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A multi-faceted intervention to reduce low value diagnostic studies in a medical intensive care unit.

Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Nursing Practice at the University of Kentucky

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Abstract

Routine daily chest x-rays (CXRs) and laboratory studies have been identified as low-value care practices that contribute to the rising cost of healthcare without improving quality or outcomes. There is a large body of evidence as well as recommendations from multiple professional organizations for providers to not order unnecessary daily or routine diagnostic studies. Rather, these should be ordered in an on-demand fashion as a response to a specific clinical query. Despite the strength of recommendations, practice remains variable across the U.S. The reasons for resistance to practice change as well as the most effective strategies for implementing sustainable change are not well understood. The purpose of this quality improvement project is to evaluate the impact of a multifaceted intervention on the number of routine or daily chest x-rays and laboratory studies ordered by advanced practice providers and medical residents in a medical intensive care unit (MICU). The project aims are to 1) examine baseline ordering practices among MICU providers, 2) survey their knowledge, confidence, beliefs, and barriers surrounding daily diagnostic testing, 3) provide education to providers on current clinical guidelines, 4) implement the guidelines through the use of a clinical decision support tool, and 5) assess provider ordering practices post intervention . The primary outcome is to decrease the number of daily CXRs, BMPs, CBCs, and ABGs ordered unnecessarily in a medical intensive care unit.

Keywords: *routine, daily CXR, chest-radiograph, critical care, intensive care*

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Dedication

This manuscript and all of the work it represents are dedicated to my family. In particular, my husband Jeff, who has been patient, loving, and supportive through the entire process. He encouraged me to pursue my doctorate from the very beginning. There were so many times I was overwhelmed and wanted to give up. He gave me the strength, confidence, and encouragement I needed to keep going and push past my own barriers. The person that I am today is a result of the love and dedication he has given me in our 19 years of marriage. I would also like to thank my kids who have been understanding and patiently waited for the last five years for me to finally be done with homework and enjoy some free time together. I also am grateful for my mother Carol Siler for always being my advocate and a helping hand.

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Background & Problem Statement

Low-value care is a term used to describe wasteful practices such as unnecessary, ineffective, and potentially harmful medical tests and procedures that do not improve quality or patient outcomes. Low-value care constitutes a large portion of wasteful spending, which contributes to the excessive cost of healthcare in the United States. *Choosing Wisely* (CW) is a national initiative from the Critical Care Societies Collaborative that seeks to reduce low-value care. A recommended CW strategy is for clinicians to order diagnostic tests in response to specific clinical questions rather than in regular or daily intervals (Halpern, Becker, & Curtis et al., 2014). This is known as an on-demand ordering strategy as opposed to daily, routine, or automated ordering practices. Daily chest x-rays (CXRs) and laboratory studies, specifically complete blood counts (CBCs), basic metabolic panels (BMPs), and arterial blood gases (ABGs) are targeted by the CW campaign as areas of low-value care. Automated ordering practices have low diagnostic and therapeutic value and can have negative consequences for the patient. The detrimental effects of overtreatment include extra radiation exposure, iatrogenic anemia from excessive phlebotomy, false positive workups, and interference with sleep which can lead to delirium and poor outcomes (Ganapathy, Adhikari, Spiegelman, & Scales, 2012; Gershengorn, Wunsch, & Rubenfeld, 2018; Hendrikse et al., 2007; Trumbo et al., 2019). Although a large body of evidence exists supporting CW recommendations, a gap remains regarding which strategies most effectively impact provider ordering practices in a sustainable way (Trumbo et al., 2019).

Context of the Problem

The practice of obtaining daily CXRs for patients who are mechanically ventilated began in the 1970's and was supported by the American College of Radiology (ACR) until 2008 (Gershengorn, Wunsch, Scales, & Rubenfeld, 2018). It was presumed necessary to detect mal-positioned endotracheal tubes or conditions such as pneumonia and pneumothorax (Keveson et al., 2017). New evidence suggested that daily CXRs were not associated with patient-centered outcomes such as mortality, length of stay, or duration of mechanical ventilation, and represented a logistical and financial burden (Gershengorn, Wunsch, & Rubenfeld, 2018; Al Shahrani & Al-Surimi, 2018). This led the ACR (2011) to

update their recommendations; routine daily chest radiographs were no longer indicated for stable ICU patients and should instead be ordered as a clinical response to a specific question or indication. In 2014 ACR updated their recommendations to remove daily CXRs from routine care of patients who are mechanically ventilated. The practice of daily CXRs continues in many U.S hospitals despite the body of evidence for their limited efficacy, negative consequences, and professional recommendations from the ACR and CW (Gershengorn Resnick et al., 2017; Wunsch, & Rubenfield, 2018). Data from 2008 to 2014 revealed daily CXRs were still obtained on three fifths of mechanically ventilated patients in a network of midwestern U.S. hospitals (Gershengorn, Wunsch, & Rubenfeld, 2018). The reasons for the resistance to practice change amongst ICUs is still not clear. Although interventions to reduce routine daily CXRs and laboratory testing have been implemented in many institutions, a standardized approach has not been established. Daily CXRs and blood work are routine within MICU practice, as evidenced by the current UK MICU daily order set. This supported the hypothesis that room for improvement existed, although ordering practices amongst UK MICU providers had not been evaluated prior to this study.

Scope & Consequences of the Problem

The high cost of health care in the U.S. relative to the comparatively low quality of care is a major concern and represents a significant health disparity. The Organization for Economic Cooperation and Development (OECD) compared the structure, performance, and spending of the U.S. health care system to 10 other high-income countries and found that the U.S. spent more and had worse outcomes (OECD, 2018). The U.S had the highest proportion of overweight and obese adults, the lowest life expectancy, highest infant mortality, and ranked second lowest in social determinants of health such as smoking (Papanicolas, Woskie, & Jha, 2018). Drivers of the high cost of care include the fee-for-service payment system which encourages volume over quality, lack of resources devoted to prevention, and overutilization of resources possibly related to fear of litigation (Papanicolas, Woskie, & Jha, 2018). Wasteful spending is estimated to contribute to 30% of the overall costs of care (Miller, Rhyan, Beaudin-Seiler, & Hughes-Cromwick, 2018). The CW campaign (2014) estimates that as much as 20% to 50% of medical imaging is unnecessary.

