

**Application of a *Clostridium difficile* Diagnostic Algorithm  
to Decrease Hospital-Occurring Infections**

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### Abstract

**Problem:** A geriatric specialty unit within a community hospital has an average monthly rate of two per 1000 patient days of hospital-occurring *Clostridium difficile* infections. A knowledge deficit among nursing staff regarding *Clostridium difficile* was identified as a potential cause of inappropriate testing.

**Purpose:** To implement a *Clostridium difficile* diagnostic algorithm to eliminate overuse of *Clostridium difficile* testing and obtain more accurate rate of infections.

**Methods:** An evidence-based *Clostridium difficile* diagnostic algorithm was implemented and evaluated over 14-weeks to increase the nursing staff's ability to identify the appropriate patients for obtaining diagnostic samples. Algorithm education was provided to registered nurses and patient care technicians and measured by rate of completion. Weekly chart reviews on collected tests, measured the rate of appropriate *Clostridium difficile* tests and the rate of intensive care unit transfers related to *Clostridium difficile*. The rates of positive and hospital-occurring *Clostridium difficile* were measured by weekly extraction of lab data.

**Results:** There was an 82% (n=62) education completion rate among staff. Appropriate *Clostridium difficile* testing increased from 14% (n=7) to 76% (n=18) (p=.02). The rate of hospital-occurring *Clostridium difficile* infections increased from 0% (n=7) to 14% (n=21), and positive infections decreased from 29% (n=7) to 14% (n=21); neither were statistically significant. There were zero critical care transfers.

**Conclusion:** A *Clostridium difficile* diagnostic algorithm increased the number of appropriate tests performed. The algorithm was found to be feasible to use with low cost. To maintain these results, a continuation of unit feedback on *Clostridium difficile* results and additional training is necessary.

## Introduction

Hospital-occurring *Clostridium difficile* infections (HO-CDI) continue to affect nearly 69,648 citizens every year, contributing a national one to five-billion-dollar yearly economic burden (Centers for Disease Control, 2018). A community hospital in the state of Maryland continues to have a higher rate of HO-CDI than the state and national average, as well as a standardized international ratio (SIR) greater than the national benchmark of one and the state benchmark of 0.8, resulting in financial penalties (Maryland Health Care Commission, 2018). In a geriatric-specialty unit of this community hospital, there has been a monthly average of two per 1000 patient days of HO-CDI, more than the national benchmark of zero. The hospital Infection Control Director found healthcare providers were bypassing the clinical decision support tools resulting in inappropriately administered diagnostic tests, likely due to a knowledge gap of CDI clinical indicators. Inappropriate testing for *C. difficile* increases false-positive results, thus increasing unnecessary antibiotic use along with financial penalties for hospitals (Johnson et al., 1992; Polage et al., 2015).

The geriatric population is more likely to be carriers of *C. difficile* resulting in false-positive results increasing unnecessary antibiotic use. Due to polypharmacy and declining liver and kidney function, this population is particularly at risk for adverse effects and drug interactions (Beckett et al., 2014). The purpose of this quality improvement project was to implement a *Clostridium difficile* diagnostic algorithm to improve the rate HO-CDIs in the geriatric specialty unit. It was anticipated that the implementation of the algorithm would decrease inappropriate testing for *C. difficile*, subsequently decreasing false-positive results and improving HO-CDI.

## Literature Review

The literature review has provided an evidence synthesis supporting the application of a *Clostridium difficile* diagnostic algorithm. The review includes studies that have implemented a *Clostridium difficile* diagnostic algorithm or decision tree and found increased testing fidelity while decreasing the rate of HO-CDI and SIR. The quality of evidence was evaluated and determined using Polit and Beck (2017) and O'Mathuna and Fineout-Overholt (2015) while grading was assigned using Newhouse (2006) and the Agency for Healthcare Research and Quality (2014) (Appendix A & B).

Implementing of a *Clostridium difficile* diagnostic algorithm or decision tool was found to increase the number of tests that met the national guidelines clinical criteria, thus improving testing fidelity (Fleming et al., 2019; Friedland et al., 2019; White et al., 2017). In a retrospective cohort study, Fleming et al. (2019) found the implementation of a diagnostic decision tool increased the number of results that met testing criteria from 310 to 324 ( $p < .0001$ ). Likewise, the quasi-experimental study by Friedland et al. (2019) found that implementing a diagnostic clinical support tool increased the percentage of appropriate tests from 40% to 53% ( $p = .004$ ). Conversely in the retrospective cohort by White et al. (2017), found implementation decreased the percentage of appropriate tests from 27.6% to 26.2%; however, these results were not statistically significant ( $p = .62$ ). Across the studies of adults in the acute care setting, there appears to be moderate-quality evidence (III-IV, A-B) demonstrating that the *Clostridium difficile* diagnostic algorithm may increase the number of tests that meet the national guidelines testing criteria (Appendix A & B).

The implementation of a *Clostridium difficile* diagnostic algorithm or decision tool was found to reduce the rate of HO-CDI (Christensen et al., 2019; Fleming et al., 2019; Madden et al., 2018; Quan et al., 2018). In a quasi-experimental study, Christensen et al. (2019) found a

reduction in the monthly rate of HO-CDI from 8.5 to 6.5 per 10000 ( $p=.0036$ ) after implementing a testing algorithm. Fleming et al. (2019) also found a reduction in the rate HO-CDI from 11.446 to 7.209 per 10000 patient days ( $p<.0300$ ). Similarly, in a retrospective cohort, Madden et al. (2018) saw a decrease of HO-CDI by 31% ( $p=.001$ ). Likewise, Quan et al. (2018), in a prospective cohort found a reduction of HO-CDI by 56% ( $p<.001$ ). Across the studies of adults in the acute care setting, there appears to be a moderate quality evidence (III-IV, B), demonstrating that implementing a *Clostridium difficile* diagnostic algorithm may reduce the rate of HO-CDI (Appendix A & B).

The implementation of a *Clostridium difficile* diagnostic algorithm or decision tool was found to reduce the hospital's SIR of HO-CDI (Christensen et al., 2019; Fleming et al., 2019; Quan et al., 2018). Christensen et al. (2019) found a reduction in the hospital SIR from a rate of 0.97 to 0.78 ( $p=.015$ ). The reduction was also found by Fleming et al. (2019), 1.424 to 0.952 in the SIR; however, the significance was not reported. Lastly, Quan et al. (2018) had a similar reduction in the quarterly SIR by 51% ( $p<.001$ ). Across the studies of adults in the acute care setting, moderate-quality evidence (III-IV, B) demonstrates that the implementation of a *Clostridium difficile* diagnostic algorithm may reduce the rate of SIR in the hospital. However, the reduction may be greater if implemented hospital-wide (Appendix A & B).

### **Theoretical Framework**

Lewin's Change Theory provides a comprehensive understanding of how the implementation of the *Clostridium difficile* algorithm will affect the unit staff's behavioral response. The theory consists of three stages that must be achieved to be successful. The unfreezing stage consists of recognizing the deficiencies as well as the awareness of the behaviors needing reform. This stage requires the encouragement of the needed change, with

strong managerial support while understanding and managing the barriers that arise. The change stage, involves planning for the desired changes, implementing an intervention to achieve the outcome, and assisting employees in learning the new concepts. In the final phase, the refreezing stage, the changes are reinforced and integrated into the workflow while developing ways to sustain the change and celebrate success (Manchester et al., 2014).

The theoretical concepts were incorporated into the implementation of the algorithm to support the sustainability of the intervention. The unfreezing stage was utilized in the evaluations to ascertain the root cause of the elevated hospital-occurring *Clostridium difficile* infections and conducted a unit assessment to identify facilitators and barriers of the algorithm. The concepts of the change stage involved project planning and encouragement in the usage of the algorithm. These concepts were utilized during the training on *Clostridium difficile* infections and the algorithm, the reinforcement of the algorithm by placing copies around the unit, providing a pocket-size algorithm, and a staff feedback box. The concepts of the refreezing stage focus on a sustainable workflow as well as celebrating success. These were leveraged by providing performance feedback, the unit champion's reinforcement of staff buy-in, the potential of incorporating the algorithm into new staff orientation.

### **Methods**

The project was performed on the geriatric-specialty unit consisting of 34-beds with approximately 150 patients per month involving 42 registered nurses and 34 patient care technicians (PCT) with the guidance of the MAP-IT framework. Unit-specific facilitators and barriers were identified using the Context Assessment Index (Appendix C, McCormick et al., 2009). Unit features that were utilized included the unit's learning culture, leadership engagement and priority for CDI improvement, and staff-nursing leadership relationships.

Barriers were identified as poor collaboration between staff and healthcare providers, and lack of feedback on unit-specific HO-CDI rates. Inclusion criteria consisted of patients with *C. difficile* samples collected on the unit, unit nurses, and unit PCTs.

The project team consisted of the infection control director and practitioner, the unit director and educator, a physician liaison, and two-unit champions. The algorithm consisted of the Infectious Diseases Society of America (IDSA)/Society for Healthcare Epidemiology of America (SHEA) for *C. difficile* testing. The algorithm was placed around the unit to be referenced before provider notification on stool description and need for testing (Appendix D). Nurses and PCT received a one-week in-service training during unit huddles and an on-line education presentation with email reminders (Appendix E). Staff received pocket algorithms as a reference (Appendix F). After a decline in algorithm compliance, daily huddle reminders and weekly *C. difficile* bulletins were emailed to staff then placed around the unit (Appendix G). A suggestion box was provided for staff feedback (Appendix H).

