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Reducing Unnecessary Laboratory Utilization in the Medical ICU: A Fellow-Driven Quality Improvement Initiative

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OBJECTIVES: Overutilization of laboratory services is now recognized as harmful to patients and wasteful. In fact, the American Board of Internal Medicine's Choosing Wisely campaign recommends against ordering routine testing that does not answer a clinical question. Per peer benchmarking, our institution as a whole occupied an extreme outlier position at the 100th percentile for laboratory utilization. We sought to address this problem starting in our medical ICUs with a quality improvement project.

DESIGN: Quality improvement project using the design, measure, analyze, improve, and control process. The primary endpoint was a sustained reduction in laboratory utilization. Counterbalance metrics were also followed, and these included mortality, renal replacement therapy initiation rates, stat laboratory orders, and central catheter–associated blood stream infections.

SETTING: The medical ICU at the Ohio State University Medical Center.

PATIENTS: All patients admitted to the medical ICU from March 2019 to March 2020.

INTERVENTIONS: Root causes were identified and addressed with the implementation of a wide range of interventions involving a multidisciplinary team led by trainee physicians.

MEASUREMENTS AND MAIN RESULTS: There was a sustained 20% reduction in the number of tests performed per patient day, with no change in the counterbalance metrics.

CONCLUSIONS: Trainees can affect positive change in the culture and processes at their institutions to safely reduce laboratory utilization.

KEY WORDS: critical care; evidence-based medicine; healthcare costs; laboratories; patient safety; quality improvement

L aboratory blood tests in the hospital are ordered for many reasons including for diagnostic evaluations, drug monitoring, and to assess response to therapy. As laboratory and phlebotomy services have become more efficient and automated, so too has ordering such that many tests are ordered on a reflexive, routine basis and without a specific question in mind. However, the notion that having more information is beneficial is being replaced by heightened awareness throughout the medical community that overutilization of laboratory blood testing can result in both harm to the patient and unnecessary costs to the medical system.

The magnitude of national overutilization is difficult to quantify, but a meta-analysis by Zhi et al (1) estimated the rate of inappropriate hospital laboratory testing to be 43.9% at the time of admission and 7.4% for subsequent testing. Proposed harms to the patient from excessive laboratory blood testing include injury during phlebotomy, anemia from repetitive phlebotomy, increased central catheter-access

potentially leading to central catheter–associated bloodstream infections (CLABSIs), and unnecessary subsequent evaluations for out of range values (2). An observational study reported that patients were phlebotomized on average 86.3 mL of blood over the course of their first 4 days in the ICU and that nearly half of these patients then required a blood transfusion for anemia (3). Excessive laboratory utilization can also result in interpretative error and data overload for the physician (2). Over $8 billion dollars annually is spent on laboratory services for Medicare patients alone (4) with still more, unquantified costs incurred due to the diversion of nursing, pharmacy, and laboratory resources.

In 2014, the Critical Care Societies Collaborative and America Board of Internal Medicine's "Choosing Wisely" campaign recommended one should not order "diagnostic tests at regular intervals, but rather in response to specific clinical questions" (5). Since then, there has been growing experience in the approach to correcting overutilization and reducing cost. Effective interventions have included educating providers and providing them with feedback, educating and empowering patients, changing order entry, and programming automated prompts into the electronic medical record (6–9).

Compared with academic medical centers of similar size within the University Health System Consortium, The Ohio State University Wexner Medical Center ranked in the 100th percentile in 2018 for total inpatient billed tests performed. This impressive ranking led us to believe that a fair portion of these laboratories are unnecessary and not ordered in response to specific clinical questions. The goal of our pulmonary and critical fellow-driven multidisciplinary quality improvement project was to reduce such unnecessary laboratory utilization specifically within the medical ICU (MICU). Providers were surveyed for current practices, root causes were analyzed, and interventions were employed across multiple levels of the medical system. The primary outcome was the number of laboratories ordered in the MICU with secondary evaluation of the rates of blood transfusions. Counterbalance metrics included mortality rate, renal replacement therapy (RRT) initiation rate, frequency of stat priority laboratory ordering, and CLABSI rate.