Theoretical Framework

The Plan-Do-Study-Act (PDSA) approach served as the guiding framework for this quality improvement project (IHI, 2020). PDSA is a cyclical framework where a plan is constructed to implement and test a change, the change is then implemented on a small scale (Do), results of the change are observed (Study), and the plan is modified and repeated (Act) based on what was learned (Melnyk & Fineout-Overholt, 2011). During the planning phase of this QI project evidence-based guidelines were evaluated, a literature review on effective interventions was conducted, and the project purpose and objectives were clarified. Strategies to reduce low-value care that were incorporated into the plan included provider education and the development of a clinical decision support tool. Identifying the root cause of lack of adoption of the CW recommendations was also a guiding principle in the planning phase. To address this a survey was developed to understand provider barriers, confidence, knowledge, and beliefs prior to the intervention. During the "do" cycle the pre-intervention survey was disseminated, providers were educated, a rounding tool was implemented, and an exit survey was conducted. The researcher also served as a unit champion and was available as a resource during the initial education and implementation phase to address any issues or concerns. In the "study" phase, data from the survey results and a chart audit collected by the University of Kentucky Center for Clinical and Translational Science (CCTS) were analyzed. The 'Act" portion of the cycle involved understanding the project results within the organizational and local context and addressing the specific limitations, barriers, and facilitators. Modifications were then suggested for future iterations of this quality improvement project.

Purpose and Objectives

The purpose of this quality improvement (QI) project is to evaluate a multifaceted intervention on reducing the number of routine or daily chest x-rays and laboratory studies ordered by advanced practice providers in a medical intensive care unit on the 9th floor at the University of Kentucky. Advanced practice providers are physicians (MDs and DOs), Acute Care Nurse Practitioners (ACNPs), and Physicians Assistants (PAs).

The specific aims of this project are as follows

1. Examine ordering practices of daily CXRs, BMPs, CBCs, and ABGs by advanced practice providers on the 9th floor MICU at the University of Kentucky Medical Center pre and post intervention.
2. Survey advanced practice providers to assess their knowledge of recommendations, confidence, beliefs, and barriers regarding daily diagnostic testing.
3. Educate 50 advanced practice providers on current national clinical guidelines for diagnostic test ordering between November 4th, 2020 and December 4th, 2020.
4. Implement the CW recommendations and ACR guidelines by introducing a clinical decision support tool.

Review of Literature

Search Methods

A literature review was conducted using the PubMed database to assess the efficacy of interventions aimed at reducing low-value care and their impact on patient outcomes. Key search terms used included 'chest x-ray', 'daily' or 'routine' and 'ICU" or critical care. Additional search terms "choosing wisely", "low-value", and "on-demand" were added to combinations of the original terms. A total of 96 articles were found and 8 were selected for this review. A second search was conducted in the PubMed database using key terms "daily", "routine", 'laboratory test", "diagnostic tests", and "choosing wisely". A total of 81 articles were found, 14 of which were selected for this review. Only articles written in the last 10 years, on human subjects, in English, and in adult patients ages 19+ were included for review. Levels of evidence were assigned as Level I through Level V based the Johns Hopkins nursing evidence-based practice model and guidelines (Dang & Dearholt, 2018). In this model Level I evidence is at the top and includes randomized controlled trials (RCTs) and systematic reviews of RCTs, while Level V is at the bottom and includes experiential and non-research-based evidence (Dang & Dearholt, 2018). A

combined total of 22 articles were selected: 20 Level II quasi-experimental studies and two-Level III qualitative studies.

Synthesis of Evidence & Evidence Based Intervention

Study interventions were categorized as either single or multifaceted and characterized by type. The prevalent types of interventions were provider education, changes to the electronic medical record (EMR), clinical decision support tools, and audit and feedback. Single interventions without an education component or with education only either reported no change in provider ordering behaviors or unsustainable change (Faisal et al. 2018; Melendez-Rosada et al., 2017; Tonna et al. , 2018, & Yorkgitis, Loughlin, Gandee, & Weinhouse ,2018). Multifaceted interventions using both education and non-electronic clinical decision support tools such as checklists were effective at reducing routine diagnostic test and reported cost savings (Keveson et al., 2017; Merkely et al., 2016 & Raad et al., 2017). Multifaceted interventions utilizing both education and audit and feedback strategies also reported reductions in both CXRs and laboratory tests (Corson et al., 2015; Minerowicz et al. 2015; & Iams et al. 2016). No impact on ICU LOS, mortality, or mechanical ventilator days was observed by any of the researchers. While cost savings were reported by the majority of investigators, the amount saved as well as the methods of determining costs varied widely. Overall, these findings suggest that provider education is a necessary component of any effective intervention but should be combined with other strategies such as either physical or electronic clinical decision support tools, EMR changes, and audit and feedback.

Methods

Design

This QI project was a prospective, non-randomized, single-center design with control data from a historical period. Retrospective baseline data from November 2019 and December 2019 was collected from the EMR following IRB approval to analyze the current number of daily CXRs, BMPs, CBCs, and ABGs ordered by advanced practice providers. Only results for patients that are on the 9th floor MICU,

over the age of 18, and mechanically ventilated were included in the analysis. Patients were excluded if they were ventilated with a tracheostomy due to the potential for chronically mechanically ventilated patients to skew results. Patients receiving continuous renal replacement therapy (CRRT) were also excluded due to the protocolized frequency of mandated laboratory testing to evaluate electrolytes in the management of citrate administration. Additional aggregate data obtained from UK CCTS from the electronic medical records included gender, diagnosis, unit census reports, deaths, ICU length of stay, and mechanical ventilator days. The same data were extracted post intervention to assess the projects impact on advanced practice provider ordering practices.

Agency Description

The University Kentucky Medical Center (UKMC) is a 945-bed academic medical center located in Lexington, Kentucky. The MICU is divided into two separate units. One unit is a 16-bed unit staffed by a pulmonary-critical care attending, a fellow, and rotating medical residents. The other unit is a 12-bed unit staffed by a pulmonary-critical care attending, and Advanced Registered Nurse Practitioners (APRNs) or Physicians Assistants (PAs).

Congruence of Project with Organization Mission & Goals

The mission of UK HealthCare (UKHC) is to improve the health of Kentuckians through advanced clinical medicine, research, and education. The values that guide the vision and mission of UKHC are diversity, innovation, respect, compassion and teamwork. Waste in healthcare represents a significant threat to the stability of our institutions and the populations they serve (Corson et al., 2015). This QI project was driven by an evidence-based initiative developed by the Critical Care Societies Collaborative which includes the American Association of Critical-Care Nurses, the American College of Chest Physicians, the American Thoracic Society, and the Society of Critical Care Medicine (CW, 2020). Evidence-based practice is consistent with UKHC's mission of using research to improve the health of Kentuckians. The multidisciplinary clinical model that is used to provide care in the MICU represents UKHC's commitment to teamwork and was a guiding factor in choosing an appropriate intervention.