The structure measure evaluated the completion rate of the on-line education by nurses and PCTs. The process measure evaluated algorithm compliance by the rate of appropriate *C. difficile* diagnostic samples as per the recommendations for *C. difficile* testing by the IDSA/SHEA guidelines and were used in the studies of Christensen et al. (2019), Fleming et al. (2019), Friedland et al. (2019), and White et al. (2017) (McDonald et al., 2018). The outcome measures include the rate of HO-CDI and the rate of positive CDI, endorsed by the National Health Safety Network and the IDSA/SHEA as well as the studies completed by Christensen et al. (2019), Fleming et al. (2019), Friedland et al. (2019), and White et al. (2017). The balance measure evaluated the rate of CDI-related intensive care unit (ICU) transfers; this was used in a study completed by White et al. (2017).

The results of the training completion were placed in the On-line Education Competition of Training Audit Tool, and ensuing skills were evaluated by the *C. difficile* post-education test (Appendices I & J). Weekly chart reviews evaluated appropriate diagnostic testing and ICU transfers during pre- and post-intervention periods using the Patient Chart Review Audit Tool (Appendix K). The weekly rate of positive CDI and HO-CDI were obtained from the collected lab tests and results were placed in the *C. difficile* Testing Audit Form (Appendix L). All data measures were analyzed using run-charts and were assessed by comparing the pre- and post-algorithm collection periods. The charts were evaluated weekly for trends after implementing the algorithm and various tactics, where the tactics were labeled to assess for data aberrations. The process and outcome measures were analyzed for significance using a two-tailed Fisher Exact Test.

The project proposal was submitted to the University of Maryland Baltimore Human Research Protection Office and the organizational Institutional Review Board, where it was determined to be non-research. To protect personal health information, completed training tests were discarded, all extracted diagnostic data remained anonymous, and addition, all project files were destroyed.

### **Results**

The purpose of implementing the *C. difficile* diagnostic algorithm was to bridge the *C. difficile* knowledge gap among nursing staff, with the desired goal of zero HO-CDI. In order to attain the project goal, on-line education was provided with a goal of 100% completion by September 26, 2020. Due to an unintended on-line education presentation delay, the completion date was extended to October 31, 2020. Despite the extension and weekly email reminders, this goal was not met due to an education completion rate of 82% (n=62). This coincided with

increasing COVID-19 pandemic numbers and an absence of several unit staff due to the Family and Medical Leave Act.

There was a small improvement in appropriate testing following education completion and algorithm initiation; however, this was not sustained. The goal of 100% appropriate *C. difficile* testing was not met until six-weeks post-algorithm and was sustained through December 22, 2020; the final chart review (Figure 1). This arose following the initiation of the weekly *C. difficile* Bulletin provided in emails, huddles, and unit posters. There was a 62% increase in appropriate *C. difficile* testing from 14% (n=7) pre-algorithm to 76% (n=18) post-algorithm (p=.02). The algorithm use was not associated with an increase in ICU transfers; there were zero transfers during the pre-algorithm and post-algorithm period.

The goal of obtaining zero HO-CDI was met on post-algorithm week 4; however, this was only maintained for three weeks (Figure 2). A true-positive result occurred following the administration of an antibiotic to a patient a week earlier. Following this incident, the goal of zero HO-CDI was re-attained for four additional weeks through project completion on December 31, 2020.

Moreover, there was a 14% increase in the rate of HO-CDI pre-and post-algorithm, 0% (n=7) to 14% (n=21), but this was not found to be statistically significant (p=.55, Figure 2). It should be noted that after the achievement of 100% appropriate *C. difficile* testing, there were zero false-positive results (Figure 1 & 2). In addition, the total positive *C. difficile* results from pre- to post-algorithm decreased from 29% (n=7) to 14% (n=21), although this was not a statistically significant difference (p=1).

During the education-implementation period, the algorithm was found to be feasible to use with low cost. Also, the organization's current use of an on-line education platform,

facilitated the initiation of the educational presentation. During the pandemic with reliance on email communication, the necessity for remote-working, contributed to mis-communication and failure to start the on-line education on the anticipated start date. To overcome this delay, in-person education was performed. The in-person education provided further insight into the staff's baseline education and influenced future tactics such as the *C. difficile* weekly bulletin. An early barrier that was encountered, was the healthcare provider's continued bypassing of the computerized soft- and hard-stops for ordering *C. difficile* tests by healthcare providers. After launching the *C. difficile* bulletin, there was an improvement in appropriate *C. difficile* testing. Lastly, a pizza party was planned for the QI project completion; however, due to the pandemic and increased organizational restrictions, the party could not be provided.

### **Discussion**

In this quality improvement project, a diagnostic algorithm was implemented and evaluated to assess its effectiveness in reducing HO-CDI in an acute care geriatric population. Following its implementation there was a statistically significant increase in appropriate *C. difficile* testing. These findings are consistent with the studies completed by Fleming et al. (2019), Friedland et al. (2019), and White et al. (2019), who found statistically significant improvement in appropriate *C. difficile* testing. Additionally, the implementation of the algorithm was not associated with increased CDI complications requiring critical care transfer, consistent with the findings of White et al. (2017); suggesting that the algorithm did not discourage or delay testing that could result in complications.

There was a small decrease in the rate of positive CDI results following the implementation of the algorithm. Although the difference was found to be insignificant, the decline was consistent with the findings of Christensen et al. (2019) and Friedland et al. (2019);

both of whom found a statistically significant decrease. On the contrary, White et al. (2017) found no change in the rate of positive CDI, for which the author's attributed these results to the decision tool did not discourage individuals from testing. A discrepancy was found by Madden et al. (2018) and Thompson et al. (2016), who noted an increase in their positive CDI results, but neither were statistically significant.

An increase was observed in the rate of HO-CDI following the initiation of the algorithm; this result was different from the findings of Christensen et al. (2019), Fleming et al. (2019), Madden et al (2018), and Quan et al. (2018), all of whom found a significant decrease in the rate of HO-CDI. Although there was an increase in the rate of HO-CDI, when algorithm compliance was 100% there were zero false-positive results; this shows an inverse relationship between appropriate testing and false-positive HO-CDI. In November, there was a true-positive HO-CDI following the usage of an antibiotic. This finding demonstrates that the algorithm eliminates false positive HO-CDI results without affecting the identification of true-positives.

A possible explanation for the HO-CDI results could be the preceding healthcare provider education presented by the infection control practitioner in June and July of 2020, just before the August pre-implementation data collection period, when there were zero HO-CDI. An additional factor was the exclusion of the healthcare providers participation in the project. This placed considerable reliance on nursing staff's influence on healthcare provider actions on a unit where the culture of provider-nurse collaboration was strained. Lastly, the lack of antibiotic stewardship component within the project could have influenced the observed findings. This was evident in the one true-positive HO-CDI after algorithm compliance was met.

This project has several limitations to the generalizability of the findings. First, the quality improvement projects are context specific and non-random samples. Thus, these results

are not generalizable. The implementation context for this project was twenty-one patients on one unit over the short project duration of fourteen weeks. Third, the project methodology of assessing appropriate *C. difficile* testing was limited to those who received *C. difficile* tests; therefore, one cannot infer the influence that the algorithm has on those who did not receive testing, potentially leading to missed results. This quality improvement project is not generalizable to other units.

### **Conclusion**

The application of a *C. difficile* diagnostic algorithm significantly increased the rate of appropriate *C. difficile* testing. Although the implementation did not eliminate all HO-CDI, it did eliminate false-positive results without affecting the identification of true-positives when consistently used. By reducing false-positive results, there was a decrease in potential adverse effects related to inappropriate antibiotic use. Additionally, there are financial benefits for hospitals that significantly decrease the monthly rate of HO-CDI by avoiding the penalties attributed to rates above the SIR benchmark.

This quality improvement project's strengths included the feasibility and low cost of the algorithm for continued use. Additionally, the on-line education presentation can easily be used for new staff orientation and educational reinforcement to maintain results. Lastly, the unit was provided needed feedback via the *C. difficile* Bulletin. Before this feedback, staff were unaware of their subpar HO-CDI rates or the financial implications it caused. Continuing this feedback will sustain the improvements that were achieved.

Future quality improvement projects may ascertain the generalizability and further investigate the association an algorithm has in improving HO-CDI outcomes. Projects that provide staff weekly results and compliance feedback, will likely show improvement in

algorithm compliance. Lastly, projects that incorporate an antibiotic stewardship component and include healthcare providers will likely show improved HO-CDI outcomes.