METHODS

In October 2018, we convened a multidisciplinary team led by six pulmonary and critical care medicine fellows. The team included three pulmonary critical care attending physicians (one who served as a faculty advisor), a clinical informatics specialist, the director of laboratory operations, two MICU nurses, and a clinical pharmacist. The define, measure, analyze, improve, and control (DMAIC) methodology was followed throughout the improvement initiative. The goal was to reduce unnecessary laboratory utilization in the 24-bed University Hospital MICU by 10% and sustain this change over at least 6 months. Our project was approved by the Medical Center Quality Department.

Team members developed a process map conceptualizing the order, collection, and resulting of laboratory testing in the MICU. Perceptions about laboratory testing were collected by anonymously surveying internal medicine residents and both fellow and attending physicians from the Division of Pulmonary, Critical Care, and Sleep Medicine. Fishbone diagramming followed by the "Five Whys" tool was used to identify root causes of unnecessary laboratory utilization. System-level root causes included default ordering of laboratories on a daily basis and admission order sets that resulted in redundant testing with the emergency department. Culture-level root causes included an unawareness of the harms of routine testing and a discomfort with not having daily tests to review.

Twenty-five laboratory blood tests were identified as being ordered daily, on a routine basis, or unnecessarily trended over time. These included the tests comprising a comprehensive metabolic panel, magnesium, phosphorus, ionized calcium, complete blood count, coagulation studies (protime, prothrombin time, and international normalized ratio), triglycerides, creatine kinase, ammonia, and pH. Thirty-one discrete orders within the electronic medical record were included in the analysis.

A benchmark level of laboratory utilization for the 25 prespecified laboratory tests was determined using the retrospective mean from March 5, 2017, to March 3, 2019. Data from March 3, 2019, to June 23, 2019, were considered a lead-in period wherein discussion and planning of interventions by members of our team were likely to influence laboratory test ordering behaviors. The initial formal implementation of our interventions started on June 17, 2019. However, as the laboratory utilization data were only obtainable on a weekly basis, we chose to begin our analysis with the first full week of data occurring after interventions

began, starting on June 23, 2019. The assessment of data ended on March 15, 2020, due to practice and workflow changes occurring as a result of the coronavirus disease 2019 (COVID-19) pandemic.

Ultimately, in response to identified root causes, a total of nine interventions were implemented: 1) The ICU admission order set was altered to encourage morning laboratory draws to occur only after a patient had been admitted to the ICU for greater than 12 hours. It also prompted the physician to avoid repeating laboratories that had recently resulted in the emergency department. 2) A prompt to review standing laboratory orders for discontinuation was added to the existing MICU rounding checklist. 3) Collaboration occurred with subspecialty consultants to reduce laboratory testing (e.g., the division of nephrology agreed to routinely assess for reduction in the frequency of laboratory monitoring for patients who were stable on continuous RRT). 4) Pulmonary and critical care faculty members were educated and encouraged to explicitly outline expectations for laboratory ordering with trainee physicians. 5) Pulmonary and critical care fellow physicians

were educated and encouraged to demonstrate leadership in reduction of unnecessary laboratory testing. 6) At the beginning of each resident rotation block, new resident teams in the MICU were educated and directed to the "Choosing Wisely" recommendations. 7) Bedside nurses were educated and empowered to challenge physicians on unnecessary testing. 8) MICU clinical pharmacists were also empowered to examine laboratory orders and advocate for discontinuation of unnecessary testing. 9) Signs were posted throughout the MICU and on portable workstations to prompt thought, discussion, and action in discontinuing unnecessary laboratory orders. See **Figure 1** for the timeline of interventions.

The primary outcome was the number of laboratory tests ordered in the MICU expressed as laboratories per patient day, both as a total per week and as a rate per patient day to account for variation in the total patient census. The secondary outcome was defined as the rate of RBC transfusions, which was hypothesized to decrease with reduced phlebotomy.