Stakeholders

Stakeholders include providers, nurses, hospital executives, and patients. The MICU providers are the primary stakeholders because have the greatest impact on low-value ordering practices. Nurses are also stakeholders because their role as patient advocates can influence physician ordering practices. Patients, which includes their family members, are subject to the negative downstream effects of low-value ordering practices such as iatrogenic anemia, sleep disturbances, radiation exposure, costs, and unnecessary downstream testing and procedures. Hospital executives should be advocates of this initiative because the negative impact of low-value care on patient outcomes and costs impact hospital rankings and financial stability.

Sample & Recruitment

This was a convenience sample of advanced practice providers at the target site. Providers included attending physicians, fellows, APRNs, PAs, and rotating medical residents. They were invited to participate in the project during November 2020 and December 2020. Participation was voluntary. Participants were recruited via email using the pulmonary critical care list-serve. A cover letter explaining the survey and research protocol was included in the email. The survey and education module were embedded in the consent form and clicking and completing the survey link was considered consent to participate.

IRB Approval

Approval from the Nursing Research Council and Graduate Medical Education Committee was obtained prior to contact with participants. Approval was obtained from the University of Kentucky Institutional Review Board (IRB) prior to project implementation or data collection. Refer to Appendix B for a copy of the introductory email and consent details.

Research Procedure

Evidence Based Intervention

A multifaceted intervention was utilized focusing on educating providers and implementing a clinical decision support tool. An education module was created explaining the CW initiative, evidence behind the recommendations, and describing the decision support tool. The education intervention consisted of developing and distributing an education module surrounding the CW initiative and two brief in-person education sessions. The survey, education module, and in-person sessions occurred twice, on November 4th, 2020, and December 4th, 2020, which corresponded with the monthly new resident orientation sessions. The APRNs and PAs did not hold in-person meetings during this time due to COVID-19 restrictions. However, those who were present during the resident orientation sessions were invited to attend. The same material disseminated at brief in-person sessions was available in the education module that was distributed by email. A pre-intervention survey was created using Research Electronic Data Capture (REDCap) and distributed to MICU providers in November and December 2020. The post-intervention survey was distributed at the end of December 2020 and again in January and February of 2021. The surveys consisted of 12 questions and were designed to take less than 10 minutes to complete.

The clinical decision support tool was a modification to an existing rounding checklist. FASTHUGS BID is an acronym for a checklist used in interdisciplinary rounds in the medical intensive care unit. This checklist is a standard of care across service lines in many ICUs and is typically performed at the end of a patient presentation to ensure providers do not miss important elements in the care of critically ill patients. The "D" stands for de-escalation of antibiotics. The proposed intervention is to expand the definition of de-escalation beyond just antibiotics and include the de-implementation of other low-value care. "Daily Diagnostics" was added as an item to the "D" component of the checklist with the sub-domains of "daily CXRs" and "daily labs". The goal was to encourage discussion amongst providers and allow attending physicians to provide their expert opinions regarding the appropriateness of daily CXRs and daily labs for individual patients.

Measures and Instruments

Provider knowledge, beliefs, confidence, and barriers were measured pre and post intervention using the previously described REDCap survey. Provider ordering practices were assessed pre and post intervention from data abstracted from the EMR from two-week periods in November of 2019 and 2020 and December 2019 and 2020.

Data Collection

The number of total and a.m. CXRs, BMPs, CBCs, and ABGs and patient census data were abstracted from the electronic medical record data warehouse by a UK CCTS data specialist. Demographic data including diagnosis, gender, ICU LOS, and mechanical ventilator days were also collected.

Data Analysis

The total and a.m. CXRs, BMPs, CBCs, and ABGs per patient over a 14-day time period were compared pre and post intervention. Due to possible variability in provider ordering practices between the medical residents and advanced practice providers, the primary outcome data was analyzed separately for each team. Descriptive statistics were used to compare provider demographic data derived from the survey including gender and job title or role. The study measures and methods of data analysis are further described in Table 1.

Results

Sample Characteristics

The pre-intervention survey evaluated provider knowledge, beliefs, confidence and barriers. A total of 13 participants completed the pre survey. Of the 13 participants 3 were medical residents and 10 were APRNs, or PAs. There were 14 participants in the post-survey: 3 medical residents, 11 APRNs or PAs. For this analysis APRNs and PAs were combined into one group because in clinical practice they work together on the same team. Also, only one participant in the pre-survey group and two in post-survey group were PAs. In the pre-survey, nine of the participants identified as female and 4 as male. In

the post survey there were 9 female participants and 5 males. Demographic characteristics including gender and race of the respondents are summarized in Table 2.

Survey Results

Knowledge of the indications for a CXR was analyzed as the total number of correct answers. Eight indications or possible answers were listed with a total of six correct answers and two incorrect answers. Participants were asked to "select all that apply". Total knowledge was relatively unchanged in both resident and APRN/PA groups individually as well as collectively. In both the pre and post survey the majority of medical residents (2/3) selected four of the 6 possible correct indications for a CXR. The majority of APRN/PA participants selected five of the six possible correct answers pre-survey (5/10) and post survey (5/11). The two wrong answers listed were "daily for endotracheal tube placement" and "daily for central line placement". None of the medical residents selected either of these as an indication and only one participant in the APRN/PA group selected a wrong answer. Knowledge about the potential harm of frequent lab testing in ICU patients remained unchanged after the intervention. The majority of APRNs/PAs and medical residents, 69% collectively, only answered one out of two questions correctly. None of the medical residents selected both correct answers pre- and post-post survey. The most frequently missed correct response, which was missed by more than half of the respondents both pre-post survey, was related to the volume of blood loss that results in a decrease in a patients hematocrit. Based on this analysis of the survey questions about knowledge, we determined the educational intervention overall did not change or alter advanced practice provider's knowledge related to the indications for ordering daily CXRs.

Participant's beliefs surrounding daily CXRs, and daily labs were assessed in four questions using a 5-point Likert scale. When asked to rate the statement 'in the majority of cases a daily CXR will change my clinical management of the patient' 69% (9/13) participants either disagreed or strongly disagreed pre-survey compared to 43% (6/14) post-survey. Responses by job role did not reveal a difference between medical resident group and the APRNs/Pas group; more than half of participants within each group

expressed a level of disagreement in the pre-post-survey. The second belief assessed was 'the benefits of daily CXRs in ICU patients outweigh the harm'. The majority of medical residents (2/3) disagreed with the statement both pre-post survey. More APRNs/PAs disagreed/strongly disagreed with the statement post-survey 55% (6/11) compared to 40% (4/10) pre-survey. Participants were asked to rate the statement 'I may miss something important by not ordering a daily CXR on my intubated ICU patient'. Collectively and within each group the majority of participants (>60%) expressed some level of disagreement with this statement pre and post survey. Beliefs surrounding daily laboratory studies were assessed by asking participants to rate the statement 'I will miss something important if I do not order daily labs on my intubated ICU patient'. Overall, medical residents disagreed with the statement while APRNs/PAs either agreed or were undecided. One medical resident was undecided pre-survey while all (2/3) disagreed post survey. Amongst APRNs/PAs 50% (5/10) agreed at some level pre-survey and 1/10 was undecided. Post-survey 45% (5/11) of APRNs/PAs agreed and (2/11) were undecided. Based on these analyses of the survey questions about advanced practice provider's beliefs, we determined the educational intervention did not significantly change advanced practice provider's beliefs related to harm or benefits of ordering daily CXRs or labs.