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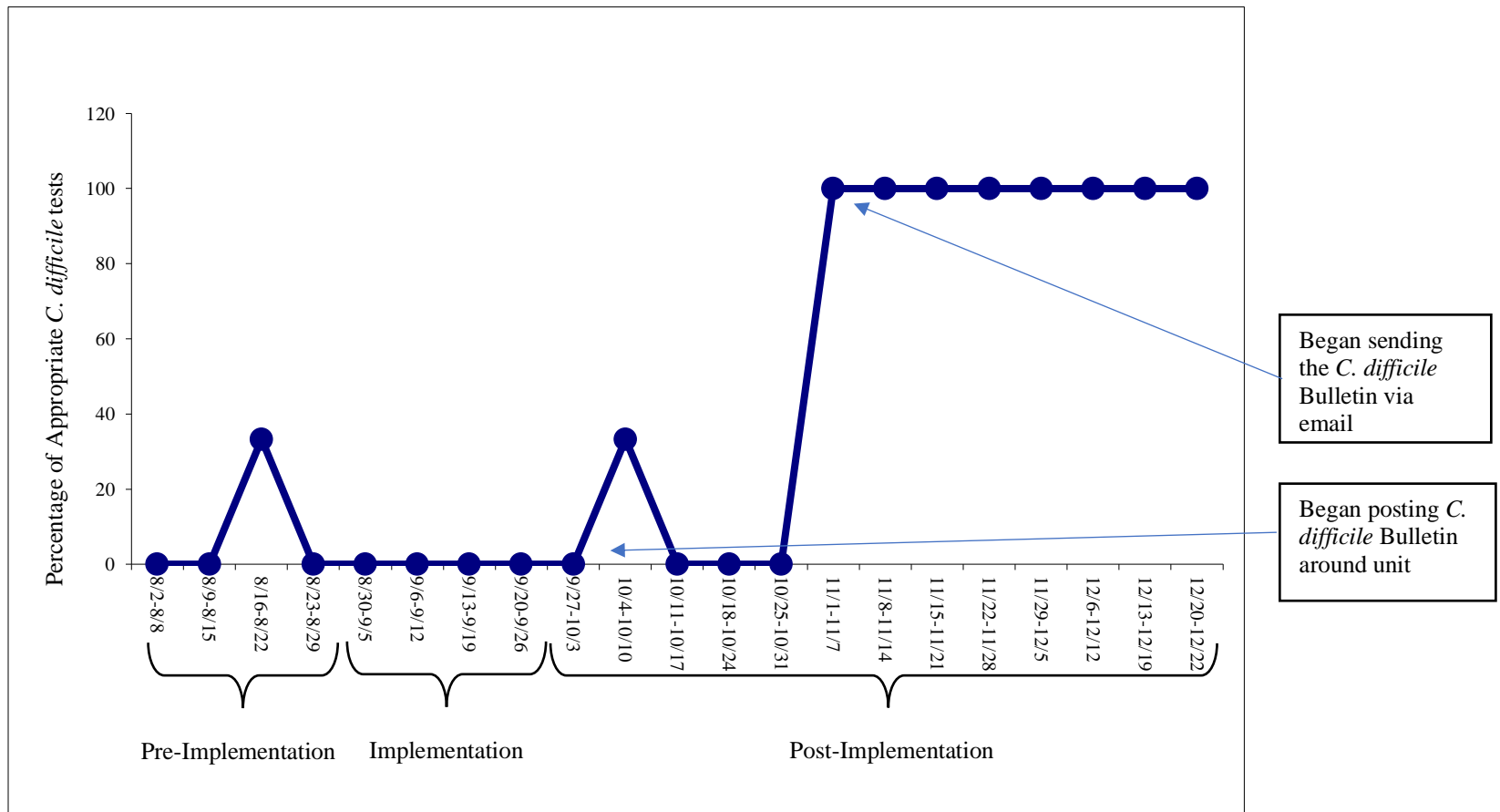
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**Figure 1**

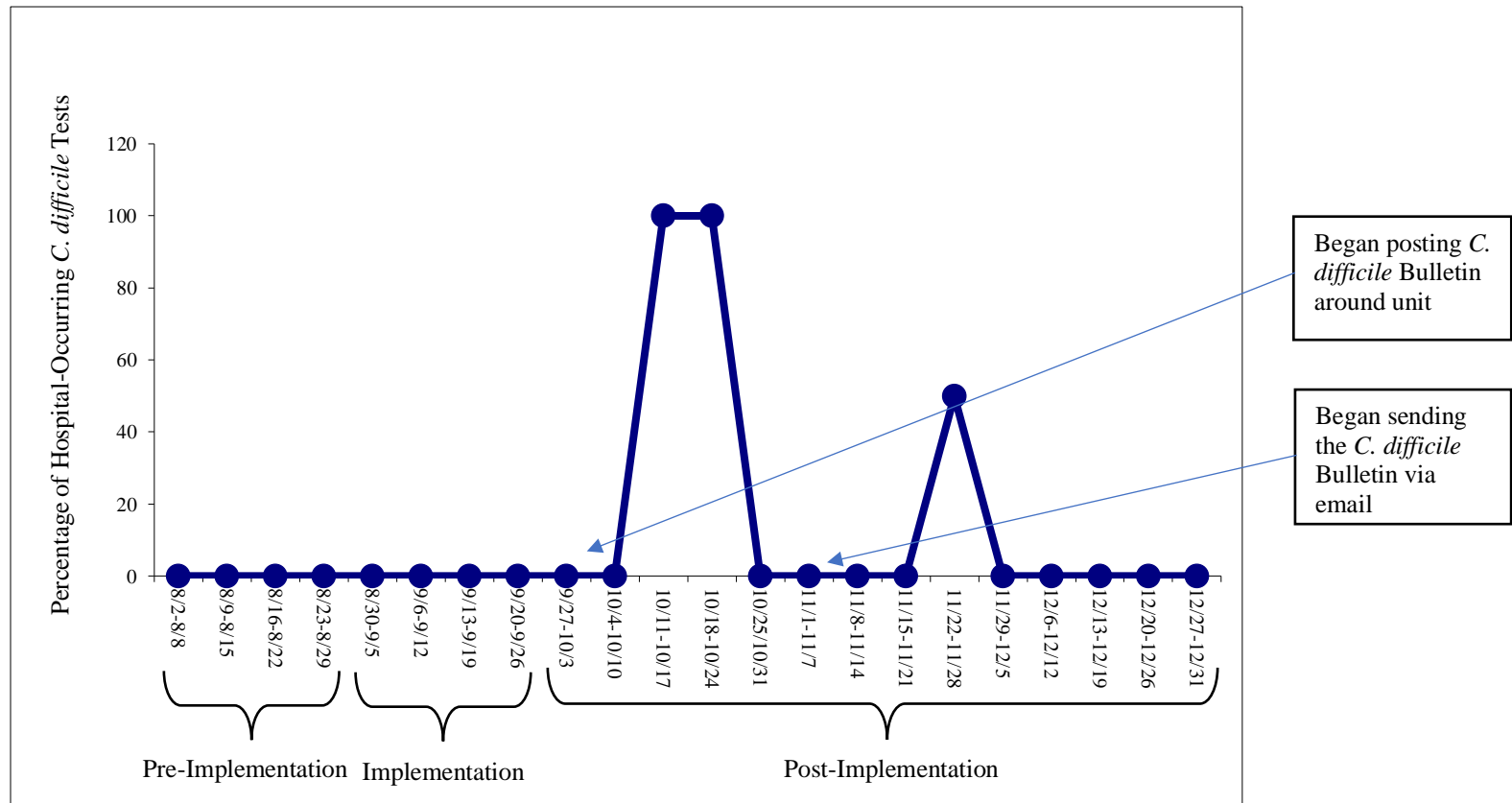
*Appropriate Clostridium difficile Tests Over Time*



*Note.* There was a 62% increase in appropriate *C. difficile* tests from the pre-implementation period (14%, n=7) to the post-implementation period (76%, n=18); p=.02.

**Figure 2**

*Hospital-Occurring Clostridium difficile Tests Over Time*



*Note.* There was a 14% increase in hospital-occurring *C. difficile* tests from the pre-implementation period (0%, n=7) to the post-implementation period (14%, n=21); p=.55.

Appendix A

Evidence Review Table

Citation: Christensen, A. B., Barr, V. O., Martin, D. W., Anderson, M. M., Gibson, A. K., Hoff, B. M., Sutton, S. H., Widmaier, V., Salim, A. A., Silkatitis, C., Qi, C., Zembower, T. R., Postelnick, M. J., & Rhodes, N. J. (2019). Diagnostic stewardship of <i>C. difficile</i> testing: A quasi-experimental antimicrobial stewardship study. <i>Infection Control &amp; Hospital Epidemiology</i> , 40(3), 269-275. <a href="https://doi.org/10.1017/ice.2018.336">https://doi.org/10.1017/ice.2018.336</a>					Level: III
Purpose/ Hypothesis	Design	Sample	Intervention	Outcomes	Results
“We evaluated whether a diagnostic stewardship initiative consisting of ASP preauthorization paired with education could reduce false-positive hospital-onset (HO) <i>Clostridium difficile</i> infection (CD)”	Quasi-experimental study control vs. intervention, one hospital	<p><b>Sampling Technique:</b> Convenience</p> <p><b>Eligible:</b> All adults that were admitted as inpatients during January 2014 to April 2018.</p> <p>Control: Patients admitted to the stem cell transplant unit.</p> <p>There was no clear statement of the total number of the samples that were evaluated, only the number of HA-CDI samples was 743.</p> <p>There was no clear statement of the control or intervention number, nor was there a statement of power analysis of group homogeneity.</p>	<p><b>Control:</b> Non-intervention units</p> <p><b>Intervention:</b> NAAT algorithm and protocol, EHR, education</p> <p><b>Intervention fidelity</b> (describe the protocol): There was a hospital-wide education on appropriate use of NAAT, how to avoid inappropriate testing, clinical false positives, and pre-disposing risk factors for <i>C. difficile</i>. During rounds, all individuals received formal education materials and the testing algorithm, an email from the specialist groups, and were posted on the hospital intranet resource. ASP team</p>	<p><b>Dependent Variable:</b></p> <p>Primary Outcome: The change in the rate of hospital-acquired (HA) <i>C. difficile</i> infections (CDI) per 10,000 patient days.</p> <p>Secondary Outcome: 1. Change in monthly CDI SIR 2. Amount of consumption of oral vancomycin days per therapy per 1000 patient days</p> <p><b>Measurement tool:</b> <i>C. difficile</i> samples were tested using NAATs, using PCR amplification for toxin B, as per manufacture protocol. Only liquid samples were excepted and they were screened twice a day at 8 A.M. and 4 P.M, and were</p>	<p><b>Statistical Procedures:</b></p> <p>1. The student t test or Wilcoxon ran-sum tests were used to analyze the before and after differences in the following outcomes: HA-CDI, SIR, and vancomycin oral consumption</p> <p>2. Regression analysis was used to evaluate the DV as a function of time-dependent predictors.</p> <p><b>Results:</b></p> <p>1. There was a decrease in the amount of monthly positive NAAT results from 15.4 (pre) to 12.4 (post) with a p = .018.</p> <p>2. There was a decrease in the amount of monthly HA-CDI from</p>