Counterbalance metrics included mortality rates, RRT initiation rates, frequency of stat priority
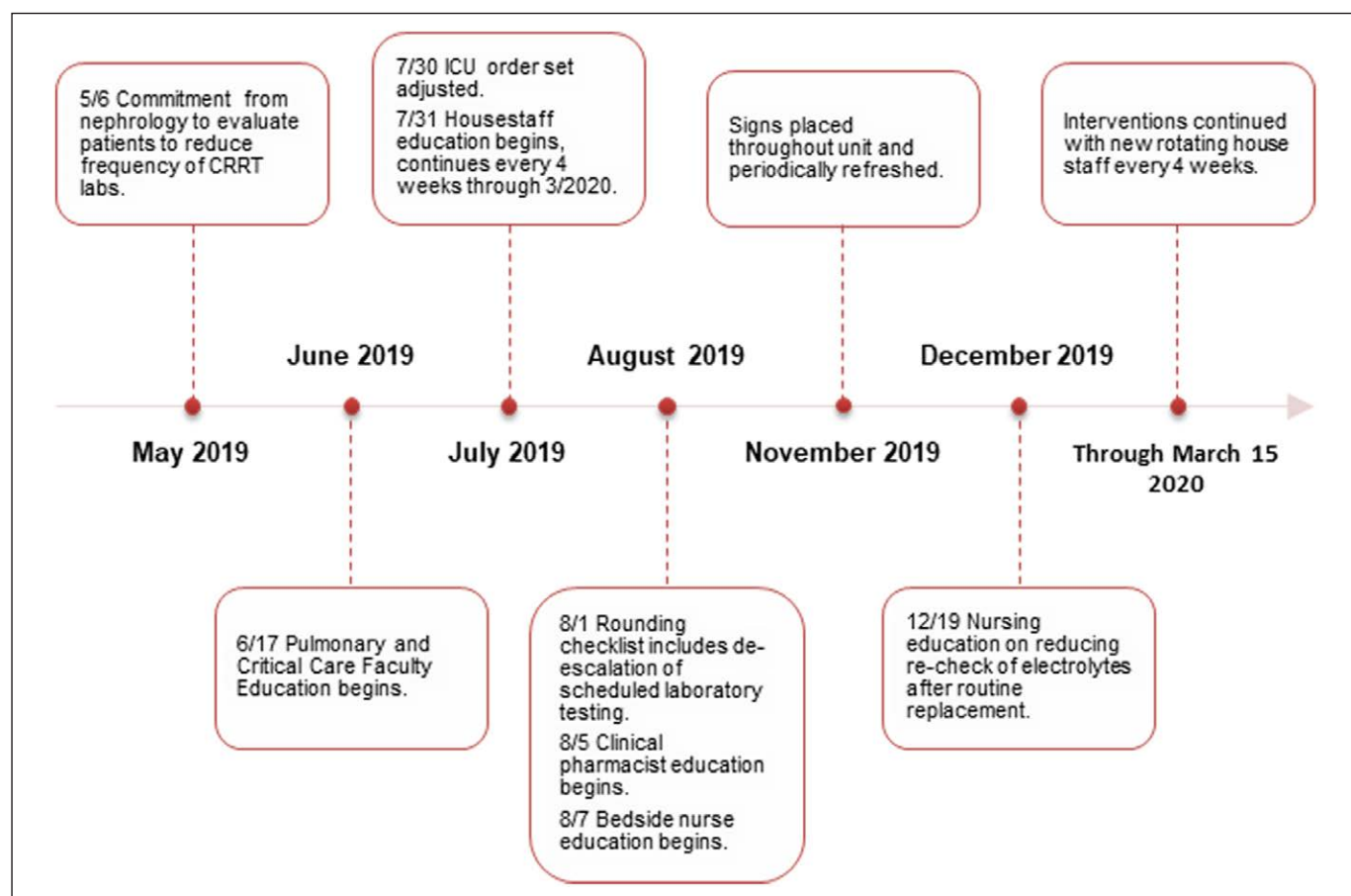

Figure 1. Timeline of roll-out of interventions. CRRT = continuous renal replacement therapy.

laboratory ordering, and CLABSI rates. All data were obtained from The Ohio State University Wexner Medical Center analytics department with the exception of blood transfusion rates which were obtained from the blood bank.

RESULTS

Surveys

To validate some of the proposed root causes for laboratory overutilization, internal medicine residents and MICU physicians were surveyed on their attitudes toward laboratory test ordering. Of the 42 fellow and attending physicians who were surveyed, 19 (42%) responded. Seventy-eight percent (14/18) reported that they "do not" or "only sometimes" discuss expectations for laboratory testing with their resident teams. Seventy-eight percent (14/18) responded that they advocate for de-escalation of laboratory testing in up to 50% of patients in a given week. Eighty-three percent (15/18) advocated for de-escalation of testing after clinical stability.