Respondents were asked in separate statements to rate their confidence in their ability to decide if a patient would benefit from a CXR or labs. Although a few participants were undecided, none in either provider group reported a lack of confidence in their ability to decide if a patient would benefit from a CXR or labs. Collectively, 92% (12/13 pre-survey and 13/14 post) reported confidence in their ability to decide if a patient would benefit from labs. With regards to CXRs 85% (11/13) of participants reported feeling confident pre-survey and 92 % (3/14) post.

Participants were asked to indicate barriers to de-implementing daily labs or chest x-ray in their clinical practice and could select all applicable results. The most commonly identified barriers were 'my attending will want them' and 'I use the results to make clinical decisions' and 'I am afraid of missing something important'. Attending preference was chosen by 62% (8/13) of participants pre-survey and 71% (10/14) post-survey.

Intervention Results

The impact of the education module and modified checklist were examined to assess for changes in provider ordering practices before and after project implementation. Baseline data were collected retrospectively during the last 14-days of November 2019 and December 2019. Post-intervention data were collected from the same 14-day time frame in November 2020 and December of 2020. The time frames were selected so that comparisons of the medical residents accounted for their experience levels. The baseline data were collected from the same months and weeks of the previous year to represent residents at the same points in the progression of their programs. The MICU is comprised of two units; the 9-200 unit is staffed by medical residents and the 9-100 unit is staffed by a team of APRNs and PAs. Data were analyzed for each unit separately to account for differences in provider ordering practices. All data are reported as per patient over a 14-day period. The "census" represents the number of patients present on each unit meeting the inclusion and exclusion criteria during the previously defined 14-day time periods pre and post intervention. To account for differences in group size the number of total vs routine CXRs or labs were analyzed as a per patient ratio. Baseline and post-intervention data abstracted from the electronic medical record data warehouse are reported in Figures 3-6.

The number of routine CXRs per patient ordered by providers on both teams was unchanged pre and post intervention. However, in both groups the total CXRs/patient ordered were higher in the post intervention period. To account for the increase in total CXRs orders, the data were also analyzed as the proportion of routine to total CXRs/patient. Proportionally, 64% (5.75/9) were ordered as routine by APRNs and 58% (3.5/6) by medical residents. The proportion of routine to total CXRs per patient increased by 6%in the APRN group and decreased by 9% in the resident group in the post-intervention period. Although the change difference between the pre and the post intervention was less than 10%, the important point is that all CXRs should be ordered for a specific clinical indication rather than routinely.

At baseline, routine CXRs accounted for more than 50% of all CXR orders in both groups of providers. Following the intervention routine CXRs/patient accounted for 70% of all orders by APRNs and 49% by medical residents. Based on these analyses, we have determined the educational intervention did not change provider's practice with regards to ordering CXRs in the MICU at UK Chandler Medical Center during this timeframe. Pre and post intervention CXR ordering practices are described in *Table 3*.

Assessment of routine lab ordering indicates the providers decreased routine CBC orders by 10% in the APRN/PA group post intervention. In both groups the proportion of pre/post routine BMPs accounted for more than 40% of the total. The number of ABGs/census decreased in both provider teams; 6.08 to 1.5 (75% decrease) in the APRN team and 57% (3.57 to 1.52) in the medical resident team. However, the total ABGs ordered by APRNs and residents also decreased by 86% and 65% respectively in the post intervention period. Based on these analyses, we determined that the educational intervention did not change provider's practice regarding routine laboratory orders in the MICU at UK Chandler Medical Center during this timeframe.

Discussion

The results of this quality improvement project demonstrate that a gap exists between the CW recommendations regarding routine diagnostic tests and current local practice. The multifaceted intervention focusing on provider education and implementing a checklist during multi-disciplinary rounds did not have an impact on provider ordering practices. At baseline, more than half of the total labs and CXRs ordered by providers were routine orders with a negligible change following the intervention. Survey data revealed that overall providers were both knowledgeable and confident regarding current evidence-based practice and their clinical decision making.

Provider beliefs were evaluated by addressing commonly held misconceptions identified in the literature. Fear of missing something important regarding labs and the idea that the benefits of daily CXRs outweigh harm were beliefs held by APRNs/PAs but not by medical residents.

Additional reasons the practice change was not adopted may include a low overall participation amongst providers, inconsistent support to reduce unnecessary test ordering from attending physicians, a lack of stakeholder engagement, and the nature of the interventions themselves. Less than 30% of over 60 participants who were invited, chose to participate in both the pre-post survey. The vital role of stakeholder influence on a project's success or failure is well known in the field of quality improvement (Brugha & Varvazovsky, 2000). While attending preference was the most commonly identified barrier to de-implementing daily diagnostic studies, engagement of attending physicians was not achieved. The nature of the interventions used in this project may be a reason for the project's ineffectiveness at influencing provider ordering behaviors. The proposed checklist modification was supposed to be implemented on multi-disciplinary rounds, but the consistency of its use was not measured. The Hierarchy of Effectiveness (HE) model, which was developed for use in process improvement strategies, provides valuable insight to further understanding the effectiveness of the project interventions. In this model there are six categories: person-oriented interventions (levels 4-6) rank at the bottom while design-oriented interventions (levels 1-3) rank at the top (Jalbert, Gob, & Chin-Yee, 2019). Education and training (level six) and checklists (level four) are person-oriented interventions. This model supports the evidence previously discussed in the literature review that education alone was not an effective strategy in quality improvement studies. Although design-oriented interventions such as computerization and forcing functions (levels one and two) are considered more effective, they are also more disruptive and require much larger changes (Jalbert, Gob, & Chin-Yee, 2019). The selections of interventions in this study were guided by the PDSA framework and the results of the literature review. While education and checklists are clearly not the most effective interventions, small and incremental changes were appropriate in the context of this study and theoretically supported by the PDSA. The HE model also asserts that change in quality improvement should use the minimum intervention required to achieve an effective result and minimize disruption (Jalbert, Gob, & Chin-Yee, 2019). Prior to this project, baseline ordering behaviors had not been examined. This project represents one PDSA cycle and is a first step towards raising awareness of a gap in evidence-based practice.