			members would alert providers if clinical and/or lab criteria were not met, and would notify them of test cancellation if the criteria were not met.	tested at 8 A. M. All specimens that were sent within 7 days of a prior <i>C. difficile</i> test were automatically rejected. All positive NAAT results on day 4 or later of the patient’s admission were reported to NHSN, as a hospital acquired <i>C. difficile</i> infection.	8.5 (pre) to 6.5 (post) per 10000 patient days, p = .0036. 3. There was a decrease in the SIR from 0.97 (pre) to 0.78 (post), p = .015. 4. There was no significant difference in the consumption of vancomycin 10.7 (pre) to 10.8 (post), p =.91. 5. Control: The mean HA-CDI rate was 32.8 +/- 19.8 per 10,000 days, and the mean was similar to the pre/post intervention or 36.5 vs 30.3 per 10,000 patient days; p=.34.
Citation: Fleming, M. S., Hess, O., Albert, H. L., Styslinger, E., Doll, M., Nguyen, H. J., McAulay-Kidd, S., Hemphill, R. R., Srivastava, T., Cooper, K. D., Stevens, M. P., & Bearman, G. (2019). Test stewardship, frequency, and fidelity: Impact on reported hospital-onset Clostridiodes <i>difficile</i> . <i>Infection Control &amp; Hospital Epidemiology</i> , 46(6), 716-712. <a href="https://doi.org/10.1017/ice.2019.63">https://doi.org/10.1017/ice.2019.63</a>					Level: IV
Purpose/Hypothesis	Design	Sample	Intervention	Outcomes	Results
“We assessed the impact of heightened <i>C. difficile</i> diagnostic test stewardship with a Cerner electronic medical record (EMR) based decision support algorithm”	Retrospective cohort, one hospital	<b>Sampling Technique:</b> Convenience  <b>Eligible:</b> All inpatient stool samples tested with NAAT. No exclusions were stated. <b>Accepted:</b>	<b>Control:</b> Pre-algorithm intervention  <b>Intervention:</b> Cerner electronic <i>C. difficile</i> decision support algorithm.  <b>Intervention fidelity:</b>	<b>Dependent Variable:</b> 1. Total of <i>C. difficile</i> tests completed 2. Testing Fidelity 3. Rate per 10000 patient days of hospital onset, <i>C. difficile</i> NHSN rate 4. SIR, hospital onset <i>C. difficile</i>	<b>Statistical Procedures:</b> The authors used a z-test to analyze the test fidelity pre-and post-intervention.  <b>Pre-Post Results:</b> 1. Total of <i>C. difficile</i> tests completed:

		<p>There was a total of n = 1513 stool samples that were completed  <b>Control:</b>                  There was a total of n = 874 stool samples that were completed prior to intervention  <b>Intervention:</b>                  There was a total of n = 639 tests</p> <p>Power analysis: It was not stated that it was completed</p> <p>Group homogeneity was not described.</p>	<p>Testing fidelity was reported monthly. Testing fidelity was confirmed with a retrospective EMR review if tested patient had diarrhea on days 1-3, 3 or more loose stools within 24 hours on or after day 4, no laxative use within 24 hours, and additional symptoms or risk: a fever of greater than 38 degrees Celsius, abdominal pain/tenderness within 48 hours, a WBC count &gt; 15000 or &lt;4000 within 48 hours, antibiotic use, or discharged from any healthcare facility within 30 days of testing. Otherwise, the test fidelity would be denied.</p>	<p><b>Measurement tool:</b>                  All stool samples were tested using NAAT testing. Audits. Retrospective chart review for test fidelity.</p>	<p>There was a 27% reduction in the total testing from pre- to post-intervention that was statistically significant, p&lt;.0001.                  2. Testing Fidelity: There was an increase of the results meeting test criteria from 310 (pre) to 324 (post) that was statistically significant, p&lt;.0001.                  3. Rate per 10000 patient days of hospital onset, <i>C. difficile</i> NHSN rate: There was a reduction in hospital acquired <i>C. difficile</i>, from a rate of 11.446 (pre) to 7.209 (post), that was statistically significant, p&lt;.0300.                  4. SIR, hospital onset <i>C. difficile</i>: Due to the decrease in the HAI CDI, there was a drop in the SIR from 1.424 to 0.952.</p>
<p>Citation: Friedland, A. E., Brown, S., Glick, D. R., Lusby, M. C., Lemkin, D. &amp; Leekha, S. (2019). Use of computerized clinical decision support for diagnostic stewardship in <i>Clostridioides difficile</i> testing: An academic hospital quasi-experimental study. <i>Journal of General Internal Medicine</i>, 34(1), 31-32. <a href="https://doi.org/10.1007/s11606-018-4659-4">https://doi.org/10.1007/s11606-018-4659-4</a>.</p>					<p>Level: III</p>
<p>Purpose/Hypothesis</p>	<p>Design</p>	<p>Sample</p>	<p>Intervention</p>	<p>Outcomes</p>	<p>Results</p>

<p>“We conducted a quasi-experimental study to evaluate the impact of CCDS on appropriateness of <i>C. difficile</i> testing”</p>	<p>Quasi-experimental study, crossover design one hospital.</p>	<p><b>Sampling Technique:</b> Convenience</p> <p><b>Eligible:</b> Consecutive hospitalized patients that were undergoing <i>C. difficile</i> testing There was no exclusion that was noted. Pre-intervention 2/19/16-3/19/16 and post-intervention 1/21/17 – 2/19/17.</p> <p><b># Accepted:</b> n = 442 <b>Pre-intervention Group:</b> n = 280 patients <b>Post-Intervention:</b> n = 167 patients</p> <p>It was not stated that power analysis was completed.</p> <p>Group Homogeneity was found to be insignificant.</p>	<p><b>Control:</b> Pre-intervention</p> <p><b>Intervention:</b> Implementation of four alerts based upon diarrhea documentation, usage of laxatives, prior <i>C. difficile</i> test, and the potential of unnecessary testing with the ability to delete the order.</p> <p><b>Intervention fidelity:</b> There was education that was electronically sent, on the four alerts.</p>	<p><b>Dependent Variable:</b> 1. The number of positive <i>C. difficile</i> tests 2. The number of testing in clinical indicated (all patients) 3. The number testing of clinically indicated with patients with positive tests.</p> <p><b>Measure:</b> The dependent variable was measured using NAAT testing. There is no reliability, time, or procedure disclosed.</p>	<p><b>Statistical Procedures(s)</b> Chi-square tests were completed by the authors.</p> <p><b>Results:</b> Pre-intervention vs. post-intervention</p> <p>There was a decrease in the number of positive <i>C. difficile</i> tests from 13% to 11%.</p> <p>Testing:</p> <ol style="list-style-type: none"> <li>3 or more loose stools per day: There was more testing of 3 or more loose stools from 60% to 69% (post), that was statistically significant, p = .04.</li> <li>Any loose stool with abdominal cramping: There was a greater amount of testing loose stool with abdominal cramping from 43% (pre) to 57% (post) and was statistically significant, p = .02.</li> <li>Clinically significant diarrhea had greater testing from 60% (pre) to 75% (post) and the difference was statistically significant, p = .04.</li> </ol>
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					<p>4. Laxative use in 48 hours: Testing after laxative use in 48 hours decreased from 46% (pre) to 37% (post), that was statistically significant, <math>p = .03</math>.</p> <p>5. Repeat testing on same admission: There was a decrease in repeat testing from 31% to 26% (post), but this was not statistically significant <math>p = .20</math></p> <p>6. All patient clinically indicated: Increased from 40% (pre) to 53% (post) was statistically significant, <math>p = 0.004</math></p> <p>8. Clinically indicated with positive tests: Increased from 53% (pre) to 69% (post) was not statistically significant, <math>p = 0.20</math></p>
<p>Citation: Madden, G. R., German Mesner, I., Cox, H. L., Mathers, A. J., Lyman, J. A., Sifri, C. D., &amp; Enfield, K. B. (2018). Reduced Clostridium <i>difficile</i> tests and laboratory-identified events with a computerized clinical decision support tool and financial incentive. <i>Infection Control &amp; Hospital</i>, 36(6), 737-740. <a href="http://doi.org/10.1017/ice.2018.53">http://doi.org/10.1017/ice.2018.53</a></p>					<p>Level: IV</p>
Purpose/Hypothesis	Design	Sample	Intervention	Outcomes	Results
<p>“We hypothesized that a computerized clinical decision support (CCDS) tool for Clostridium <i>difficile</i> testing would reduce unnecessary inpatient tests, resulting in fewer</p>	<p>Retrospective cohort, single hospital</p>	<p><b>Sampling Technique:</b> Convenience</p> <p><b>Eligible:</b> All inpatient samples, no exclusions were stated.</p>	<p><b>Control:</b> Pre-intervention</p> <p><b>Intervention:</b> CCDS Tool and education</p> <p><b>Intervention Fidelity:</b></p>	<p><b>Dependent Variable:</b> 1. The change in the rate of <i>C. difficile</i> tests per 10,000 patient days 2. The change in duplicate positive results, within 14 days</p>	<p><b>Statistical Methods:</b> The testing rates and proportions of positive tests were compared between the pre/post-intervention groups using an independent t-test and chi-squared</p>