Of 126 surveys sent to residents, 82 (65%) replied. Seventy-five percent (62/82) responded that daily morning laboratories are expected on every patient in the MICU, whereas 22% (30/82) thought that the attending physicians expected daily laboratory blood testing on every patient. Fifty-three percent (43/81) responded that they "do not" or "only sometimes" review standing laboratory orders on their patients. On a Likert scale, attending and fellow physicians reported moderate comfort with the lack of daily laboratory data. Resident physicians on average were neutral on the Likert scale.

Primary, Secondary Outcomes, and Counterbalance Metrics

As data prior to March 3, 2019, were retrospective in nature, the entirety of these data was used to establish the benchmark average. The benchmark for the specified laboratories that were ordered and resulted per week was 1,334, with an average of 10 laboratories per patient day in the MICU. During our implementation period, the average utilization was 1,107 laboratories per week, with an average of eight laboratories per patient day. This amounted to a 20% reduction in laboratories per patient day (**Fig. 2**).

For the secondary outcome, packed RBC transfusion rates from December 1, 2019, to February 28, 2020, were compared with a benchmark transfusion rate from December 1, 2018, to February 28, 2019. Total packed RBC transfusions per month were noted to vary widely from month to month (range of 34–140 transfusions per month). In attempt to exclude transfusions related to acute hemorrhage, a subgroup of transfusions that were limited to one unit of packed RBCs per patient per week was identified. The frequency of these limited transfusions was low at seven to 19 transfusions per month, but there were not enough data to discern a trend.

Counterbalance metrics for mortality index (ratio of observed deaths to the Medicare severity diagnosis-related group expected deaths), RRT initiation rates, frequency of stat priority laboratory ordering, and CLABSI rates are summarized in **Figure 3**. There were no consistent trends in the counterbalance metrics during the implementation period as compared to baseline.

DISCUSSION

Laboratory testing plays a crucial role in modern medicine. However, overutilization is actually detrimental to the patient and the health system alike. Recognition of this problem is highlighted by the Choosing Wisely campaign's recommendation to avoid unnecessary laboratory utilization and its endorsement by multiple multidisciplinary critical care societies. In this study, we implemented a quality improvement process using the DMAIC model to address the problem of overutilization in the MICU. We exceeded our goal of achieving a 10% reduction in laboratory utilization and averaged a reduction of 20% laboratories per patient day over the course of 9 months.