Limitations

There were several limitations to the conclusions and generalizability of this project. The results of the project may not be generalizable as this was a single center design within an academic medical center. The small sample size limits the ability to statistically analyze the results for significance. The results compared ordering practices between a group of medical residents and APRNs/PAs, however, only three medical residents participated. There were several limitations related to the data abstracted from the charts. These data were abstracted in an aggregate fashion, which limited the statistical analysis.

Accuracy of costs analysis was also a study limitation. The CCTS could only provide the total costs of hospitalization and not the individual costs of the labs or CXRs. The cost of diagnostic studies includes the direct cost of performing the test, and indirect costs such as the equipment, time, and personnel to perform and analyze the tests (Vidyarthi et al., 2015). Many similar studies that reported costs utilized indirect or extrapolated measures, such as standardized reimbursement rates (Corson et al., 2015; Sadowski et al., 2017; Thakkar et al., 2015; Yarbrough et al., 2016; Vidyarthi et al., 2015). Projected cost in this study were based the Centers for Medicare and Medicaid services standardized reimbursement rates and did not account for human and physical factors such as equipment and time. These are conservative estimates, as they only take into account the amount of reimbursement for each test and not any other human and material cost of conducting the procedures or the downstream impact of inappropriate testing.

There were also several limitations related to the project timeline and IRB approval. First, the projected start date was delayed by one month resulting in less data collection and fewer opportunities to provide education and engage providers. Secondly, part of the multifaceted intervention was to post flyers in the physical environment with educational content related to the project. These flyers were not approved for use by the IRB. Audit and feedback were originally planned for this project but were not able to be provided in a real time fashion within the project's limited timeline.

The circumstances surrounding the COVID-19 pandemic also created limitations. In-person activities such as staff meetings, which were intended to be opportunities for education, were not being

held with APRNs/PAs due to COVID-19 restrictions. This limitation developed following IRB approval and relative to the progression of COVID-19 cases during the pandemic. The scale and impact of the pandemic were unknown to the PI at the time of IRB approval, thus alternative online sessions such as zoom meetings were not included and approved. While resident education was able to be provided at their orientation sessions, APRNs/PAs did not receive formal education sessions. Although COVID-19 positive patients were not included in this study, it is unclear if a viral respiratory pandemic may have influenced CXR ordering patterns amongst MICU providers.

Implications for practice

Organizational context is an important component of QI design and a focus of the Doctor of Nursing Practice (DNP) curricula. Standardized approaches to QI often do not take the unique barriers and facilitators into account. Through the lens of the DNP curriculum, this project helped to identify issues that exist within the context of this unit and organization. The culture of daily diagnostic testing is strongly rooted in the ICU environment and impacting change will take more than one project or a simple awareness of the evidence. The program cost and savings may also be important to the organizations decision to pursue future iterations of this project. While this project did not incur any costs, sustained education, audit, and feedback would. In a similar study, program costs were estimated to be $1600 initially and $1000 annually for creation of a dashboard , curriculum development, educational materials, and teaching (Trumbo et al., 2019). Cost savings were estimated indirectly for this QI project based on the Medicare reimbursement rate for a single view CXR (CPT code 71045, global fee) and the CMS 2021 Clinical Laboratory fee schedule. ABGs were excluded from the assessment as they are often done using point-of care testing. . The tests were analyzed as per patient to account for differences in the census. A total of $30/patient was saved following the intervention. Using the average number of patients in the pre/post groups (n=36) the projected cost savings was $1065 in 14 days. Thus, in less than one month the annual cost of the program would be covered. Furthermore, over the period of a year this could be extrapolated to an annual savings of approximately $27,766.

Future Nursing Research

The insight gained from this project provides a foundation for future PDSA cycles. The first recommendation is to raise awareness amongst providers of the existing practice gap identified in this project. Secondly, a more robust effort to engage attending physicians as primary stakeholders should be attempted. They represent both a barrier and a facilitator to the project's success and their engagement needs to be consistent and united. The next tier of recommendations for future research relate to the specific limitations encountered in this project. More in-person and alternative education opportunities to address the lack of participation amongst providers should be created. Future educational activities should focus on the 'fear of fear missing something important' regarding daily lab testing as this was identified as a barrier in this project. Educational flyers posted in the physical environment were a previously discussed limitation related to IRB approval that could enhance awareness of project objectives. Lastly, the effectiveness of the checklist used in this project requires a more thorough evaluation to determine its effectiveness. The checklist was to be implemented during multi-disciplinary rounds, but adherence was not monitored. Lastly, incorporating audit and feedback into the intervention should be considered in the future. Auditing and feedback were used as a component in several multifaceted interventions that reported reduced ordering practices (Corson et al., 2015, Harb et al., 2019; Iams et al., 2016; Keveson et al, 2017; Raad et al., 2017; Trumbo et al., 2019 & Vidyarthi et al., 2015).

Conclusion

The QI project did identify meaningful practice gaps between medical society practice recommendations to reduce unnecessary testing and the current UK MICU practice of routine ordering of CXRs and morning blood work. The project's interventions did not result in significant changes to provider ordering behaviors despite evidence of a need for improvement. Engagement of stakeholders, which includes both attending physicians and providers, is a necessary next step. The purpose of this project was to reduce low-value care in the UK MICU by implementing a multifaceted intervention

focused on provider education and encouraged alignment with medical societal practice recommendations.

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Figure 1. PRISMA Flow Diagram for Daily CXRs