<p>laboratory-identified events”</p>		<p><b>Total:</b> n=366,218</p> <p><b>Control:</b> June 2014 to November 2016 n = 233,577</p> <p><b>Intervention:</b> December 2016 to September 2017. n = 132,641</p> <p>Power analysis: It was not stated, whether this was completed.</p> <p>Group homogeneity: This was not described.</p>	<p>All providers and nurses were educated prior to the implementation of the tool. This was completed through emails, flyers, and a video. A graduate medical education trainee, provided staff with inpatient education. There are 2-parts of the tool. First, the tool will display a duplicate-order screen if a <i>C. difficile</i> test in 28 days. Then there is an algorithm with questions used to guide the provider toward appropriate testing. The questions were based upon the IDSA guidelines including: testing only symptomatic patients and high- risk patients. The test could be ordered regardless of the provider response. There was a hospital-wide change in the cleaner used (peroxyacetic acid/hydrogen peroxide and bleach) for daily and terminal hospital room cleaning. There was a policy change that restricted</p>	<p>following a previously positive result. 3.The change of duplicate negative results, a negative result within 3 days of the previously negative result. 4. The change in rejected stool samples 5. Percentage of positive <i>C. difficile</i> results</p> <p><b>Measurement:</b> NAAT testing was used to evaluate for <i>C. difficile</i>. Retrospective analysis of the rates of hospital acquired <i>C. difficile</i> infection (HA-CDI) by the NHSN definition of an infection on day 3 or later from admission. This was completed pre-post intervention. All solid stools were rejected for NAAT testing. There was daily monitoring using a <i>C. difficile</i> dashboard of daily tests, new positive tests, duplicate tests, and test attempts prevented by the CCDS. The stewardship team performed chart reviews of patients with positive tests,</p>	<p>tests. A quasi-Poisson model assessed the changes in number of HA-CDI per patient days of onset.</p> <p><b>Results:</b> 1. The change in the rate of <i>C. difficile</i> tests per 10,000 patient days: There was a 41% decrease in the total number of <i>C. difficile</i> tests after the intervention, <math>p &lt; .001</math>. After the intervention there was a decrease of 31% fewer HA-CDI, <math>p = .001</math>. 2. The change in duplicate positive results: There was a decrease in duplicate positive results from (pre) 0.9 per 10,000 patient days or 22 duplicate positives to (post) 0.15 per 10,000 patient days or 2 duplicate positives; <math>p = .004</math>. 3.The change in duplicate negative results: There was a decrease from 5.7 per 10,000 patient days or 134 duplicates to 1.5 per 10,000 patient days or 20 duplicate negatives; <math>p &lt; .001</math>.</p>
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			antibiotics for neuro-surgery prophylaxis.	evaluating appropriate testing, and other opportunities to reduce HA-CDI.	3. The change in rejected stool samples: There was no significant change $p = .064$ , 15.9 to 10.8 per 10,000 patient days 4. Percentage of positive <i>C. difficile</i> results: There was no significant change, $p = .195$ , from 16.2% to 17.5%.
Citation: Mizusawa, M., Small, B. A., Hsu, Y. J., Sharara, S. L., Advic, E., Kauffman, C., Milstone, A. M., Feldman, L., Pahwa, A. K., Trivedi, J. B., Landrum, M. B., Maragakis, L. L., Carroll, K. C., Cosgrove, S. E., & Rock, C. (2019). Prescriber behavior in <i>Clostridioides difficile</i> testing: A 3-hospital diagnostic stewardship intervention. <i>Clinical Infectious Diseases</i> , 69(11), 2019-2021. <a href="https://doi.org/10.1093/cid/ciz295">https://doi.org/10.1093/cid/ciz295</a> .					Level: IV
Purpose/Hypothesis	Design	Sample	Intervention	Outcomes	Results
“This report evaluates efficacy, safety, and provider response to a computerized clinical decision support (CCDS) best practice alert (BPA) for appropriate <i>C. difficile</i> testing at 3 hospitals in the Johns Hopkins Health System”	Retrospective cohort study, 3-hospital	<p><b>Sampling Technique:</b> Convenience</p> <p><b>Eligible:</b> All inpatient at three hospitals No exclusion criteria stated.</p> <p>Pre-intervention: Was not written on placed in the chart.</p> <p>Intervention: <math>n = 195</math> Group 1: patients where providers followed the BPA and did not follow through with test <math>n = 102</math></p>	<p><b>Control:</b> Pre-intervention</p> <p><b>Intervention:</b> Decision tree support and best practice alert</p> <p><b>Intervention fidelity:</b> The first BPA was activated when physicians ordered <i>C. difficile</i> tests for patients who had any of the following: laxative within the preceding 48 hours, a negative <i>C. difficile</i> test resulted within 7 days, and positive test resulted</p>	<p><b>Dependent Variable:</b> 1. Primary: Change in test ordering frequency measured by rate per 1000 inpatient days and percentage absolute reduction 2. Provider response to BPA as measured by frequency. 3. Antibiotic use as measured by frequency</p> <p><b>Measurement:</b> Reviewed patient medical records for 3 months post-intervention at each hospital. Medication</p>	<p><b>Statistical Procedures:</b> Wilcoxon rank sum tests to compare the weekly number of CD tests per 1,000 inpatient days before and after the intervention.</p> <p><b>Results:</b> 1. Primary: Change in test ordering frequency: the weekly average in the number of orders significantly decreased by 24% or 12.6 +/- 1.7 to 9.5 +/- 1.3 per 1000 patient days; <math>p &lt; .001</math> at JHH. There was a significant decrease by</p>

		<p>Group 2: patients where the providers ignored BPA and continued to pursue tests n = 93</p> <p>Power analysis was not stated that it was completed.</p> <p>Group homogeneity: displayed in a table; no significant difference in age, gender, or CDI risk factors between group 1 and group 2</p>	<p>within the previous 14 days. When the sign button was clicked (bypass attempt), the second BPA would be activated and the pop-up warning message with a hard-stop would state the contraindication and that further testing is not indicated, however, after reviewing the one-minute guide, if the provider still felt the test was indicated, they could call microbiology for the bypass. The team created a one-minute guide of the guidelines for C. difficile testing and was distributed through the Department of Medicine. Hardcopy fliers to all units were distributed by the infection control practitioners and the antimicrobial stewardship team members. Screensavers were introduced with the same message. Clinical Inservice was provided by peer leaders and in a conference.</p>	<p>databases were used to collect data on oral vancomycin and oral metronidazole used.</p>	<p>34%, p&lt;.001, at HCGH or 10.1 +/- 2.9 to 6.4 +/- 2.9 per 1000 patient days. Lastly, at SH there was a significant reduction by 31%, p&lt;.001, from 14 +/- 4.2 to 9.6 +/- 3.5 per 1000 patient days.</p> <p>2. Provider response to BPA: 527 total providers activated the BPA at least once, 15.4% followed the soft stop and 57.7% followed the hard-stop and 26% ignored both BPAs and completed the test order.</p> <p>3. Antibiotic use: In the first quarter after intervention there was a decrease in PO vancomycin use with incidence RR 0.69 [95% CI, .48-.99]</p>
<p>Citation: Quan, K. A., Yim, J., Merrill, D., Khusbu, U., Madey, K., Dickey, L., Dangodara, A. A., Rudkin, S. E., O'Brien, M., Thompson, D., Parekh, N., Albers, C. G., Wilson, W. C., Thrupp, L., Bittencourt, C. E., Huang, S. S. &amp; Gohil, S. K. (2018).</p>					<p>Level: IV</p>

Reductions in Clostridium <i>difficile</i> infection (CDI) using real-time automated clinical criteria verification to enforce appropriate testing. <i>Infection Control &amp; Hospital Epidemiology</i> , 39(5), 625-627. <a href="https://doi.org/10.1017/ice.2018.32">https://doi.org/10.1017/ice.2018.32</a> .					
Purpose/Hypothesis	Design	Sample	Intervention	Outcomes	Results
“We created a real-time computer physician order entry (CPOE) alert to enforce appropriate <i>C. difficile</i> testing and to reduce CDI rates”	Prospective cohort, single hospital	<p><b>Sampling Technique:</b> Convenience</p> <p><b>Eligible:</b> In-patient, adult patients. Exclusion was not stated.</p> <p>Total, control, and intervention number was not stated, only displayed in a graph format. Neither was power analysis or group homogeneity.</p> <p>Control: April 1, 2015 – March 31, 2016</p> <p>Intervention: June 1, 2016 – June 20, 2017.</p> <p>Power analysis: It was not stated, whether this was completed.</p> <p>Group homogeneity: This was not described.</p>	<p><b>Control:</b> Pre-intervention</p> <p><b>Intervention:</b> Automated real-time CPOE algorithm</p> <p><b>Intervention fidelity:</b> The intervention criteria included: diarrhea with 3 or more liquid or watery stool in 24 hours; no alternate cause for diarrhea; no laxative use within 24 hours; no previous CDI test result within 7 days of the order; age &gt;1 year. The clinician was required to attest to the first two criteria with the other criteria automatically populating to the order. Any contraindication would prompt the provider to exit the order or state the name of the approving infectious disease or gastrointestinal specialist to override the protocol. The infection preventionists reviewed the override</p>	<p><b>Dependent Variable:</b> 1. NHSN HA-CDI counts per 10,000 patient days 2. NHSN SIR 3. Tests ordered in patients who had received laxatives within 24 hours. 4. Testing for CDI within 7 days of prior order 5. Protocol overrides 6. CDI testing rate per 10,000 patient days</p> <p><b>Measurement:</b> PCR was used for CDI testing</p>	<p><b>Statistical Procedures:</b> The authors used chi-squared tests to compare the pre-intervention results to the post-intervention results. The quarterly SIR results were compared using t-tests.</p> <p><b>Results:</b> 1. NHSN HA-CDI counts per 10,000 patient days: There was a decrease of 56%, 155 to 84 per 10,000 patient days; p&lt;.001. HA-CDI decreased by 54%, from 17 to 7 per 10,000 patient days. 2. NHSN SIR quarterly: There was a 51% reduction in the average HA-CDI SIR, 1.62 to 0.82; p&lt;.001 3. Tests ordered in patients who had received laxatives within 24 hours.: Testing decreased by 64%, 77 to 24 per 10,000 patient days; p&lt;.001.</p>