Special cause variation was identified early into the lead-in period with several possible explanations. Surveying of physicians about laboratory utilization in the MICU during the planning phases may have contributed to practice changes. We had also been in discussions with our colleagues in the division of nephrology to routinely assess for reduction in the frequency of laboratory monitoring for patients who were stable on continuous RRT. Finally, given that this initiative was led by critical care trainees and staff with significant buy-in, it is likely that individual practice patterns began to change even before the formal
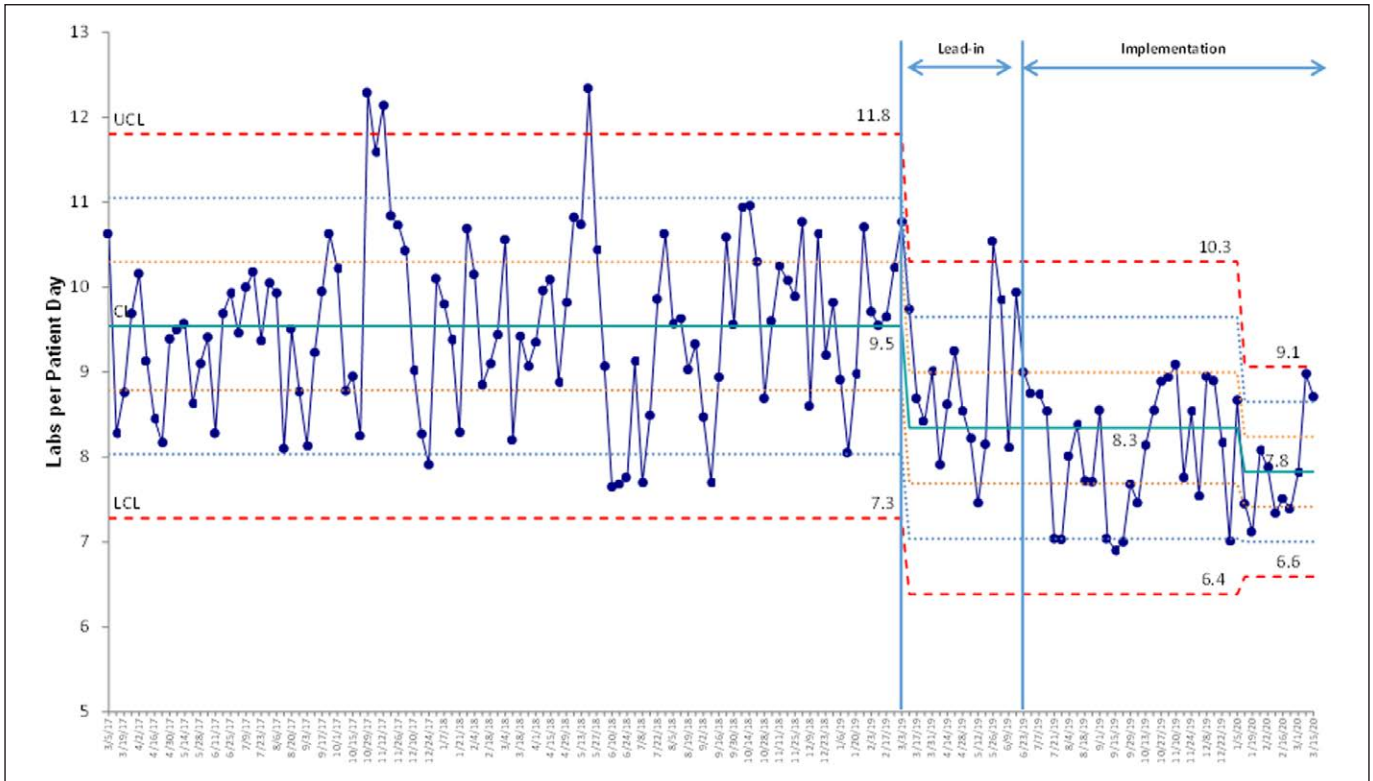
Figure 2. XmR control chart showing laboratory utilization in the 24-bed medical ICU depicted as laboratories per patient day. Center *line* (*teal*), upper control limit (UCL), and lower control limit (LCL) (*red dash*), 1 sigma variation (*orange dash*), and 2 sigma variation (*blue dash*) are denoted. The benchmark utilization level is obtained by averaging data from March 5, 2017, until the beginning of the lead-in period on March 3, 2019. Note down shift in process center *line* due to special cause variation during the lead-in and implementation periods.
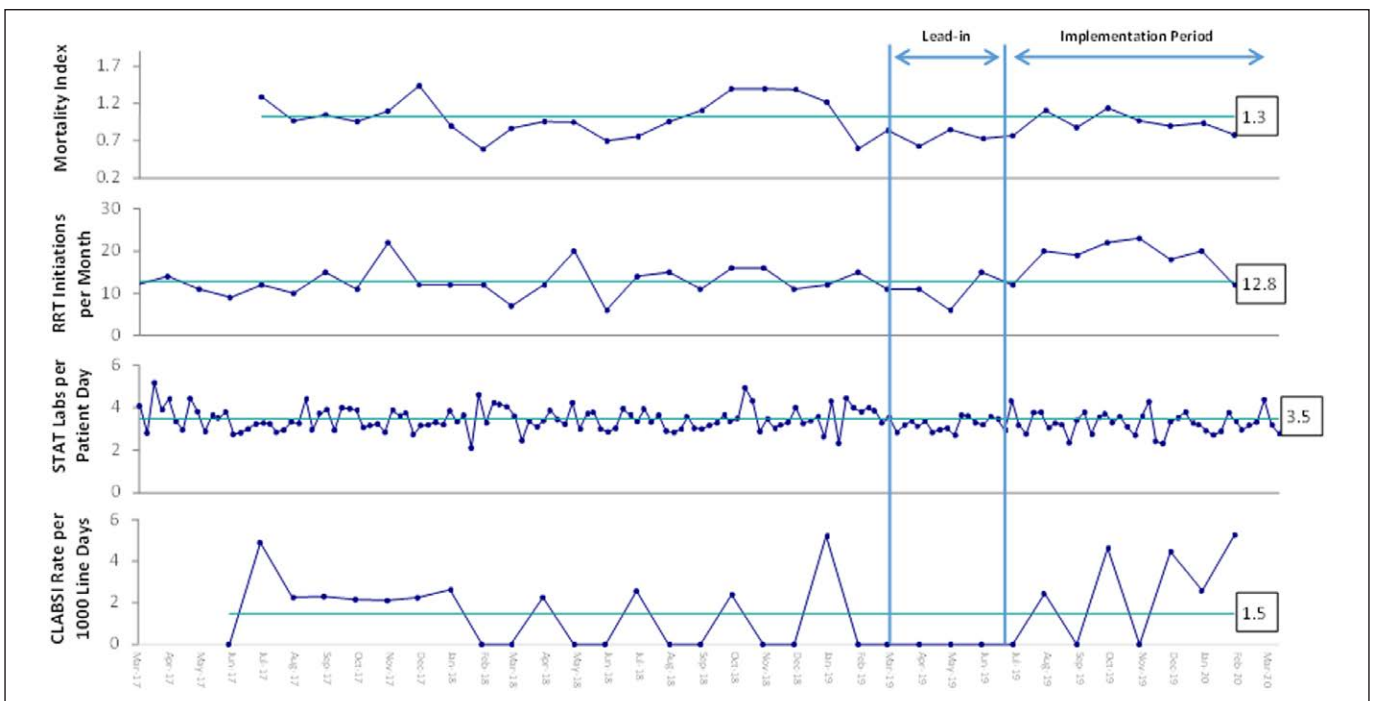