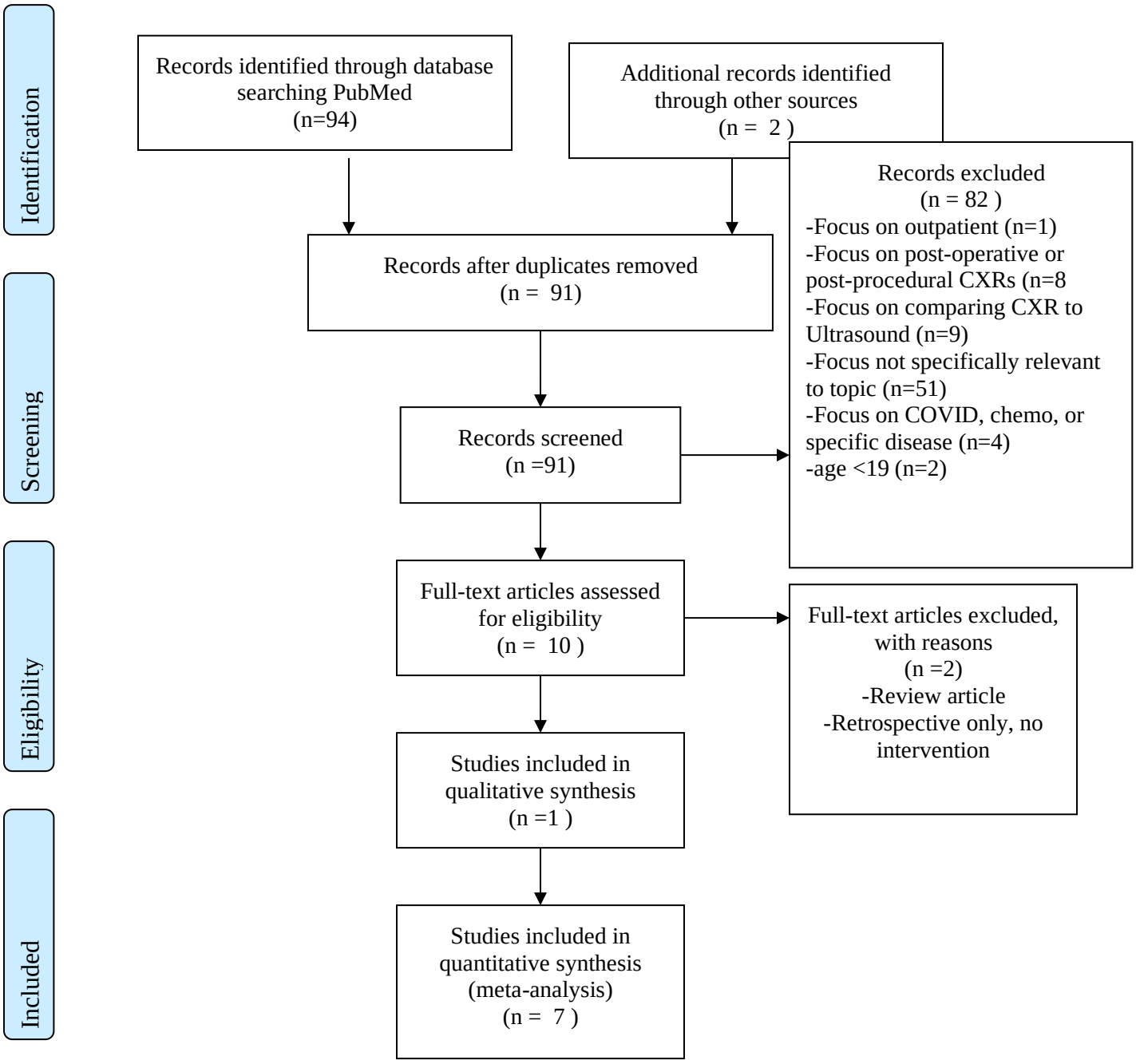


Figure 2. PRISMA Flow Diagram for Daily Labs

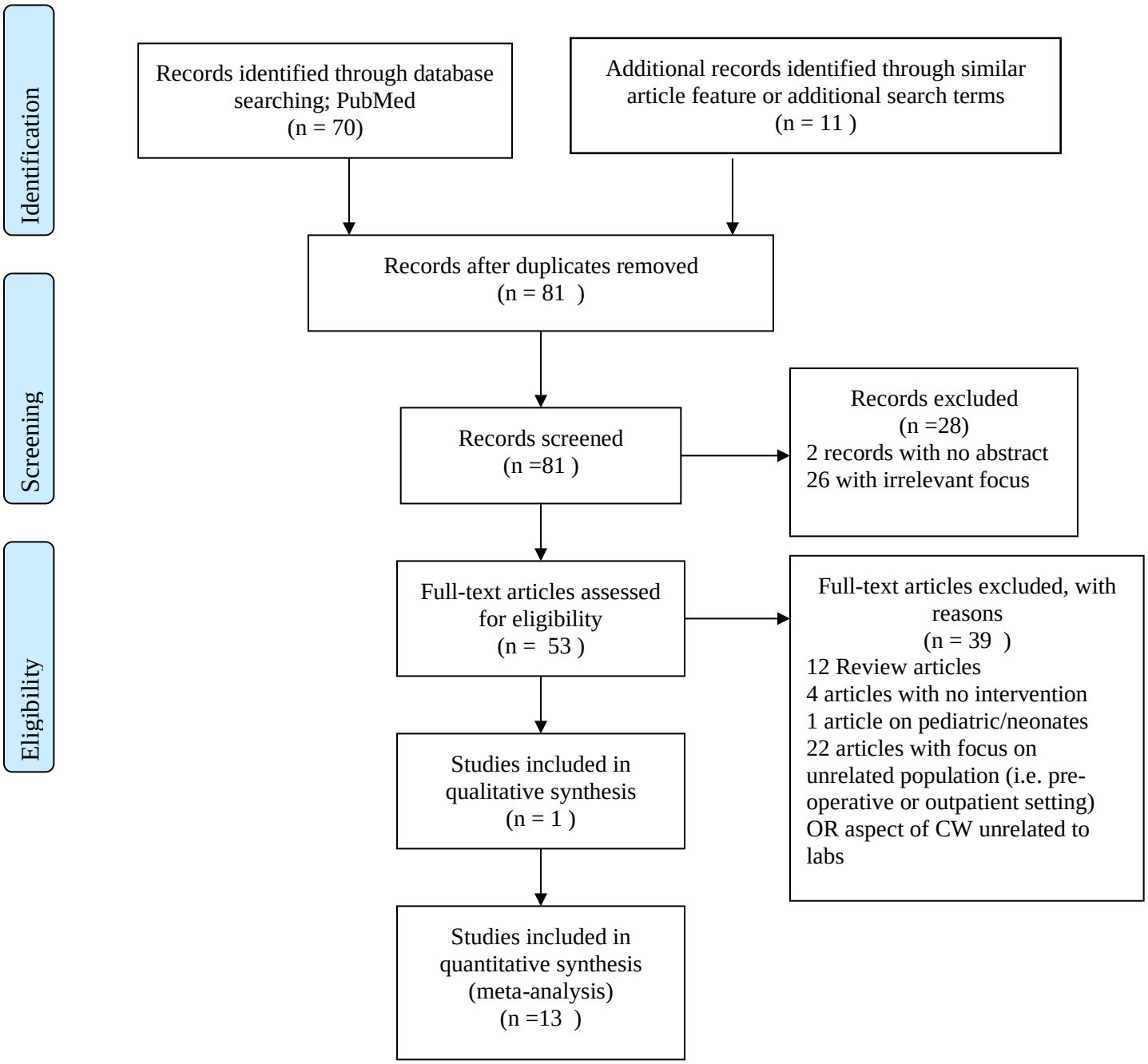
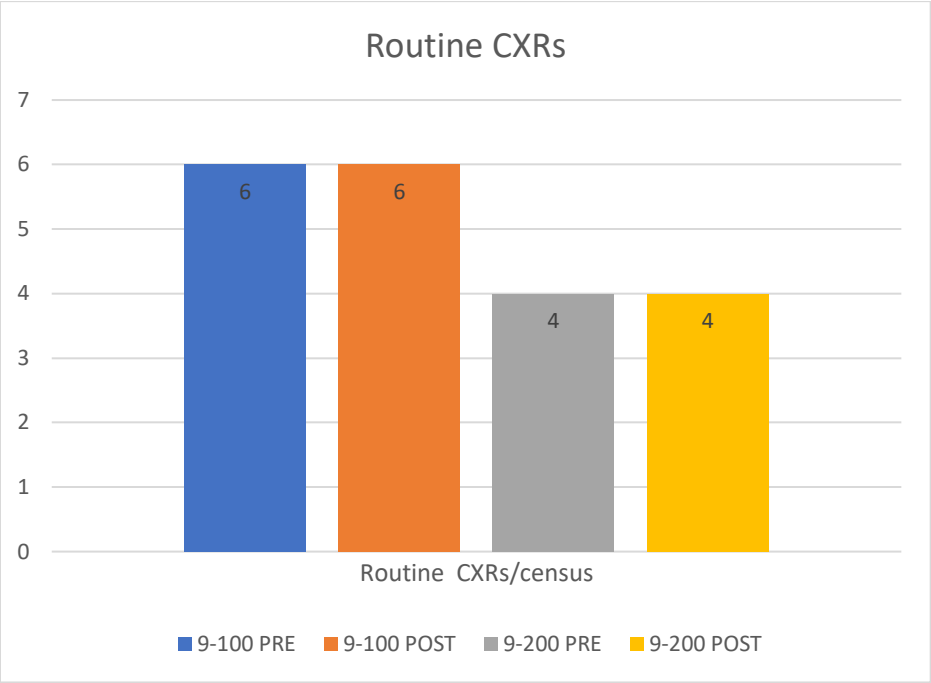
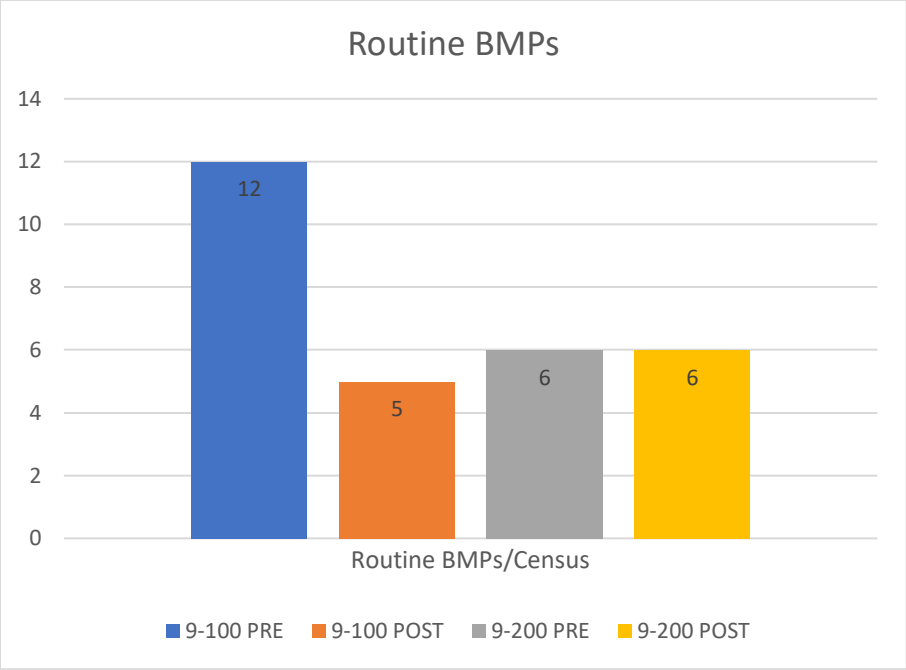


Figure 3. Pre-Post Comparisons of Routine CXRs



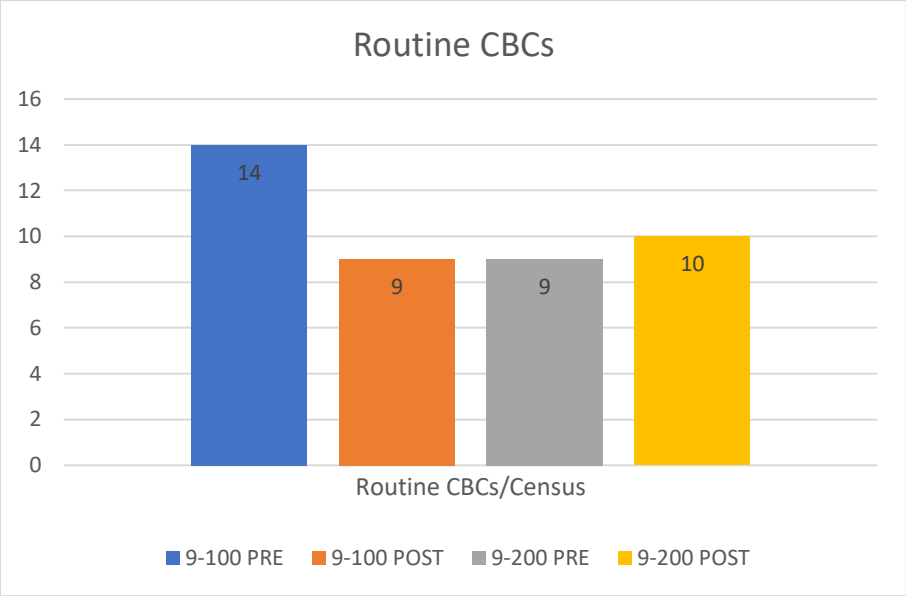
The data in *Figure 3* represents the number of routine CXRs per census ordered by providers during a 14-day period pre/post intervention. Only orders for patients meeting the study inclusion criteria were included. Patients were included if they were mechanically ventilated, not requiring CRRT, and ventilated through a tracheostomy. The 9-100 data represents the APRN/PA group. The 9-200 data represents the medical resident group.