			weekly, verified the approval names, and who was without approval. Those providers without approval would receive a warning email from the infectious disease or GI leadership and the CMO, reiterating the protocol criteria and to remind they are being monitored.		4. Testing for CDI within 7 days of previous order: Testing decrease by 64%, from 28 to 8 per 10,000 patient days; p<.001 5. Protocol overrides: Initially there were 22 overrides, but with the compliance protocol and monitoring, the compliance decreased to 0 by the completion. 6. CDI testing rate: There was a decrease from 284 per 10,000 patient days preintervention to 268 per 10,000 patient days postintervention; p=.02.
Citation: Thompson, I., Lavelle, C., & Leonard, L. (2016). An evaluation of the effectiveness of an algorithm intervention in reducing inappropriate faecal samples sent for Clostridium <i>difficile</i> testing. <i>Journal of Infection Prevention</i> , 17(6), 278-286. <a href="https://doi.org/10.1177/1757177416657163">https://doi.org/10.1177/1757177416657163</a>					Level: IV
Purpose/Hypothesis	Design	Sample	Intervention	Outcomes	Results
“To evaluate the effectiveness of an intervention by an Intervention Prevention and Control Team in reducing the number of samples sent for C. <i>difficile</i> testing”	Retrospective cohort, one hospital	<b>Sampling Technique:</b> Convenience  <b>Eligible:</b> All stool samples that the lab received from the inpatient department within the study period.  Excluded: Patients that were 16 years old or	<b>Control:</b> 1. Pre-memorandum 2009 intervention.  <b>Intervention</b> 1. The 2009 intervention was a memorandum.  2.The 2013 intervention was a C. <i>difficile</i> diagnostic algorithm.	<b>Dependent variable:</b> The dependent variable in the 2009 and 2013 studies, was the number of stool samples that were sent for CDI after the intervention. In addition, the dependent variable was the number inappropriate stool samples.	<b>Statistical Procedure:</b> The data for 2009 and 2013 had normal distribution.  The authors used a paired t-test for the paired groups of 2009 and 2013.  Independent t-tests were used for the pre-

		<p>under and community specimens</p> <p><b>Accepted:</b> 2013 algorithm intervention: There was a total of n= 1819 samples. 2009 Pre-memorandum intervention: There was a total of n = 3289 samples</p> <p><b>Control:</b> 2013 pre-algorithm intervention: There were, n = 993, samples in the 2013, 12-week pre-intervention period. 2009 Pre-memorandum intervention: There were, n = 1680 samples in the 2009 pre-intervention period.</p> <p><b>Intervention:</b> 2013 post-algorithm intervention: There were, n = 826, samples in the 2013, 12-week post-intervention. 2009 Post-memorandum intervention: There were n = 1607 samples in the 2009 post-intervention period.</p>	<p><b>Intervention fidelity:</b> 1. The 2009 intervention of a memorandum was sent to all unit managers by the infection prevention and control team. The memo was meant to educate the manager and subsequently the staff nurses, of when to send and when to not send <i>C. difficile</i> stool samples. 2. The 2013 decision-making algorithm intervention asked various initial questions about the patient if “yes” therefore further questions. Additionally, there was a “do not send sample” criteria. There was an in-service performed on the algorithm. The algorithm was a permanent visual aide when bedside staff assessed the need for sampling.</p>	<p><b>Measurement:</b> The patient was considered <i>C. difficile</i> positive if there was a positive <i>C. difficile</i> toxin result. There was no reliability, time, or procedure given.</p>	<p>post intervention data for 2009 and 2013.</p> <p><b>Results:</b> 1. Number of samples sent pre and post intervention 2009 intervention: There was a mean reduction of samples by 6.1%, but this was not statistically significant, p =.36. 2013 intervention There was a mean reduction of samples by 13.5%, that was statistically significant, p = .046. 2. Inappropriate samples; pre-post interventions: 2009 Intervention: Prior to the 2009 intervention, the average frequency of positive <i>C. difficile</i> positive samples was 4.27%; whereas, it was 2.17% after the intervention. There was a 2.10% reduction that was statistically significant, p = .011. 2013 Intervention: Prior to the intervention, the <i>C. difficile</i> rate was 2.07%. After the</p>
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		<p>It was not stated that a power analysis was not completed.</p> <p>Group homogeneity was not presented.</p>			<p>intervention there was a rise of the rate, to 3.06%; however, this change was not statistically significant (p=.99).</p>
<p>Citation: White, D. R., Hamilton, K. W, Pegues, D. A., Hanish, A., &amp; Umscheid, C. A. (2017). The impact of a computerized clinical decision support tool on inappropriate Clostridium difficile testing. <i>Infection Control &amp; Hospital Epidemiology</i>, 38(10), 1204-1208, <a href="https://doi.org/10.1017/ice.2017.161">https://doi.org/10.1017/ice.2017.161</a></p>					<p>Level: IV</p>
Purpose/Hypothesis	Design	Sample	Intervention	Outcomes	Results
<p>“We hypothesized that a computerized clinical decision support (CDDS) tool could reduce inappropriate testing for <i>C. difficile</i> among patients receiving concurrent laxative therapy”.</p>	<p>Retrospective cohort study completed in three hospitals</p>	<p><b>Sampling Technique:</b> Convenience <b>Eligible:</b> All inpatient, adult patients hospitalized during study period; pre-intervention March 1, 2013 – February 28, 2014 and the post-intervention period April 1, 2014 – March 31, 2015. Excluded: Hospitalized patients between March 1, 2014 – April 1, 2014. <b>Total:</b> n = 137,176 <b>Pre-intervention:</b> n = 69,362 <b>Post-intervention:</b> n=67,814 It was not stated that a power analysis was completed. The group homogeneity was described in a table.</p>	<p><b>Control:</b> Pre-intervention <b>Intervention:</b> The authors implemented a CDDS tool that required providers to use an automatic order set for <i>C. difficile</i>. <b>Intervention fidelity:</b> The clinician would order the sample and the order would automatically display if the patient had received laxatives within 36 hours and state not to send sample, and to stop the laxatives for 24 hours, then reassess. Then the provider only has the option to discontinue the laxative and will not be able to send the stool sample for 24 hours. The stool test was restricted to</p>	<p><b>Dependent Variable:</b> 1. Primary Outcome: Change in proportion of inappropriate <i>C. difficile</i> tests sent. The number of stool assays for <i>C. difficile</i>, that were sent within 36 hours after receiving laxatives 2. Secondary Outcome: -Number of patients who had laxatives discontinued within 15 minutes of the order. -The number of patients with positive <i>C. difficile</i> tests -The number of positive tests in patients receiving laxatives; false positives. -The number of <i>C. difficile</i> related complications: ICU transfer, colectomy, or CDI death</p>	<p><b>Statistical Procedures:</b> Chi-squared and t-tests were used to compare dichotomous and continuous outcomes. Chi-squared analysis was used for categorical data, while Mann-Whitney U was used for continuous variables. <b>Results:</b> 1. Proportion of inappropriate <i>C. difficile</i> testing sent: There was a decrease in testing from 29.6% (pre) to 27.3% (post); p = .02. 2. Number of patients who had laxatives discontinued within 15 minutes of the order: The authors found there was an increase from 5.8% to 46.4%, p &lt;.01.</p>