Figure 3. Run charts of counterbalance metrics for the 24-bed medical ICU. Center *line* reflects average values. No significant sustained changes are noted. CLABSI = central catheter-associated bloodstream infection, RRT = renal replacement therapy.

structured roll out of interventions. These findings speak to the degree to which laboratory utilization behaviors are reflective of team culture, perhaps more than hard-wired workflow processes.

Special cause variation was identified again in the final months of our data with a further reduction in control limits likely due to a cumulative effect from our interventions. As a result, our initiative did not reach a phase of true control. Our data collection ended in March 2020 as our MICU began to care for patients with infectious COVID-19. As a novel disease, there were many clinical unknowns that resulted in dramatic changes to MICU workflow, and it was decided that pausing the initiative would be best.

The cost savings from this quality improvement project are substantial. Although real costs are difficult to estimate, using laboratory code charges, savings for the 24 beds averaged about $29,800 per week during our implementation phase. Analyses of the secondary outcome of transfusion rates proved to be difficult due to wide variations in monthly transfusion rates. There were no obvious trends for mortality, RRT initiation rates, stat laboratories, or CLABSI rates. In all, these data suggest that the achieved reductions in testing were not associated with adverse outcomes.

These findings are in line with several other studies that have demonstrated that a multifaceted approach to reducing laboratory utilization results in a more robust effect (6–9). Furthermore, interventions aimed at changing behavior have also demonstrated more sustainable success (10, 11). Education alone is associated with mixed results, partly due to the fact that education must be a continual process with frequent reinforcement (12). Although challenging and time consuming, we did find that meeting with each new MICU resident team was crucial to maintaining our momentum. Interestingly, the surveys revealed discordance between attending and resident physician expectations about the need for daily testing, and we worked to reconcile that. Partnering with our medical center's bioinformatics division proved to be invaluable to the success of our initiative. By getting access to existing reporting systems, we were able to set up customized and automated weekly utilization reports that allowed us to effortlessly track the data closely and iteratively evaluate our interventions as changes occurred. Future plans include using this tool to give each MICU unit weekly feedback on their levels of laboratory utilization.

This single-center experience limits the generalizability of our interventions as there may be different root causes to overutilization at other institutions; however, the process itself is universal. Second, because multiple interventions were performed at once, it is not possible to assess the effectiveness of individual interventions. We did not perform any adjustment for severity of illness or other patient-level factors as it was assumed that these variables, on average, remain relatively stable over time. As a graduating fellow-driven project, one challenge will be to find a way to sustain the project. Some of our interventions have been permanently incorporated into MICU operations including the changes to the order sets and rounding checklists. However, new process ownership is necessary, and to this end, we have engaged vested interests in hospital and MICU leadership. We also sought collaboration with other groups that are working on reducing unnecessary laboratory utilization including the surgical ICU and hospital medicine. The established laboratory utilization reporting system will be key to facilitating a resumption of the initiative as hospital functions begin to normalize amidst the ongoing COVID-19 pandemic. More longitudinal data may also help better inform of any effect from laboratory utilization on transfusion rates.

CONCLUSIONS

A sustained reduction in inappropriate laboratory use in the MICU can be implemented safely and effectively by using a multidisciplinary approach and applying a multifaceted process and quality improvement model.

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