewhat Agree (4)

- ○ Strongly Agree (5)

Question 9: The current medication administration system provides me with information to know that a medication order has been checked by a pharmacist before I administer the medication.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 10: I have to keep stashes of medications to be sure I have medications for when I need them.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 11: The medications I need are readily available to me when I need them.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 12: The current medication administration system makes it easy to check active medication orders before administering medications.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 13: The PowerPoint Education provided during the staff meeting helped improve my knowledge to deliver medications in a more efficient manner.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Question 14: The Medication Alert placards placed at nursing stations helped improve my knowledge to deliver medications in a more efficient manner.

○ Somewhat Disagree (1)

○ Strongly Disagree (2)

○ Neither Agree nor Disagree (3)

○ Somewhat Agree (4)

○ Strongly Agree (5)

Appendix C – Medication Alert Placard

Medication Alert

Please consult your patients Medication Administration Record after shift report to check availability for the following medications in the Omnicell™ or patient medication bins:

Verapamil (Calan) 40 mg tablet

Omeprazole (Prilosec) 2mg/mL oral liquid

Miconazole (Micotin) 2% powder

Lactulose (Chronulac) 0.67 gram/mL oral liquid

Cholecalciferol (Vit D3) tablet 1,000 u

Acetylcysteine (Mucomyst) 200 mg/mL (20% oral solution)

Albumin (human) 25% 50 mL IV

For missing medications, please contact pharmacy using the following protocol:

1. For non-urgent medications: Send message via the MAR. You may also send a message via the group chat (See below).

2. For urgent medications, **call triage 5-5593.**

When should I Secure Chat the pharmacist?

Non-urgent, clinical questions ONLY

- Switching from a tablet to suspension, compatibility questions, etc.
-

Open SecureChat in eDH

- Click on the groups icon, search name of SecureChat group (MMH {unit name} pharmacist)
- Ensure a pharmacist is "available)