			<p>stool specimens that were a Bristol score of 5 or 6, and testing could not be repeated for 9 days after last test.</p>	<p>-If there was a delay, due to laxative use, in sending the test more than 24 hours  <b>Measurement:</b>                  Stool samples were tested with enzyme immunoassay for glutamate dehydrogenase and toxins A/B. All causes of <i>C. difficile</i> were documented in a surveillance program Theradoc and the CDC's National Healthcare Safety Network (NHSN) database. Hospital acquired <i>C. difficile</i> was defined as a positive <i>C. difficile</i> sent 48 or more hours after hospital admission and from patients that had been readmitted within 14 days from last discharge.                  Inappropriate <i>C. difficile</i> test: The authors defined the latter as a stool sample that was tested on a patient who had received laxatives in the 36 hours prior to the test.</p>	<p>-The number of patients with positive <i>C. difficile</i> tests: No significant change was found, 6.5% (pre) and 6.5% (post), <math>p = .99</math>.                  -The proportion of patients with positive <i>C. difficile</i> tests: There was no significant difference, <math>p = .67</math>, between the pre- (14.0%) to post- (13.7%) results.                  -The number of positive tests in patients receiving laxatives; false positives: There was no significant difference, <math>p = .62</math>, found from the pre- (27.6%) and the post- (26.2%) intervention                  -The number of <i>C. difficile</i> related complications: ICU transfer, colectomy, or CDI death: There was a nonsignificant increase, <math>p = .11</math>, from 5.0% (pre) to 8.9% (post).</p>
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*Note.* Acronym Key: Electronic Health Record (EHR); Clinical decision support (CDS); Hospital acquired Clostridium *difficile* infection (HA-CDI); Nucleic acid amplification test (NAAT); National Healthcare Safety Network (NHSN); Polymerase Chain Reaction (PCR); Standard Deviation (SD); Standardized Infection Rate (SIR); White Blood Cell (WBC)

## Appendix B

## Evidence Synthesis and Quality Analysis Table

<b>Evidence Based Practice Question (PICO):</b> In an acute care geriatric unit, how will a diagnostic decision-tree compared to current practice affect the rate of hospital-acquired Clostridium difficile?			
<b>Level of Evidence</b>	<b># of Studies</b>	<b>Summary of Findings</b>	<b>Overall Quality</b>
<b>III</b>	<b>2</b>	<p>1. Christensen et al. (2019): This is a quasi-experimental study that investigated the effects of a diagnostic stewardship initiative that included a diagnostic decision tool, compared to no diagnostic stewardship in inpatient adults. There was a statistically significant reduction in the rate of amount of positive CDI results 15.4 to 12.4 (<math>p = .018</math>), these results are consistent with the findings found in other studies (Fleming et al., 2019; Madden et al., 2018; Mizusawa et al., 2018; Quan et al., 2018; Thompson et al., 2016; White et al., 2017). There was a significant reduction in the monthly HA-CDI 8.5 to 6.5 per 10000 (<math>p = .0036</math>), also found by Fleming et al. (2019), Madden et al. (2018), and Quan et al. (2018). Lastly, there was a significant reduction in the HA-CDI SIR from 0.97 to 0.78 (<math>p = .015</math>), which consistently decreased over time. The reduction in the SIR was also found by Quan et al. (2018). There was no significant change or reduction in oral vancomycin consumption from 10.7 to 10.8 (<math>p = .91</math>) and HA-CDI in control unit 36.5 to 30.3 per 10000 (<math>p = .34</math>). Implementation of CDI diagnostic tool and the formation of a hospital CDI initiative has the potential to decrease the amount of total positive CDI and HA-CDI as well as HA-CDI SIR.</p> <p>2. Friedland et al. (2019): This was a quasi-experimental study with pre-post-test design to evaluate the impact that the implementation of a clinical decision support system (CDSS) would have on appropriate <i>C. difficile</i> testing. The study had a</p>	<p>1. <b>B:</b> There was comprehensive literature review with consistent recommendations based upon the review. The results were consistent. The Agency for Healthcare Research Quality (AHRQ, 2014) grading criteria and definition of moderate certainty, there is a constraint in the confidence due to limited generalizability and study quality. The study design of quasi-experimental provides a fair amount of control; however, due to the lack of randomization and blinding, there are threats to internal validity related to testing and selection bias (O'Mathuna and Fineout-Overholt, 2015). Also, there was no power-analysis completed; therefore, the sample size cannot be adequately be determined increasing the potential for threats to external validity. The single hospital sample setting can contribute to potential threats toward external validity (Polit &amp; Beck, 2017).</p> <p>2. <b>B:</b> As per the AHRQ (2014) criteria and definition of moderate certainty due to reasonably consistent results, sufficient sample size, and fairly definitive conclusions The non-randomized design, pre-test/post-test design, and lack of blinding increase the potential for threats to internal validity,</p>

		<p>total sample of 442, pre-intervention sample 280, and intervention sample 167. The sample included all in-patient samples from 2/16/2016 to 3/19/2016 for the pre-intervention and 1/21/2017 to 2/19/2017. There was a decrease in the number of positive CDI tests from 13% to 11% and an increase in the number of tests that met the national guideline’s clinical criteria from 40% to 53% (p .004). However, Fleming et al. (2019), Madden et al., (2018), Mizusawa et al. (2018), Quan et al., (2018), Thompson et al. (2016), and White et al. (2017) had found statistically significant reductions in the number of CDI testing. There was an increase in testing in clinically indicated patients from 40% to 53% (p=.004). There was an increasing number of positive tests in clinically indicated patients from 53% to 69%, although this was not statistically significant. In addition, there was not a statistical significance in the reduction of the repeat testing from 31% to 26% (p=.20). Implementation of CDI diagnostic tool has the potential to decrease the amount of inappropriately sent CDI tests and increasing appropriate CDI testing.</p>	<p>including confounding variables and selection bias. There was no power analysis completed, and while there was a seemingly sufficient sample size, the reader cannot validate the sample as adequate (Polit &amp; Beck, 2017). The short study length and single hospital setting for sampling increases the potential for external validity threats (Polit &amp; Beck, 2017). There was a comprehensive literature review with consistent recommendations. This was only one hospital involved in the study, decreasing the generalizability.</p>
<p>IV</p>	<p>6</p>	<p>1. Fleming et al. (2019): Fleming et al. (2019) performed a single hospital, retrospective cohort to analyze how an automated <i>C. difficile</i> diagnostic decision support algorithm would reduce HA-CDI. The study population included all in-patient stool samples testing for CDI; there was a total of 1513 samples with 874 stool samples before the intervention and 639 samples after the intervention. There was a statistically significant decrease by 27% in the number of CD tested samples (p&lt;.0001) and the rate of HA-CDI from 11.446 to 7.209 (p&lt;.0300). The decline in CD tested samples is consistent with the results reported by Madden et al. (2018), Mizusawa et al. (2018), Quan et al. (2018), and White et al. (2017). In addition, the significant reduction in the rate</p>	<p>1.B: Based upon the AHRQ (2014) the definition of moderate certainty due to reasonably consistent results, sufficient sample size, and fairly definitive conclusions. The cohort study design, the lack of randomization and blinding increases the potential for threats to internal validity, such as information bias, history bias, and selection bias. In addition, due to the retrospective design, there is the potential for the ambiguity of influence, increasing the potential threat to internal validity (O’Mathuna &amp; Fineout-Overholt, 2015). The study was relatively long in length, but was completed in a single hospital setting for sampling, increasing the potential for external validity threats (Polit &amp; Beck, 2017).</p>