Figure 4. Pre-Post Comparison of Routine BMPs



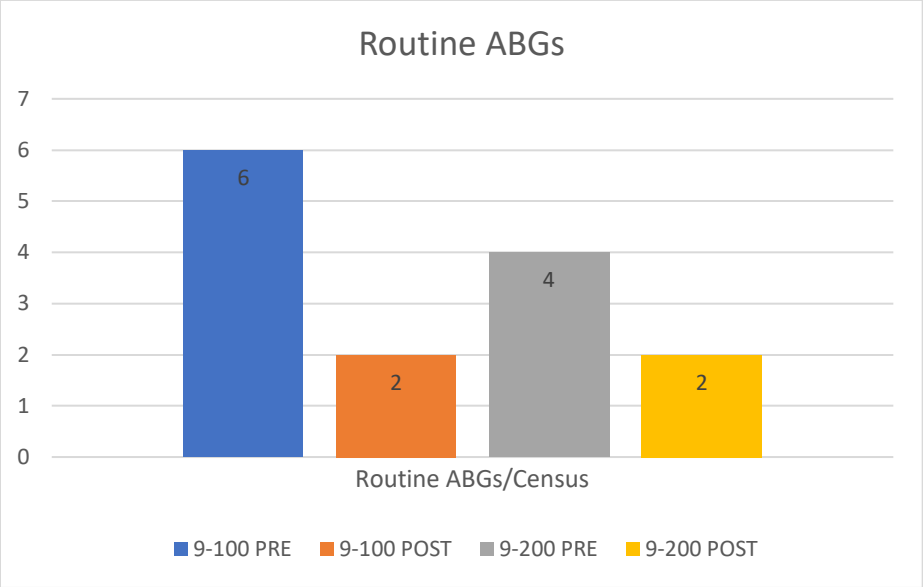
The data in *Figure 4* represents the number of routine BMPs per census ordered by providers during a 14-day period pre/post intervention. Only orders for patients meeting the study inclusion criteria were included. Patients were included if they were mechanically ventilated, not requiring CRRT, and ventilated through a tracheostomy. The 9-100 data represents the APRN/PA group. The 9-200 data represents the medical resident group.

Figure 5. Pre-Post Comparison of Routine CBCs



The data in *Figure 5* represents the number of routine CBCs per census ordered by providers during a 14-day period pre/post intervention. Only orders for patients meeting the study inclusion criteria were included. Patients were included if they were mechanically ventilated, not requiring CRRT, and ventilated through a tracheostomy. The 9-100 data represents the APRN/PA group. The 9-200 data represents the medical resident group.

Figure 6. Pre-Post Comparison of Routine ABGs



The data in *Figure 6* represents the number of routine ABGs per census ordered by providers during a 14-day period pre/post intervention. Only orders for patients meeting the study inclusion criteria were included. Patients were included if they were mechanically ventilated, not requiring CRRT, and ventilated through a tracheostomy. The 9-100 data represents the APRN/PA group. The 9-200 data represents the medical resident group

Tables

Table 1. Table of Study Measures

Measures	**Description**	**Level of Measurement**	**Data Source**
Provider Demographics			
Job title/Education Level	a. MD or DO b. Fellow c. Medical Resident d. APRN e. PA	Nominal	Survey
Gender	a. Male b. Female	Nominal	Survey
Race	a. White or Caucasian b. Hispanic or Latino c. Black or African American d. Asian or Pacific Islander e. Native American/Alaskan Native f. Multiracial or Biracial g. Other/not listed	Nominal	Survey
Provider Ordering Practices (Pre-Post Intervention)			
Census	# of patients meeting inclusion/exclusion criteria within specified time frame		Medical Records
CXRs/census	total #CXRs/ census	Ratio	Medical Records
Routine CXRs/census	# CXRs ordered as a.m. (between midnight and 7a.m)/ census	Ratio	Medical Records
CBCs/census	total # CBCs/census	Ratio	Medical Records
Routine CBCs/census	#a.m. CBCs/census	Ratio	Medical Records
BMPs/census	total #BMPs/census	Ratio	Medical Records
Routine BMPs/census	# of a.m BMPs/census	Ratio	Medical Records
ABGs/census	total # of ABGs/census	Ratio	Medical Records
Routine ABGs/census	# a.m. ABGs/census	Ratio	Medical Records

Table 2. Sample Characteristics

Variable	Pre-Survey (n=13)	Post Survey (n=14)
Job Role	Attending 0 Fellow 0 Resident. 23% (3) APRN/PA 77% (10)	Attending 0 Fellow 0 Resident. 21% (3) APRN/PA 79%(11)
Gender	Male 31% (4) Female 69% (9)	Male 36% (5) Female 64% (9)
Race	White or Caucasian 85% (11) Asian or Pacific Islander 8% (1) Other/not listed 8% (1)	White or Caucasian 100%

Table 3. Raw CXR Data

LOCATION	PHASE	Census	total cxr	am cxr	Total CXR/census	AM CXR/Census
9-100	PRE	12	108	69	9	5.8
9-100	POST	17	145	102	8.5	6
9-200	PRE	21	126	74	6	3.5
9-200	POST	21	157	77	7.5	3.7

The above data in the table above was obtained from electronic medical record warehouse by the CCTS. Ratios were calculated by the PI. Each intervention phase was a 14-day time period. The APRNs/PAs practice in the 9-100 location while medical residents practice in the 9-200 location.

Table 4. Proportion of Routine to Total CXRs/Patient Pre and Post Intervention

	Pre-Intervention	**Post-Intervention**
Variable	Proportion of Routine to Total CXRs (per patient)	Proportion of Routine to Total CXRs (per patient)
APRNs/PAs	64% (5.8/9)	70% (6/8.5)
Medical Residents	58% (3.5/6)	49% (3.7/7.5)

The table above represents the proportion of routine to total CXRs per patient ordered by providers in the pre and post intervention periods. The ratio of routine CXRs/patient to total CXRs/patient was calculated from the raw data in Table 3 to account for differences in the census between groups of providers and intervention periods.

Table 5. Projected Costs

Test (Estimated Charges based on CM pricing)	**Pre-Intervention (n=33)**		**Post-Intervention (n=38)**	
	# tests	Cost/patient	# tests	Cost/patient
BMP ($10.46)	274	$88	207	$57
CBC ($6.47)	355	$70	370	$63
CXR ($19)	153	$82	179	$90
Total Cost/patient	$240		$210	

For this analysis the total number of routine tests ordered by APRNs/PAs and medical residents were combined. The tests were analyzed as per patient to account for differences in the census. A total of $30/patient was saved following the intervention. Using the average number of patients in the pre/post groups (n=36) a cost savings of $1065 in 14 days.