	<p>of HA-CDI finding is consistent with the findings with other studies (Christensen et al., 2019; Madden et al., 2018; Quan et al., 2018). The SIR decreased from 1.424 to 0.952; the statistical significance was not reported. However, there was a significant reduction in the SIR that had been found by Christensen et al. (2019), and Quan et al. (2018). Lastly, there was an increase in test fidelity from 310 to 324 (p&lt;.0001). Implementation of CDI diagnostic tool has the potential to decrease the amount of total CD tests due to appropriate diagnostic sampling and decreasing HA-CDI by decreasing the number of false positive. With the potential decrease in HA-CDI, there is potential in decreasing the SIR.</p> <p>2. Madden et al. (2018): This is a retrospective cohort study, in a single hospital setting, to evaluate the influence the implementation of a CDSS tool and education would have on inappropriate inpatient CDI testing. The study utilized all inpatient samples, with a total of 366,218; the control had 233,577, and intervention had 132,641. After six months there was a significant decrease in the rate of CD test samples by 41% (p&lt;.001), which was also found by Fleming et al. (2019), Mizusawa et al. (2018), Quan et al. (2018), Thompson et al. (2018), and White et al. (2017). There was a significant reduction in the frequency of HA-CDI by 31% (p=.001), which had also been found in other studies (Christensen et al., 2019; Fleming et al., 2019; Quan et al., 2018). There was a significant reduction in duplicate positive results from 0.9 to 0.15 per 10,000 (p=.001) and duplicate negative results from 5.7 to 1.5 per 10,000 (p&lt;.001). There was an insignificant increase in the frequency of total positive CDI from 16.2% to 17.5% (p = .195). Thompson et al. (2016) and White et al. (2017) had also found insignificant results in total positive CDI results. Lastly, there was an insignificant change in the number of rejected stool samples from 15.9 to 10.8 per 10,000 (p = .064). Implementation of CDI diagnostic tool has the potential to decrease the amount of total CD tests due to appropriate diagnostic sampling and decreasing HA-CDI by decreasing the number of false positive. The is a potential for</p>	<p>2. <b>B:</b> As per the AHRQ (2014) grading criteria and definition of moderate certainty due to reasonably consistent results, sufficient sample size, and fairly definitive conclusions. The cohort study design, lack of randomization and blinding increasing the potential for threats to internal validity, such as information bias, history bias, and selection bias. There was a seemingly large sample size, but there was no power analysis completed. The retrospective design, there is the potential for the ambiguity of influence, increasing the potential threat to internal validity (O’Mathuna &amp; Fineout-Overholt, 2015). The study timeframe was relatively long, but sampling was only from one hospital setting, increase the potential for external validity threats (Polit &amp; Beck, 2017).</p>
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	<p>increase in positive CDI results; however, the purpose of the tool is not to eliminate positive test results, but to increase the efficacy of CDI testing.</p> <p>3. Mizusawa et al. (2018): This retrospective cohort study was completed in a three-hospital setting, to assess the efficacy, safety, and provider response to a CCDS and best practice alert for appropriate CDI testing. After an 85-week study, there was a statistically significant reduction in average weekly CDI tests at all three hospitals by 24% (p&lt;.001), 34% (p&lt;.001), and 31% (p&lt;.001). The authors found a significant decline in average weekly CDI tests at all three hospitals by 24% (p&lt;.001), 34% (p&lt;.001), and 31% (p&lt;.001). These results were also found by Fleming et al. (2019), Madden et al. (2018), Quan et al. (2018), Thompson et al. (2016), and White et al. (2017). Implementation of CDI diagnostic tool has the potential to decrease the amount of CDI tests due to appropriate diagnostic sampling without adversely affecting the patient population.</p> <p>4. Quan et al. (2018): This is a prospective cohort study that investigated a computerized provider order entry algorithm in enforcing appropriate Clostridium difficile diagnostic testing and reducing the rate of CDI. The study included all adult, inpatient populations during April 2015 to June 2017; the sample total was not described in the author’s narrative, and was only displayed as the monthly sample average, which could only be found in a graphical format. There was a significant reduction in the rate of HA-CDI by 56% (p&lt;.001), consistent with the findings found by Christensen et al. (2019), Fleming et al. (2019), and Madden et al. (2018). The average quarterly SIR was significantly reduced by 51% (p&lt;.001), as seen in by Christensen et al. (2019). There was a significant decreased in the frequency of tests ordered in patients who received laxatives within 24 hours by 64% (p&lt;.001). There was a significant reduction in the frequency of testing within 7 days from previous CDI test by 64% (p&lt;.001), this finding is not consistent with Friedland</p>	<p>3. <b>C:</b> Based upon the AHRQ (2014) grading criteria and definition of low certainty, there is a constraint in the confidence due to limited sample size, generalizability, and study quality. The retrospective cohort design does not have randomization or blinding, thus, increasing potential internal validity threats related to information bias, history bias, selection bias, and the potential for the ambiguity of influence (O’Mathuna &amp; Fineout-Overholt, 2015). The authors completed a comprehensive literature review with consistent recommendations and the results were consistent, but there was questionable sample size.</p> <p>4. <b>B.</b> The AHRQ (2014) criteria and definition of moderate certainty due to reasonably consistent results, sufficient sample size, and fairly definitive conclusions. Although a well-designed cohort study design due to the cohort design there is lack of randomization and blinding increase the potential for threats to internal validity, such as information bias, history bias, and selection bias (O’Mathuna &amp; Fineout-Overholt, 2015). The study timeframe was relatively long, but sampling was only from one hospital setting, increase the potential for external validity threats (Polit &amp; Beck, 2017).</p>
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	<p>et al. (2019). There was a significant reduction in rate of CDI testing from 284 to 268 per 10,000 (<math>p=.02</math>), these are consistent with the results found in other studies (Fleming et al., 2019; Madden et al., 2018; Mizusawa et al., 2018; Thompson et al., 2016; White et al., 2017). Overrides of the tool decreased from start of the study with 22 overrides to 0 by the end of the study. Implementation of CDI diagnostic tool has the potential to decrease the frequency of CDI tests due to appropriate diagnostic sampling and decreasing HA-CDI by decreasing the number of false positives. With the potential decrease in HA-CDI, there is potential in decreasing the SIR.</p> <p>5. Thompson et al. (2016): This is a retrospective cohort study that evaluated the effect of a memorandum intervention in 2009 and the intervention of a Clostridium difficile diagnostic algorithm intervention completed in 2013, in the reduction of inappropriate stool samples sent for Clostridium difficile testing inpatient. Each study period was twelve-weeks long, and the samples included all in-patients, except those samples that were community specimens or specimens for patients sixteen or younger. The total number of samples for the 2013 intervention was 1819, the pre-intervention had 993, and the intervention had 826. The total number of samples for the 2009 intervention was 3289, where there were 1680 pre-intervention samples and 1607 intervention samples (Thompson et al., 2016). After the twelve-week study periods, there was a significant reduction in the average number of stool samples by 13.5 (<math>p=.046</math>), after the algorithm whereas there was reduction in the samples after the memo by 6.1%, but the results were not significant (<math>p=.36</math>). These results are consistent in the findings that were found by Fleming et al. (2019), Madden et al. (2018), Mizusawa et al. (2018), Quan et al. (2018), and White et al. (2017). The memo intervention did have a significant reduction in the average frequency of positive CDI samples by 2.10% (<math>p=.011</math>). However, there was an insignificant increase in the frequency of positive CDI samples from 2.07% to 3.06% algorithm (<math>p=.99</math>), which is</p>	<p>5. <b>B.</b> As per the AHRQ (2018) criteria and definition of moderate certainty due to reasonably consistent results, sufficient sample size, and fairly definitive conclusions. Although there was some control there is a constraint in the confidence due to the cohort study design due to lack of lack of randomization and blinding increasing the potential for threats to internal validity, such as information bias, history bias, and selection bias. Despite the latter, the prospective design the decreases the potential for the ambiguity of influence, decreasing the potential threat to internal validity (O’Mathuna &amp; Fineout-Overholt, 2015).</p>
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	<p>consistent with the findings in other studies (Madden et al., 2018; White et al., 2017). Implementation of CDI diagnostic tool has the potential to decrease the amount of total CD tests due to appropriate diagnostic sampling and decreasing HA-CDI by decreasing the number of false positives. There is a potential for increasing the positive CDI results; however, the purpose of the tool is not to eliminate positive test results, but to increase the efficacy of CDI testing.</p> <p>6. White et al. (2017): In a retrospective cohort study, there was an investigation into the effect a computerized decision support intervention had in the reduction of inappropriate Clostridium difficile tests in inpatient adults. The study population included all adult patients that were admitted over two-years. CDS tool would display messages and alerts regarding appropriate <i>C. difficile</i> criteria (White et al., 2017). There was a total sample size of 137,176, with a pre-intervention sample number 69,362 and a post-intervention sample of 67,814 (White et al., 2017). After two years, there was a significant reduction in the frequency in CDI testing from 29.6% to 27.3% (p=.02), these results are consistent with Fleming et al. (2019), Madden et al. (2018), Mizusawa et al. (2018), Quan et al. (2018), and Thompson et al. (2016). There was a significant increase in the number of patients who had their laxatives discontinued prior to CDI order from 5.8% to 46.4% (p&lt;.01). There was no significant change in the reduction number of patients with positive CDI tests 6.5% to 6.5% (p=.99) and an insignificant change in the reduction proportion of patients with positive CDI 14.0% to 13.7% (p=.67). These results are consistent with the findings from other studies (Madden et al., 2018; Thompson et al., 2016). There was an insignificant reduction in the number of false positive tests 27.6% to 26.2% (p=.62). There was a nonsignificant increase in the proportion of patients with complications related to CDI from 5.0% to 8.9% (p=.11). Implementation of CDI diagnostic tool has the potential to decrease the amount of total CD tests due to appropriate</p>	<p>6. A. The AHRQ (2018) grading criteria and definition of high certainty, this study was well designed, with a large sample size among three hospitals; thus, it is unlikely that conclusions will be affected by future studies. The results were consistent with a large sample size and adequate control, although a retrospective cohort design. The authors completed an extensive literature review and were able to provide definitive conclusions. The retrospective cohort design does not have randomization or blinding, thus increasing potential internal validity threats related to information bias, history bias, selection bias, and the potential for the ambiguity of influence (O’Mathuna &amp; Fineout-Overholt, 2015). The study length and the multiple hospital sample setting increases external validity (Polit &amp; Beck, 2017).</p>
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		diagnostic sampling and decreasing HA-CDI by decreasing the number of false positives.	
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*Note.* Acronym Key: Hospital acquired Clostridium *difficile* infection (HA-CDI); Nucleic acid amplification test (NAAT); National Healthcare Safety Network (NHSN); Standardized Infection Rate (SIR). Polit and Beck (2017) and O’Mathuna and Fineout-Overholt (2015) were used in the critical appraisal of these studies. Quality grading completed by Newhouse (2006) and USPTF (2014) for each article.

## Appendix C

### Context Assessment Index

#### The Context Assessment Index (CAI)

For each of the following statements, please put a cross in one box only.

A – Strongly agree; A – Agree; D – Disagree; SD – Strongly disagree

HCP= Healthcare professionals

	SA	A	D	SD
01 Personal and professional boundaries between HCPs are maintained	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
02 Decisions on care and management are clearly documented by all staff	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
03 A proactive approach to care is taken	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
04 All aspects of care/treatment are based on evidence of best practice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
05 The nurse leader acts as a role model of good practice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
06 HCPs provide opportunities for patients to participate in decisions about their own care	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
07 Education is a priority	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
08 There are good working relations between clinical and non-clinical staff	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
09 Staff receive feedback on the outcomes of complaints	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10 HCPs in the MDT have equal authority in decision making	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11 Audit and/or research findings are used to develop practice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12 A staff performance review process is in place which enables reflection on practice, goal setting and is regularly reviewed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13 Staff have explicit understanding of their own attitudes and beliefs towards the provision of care	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14 Patients are encouraged to be active participants in their own care	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15 There is high regard for patients privacy and dignity	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16 HCPs and healthcare support workers understand each others role	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17 The management structure is democratic and inclusive	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18 Appropriate information (large written print, tapes, etc) is accessible to patients	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19 HCPs and patients work as partners providing individual patient care	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Appendix D

*Clostridium difficile* Algorithm

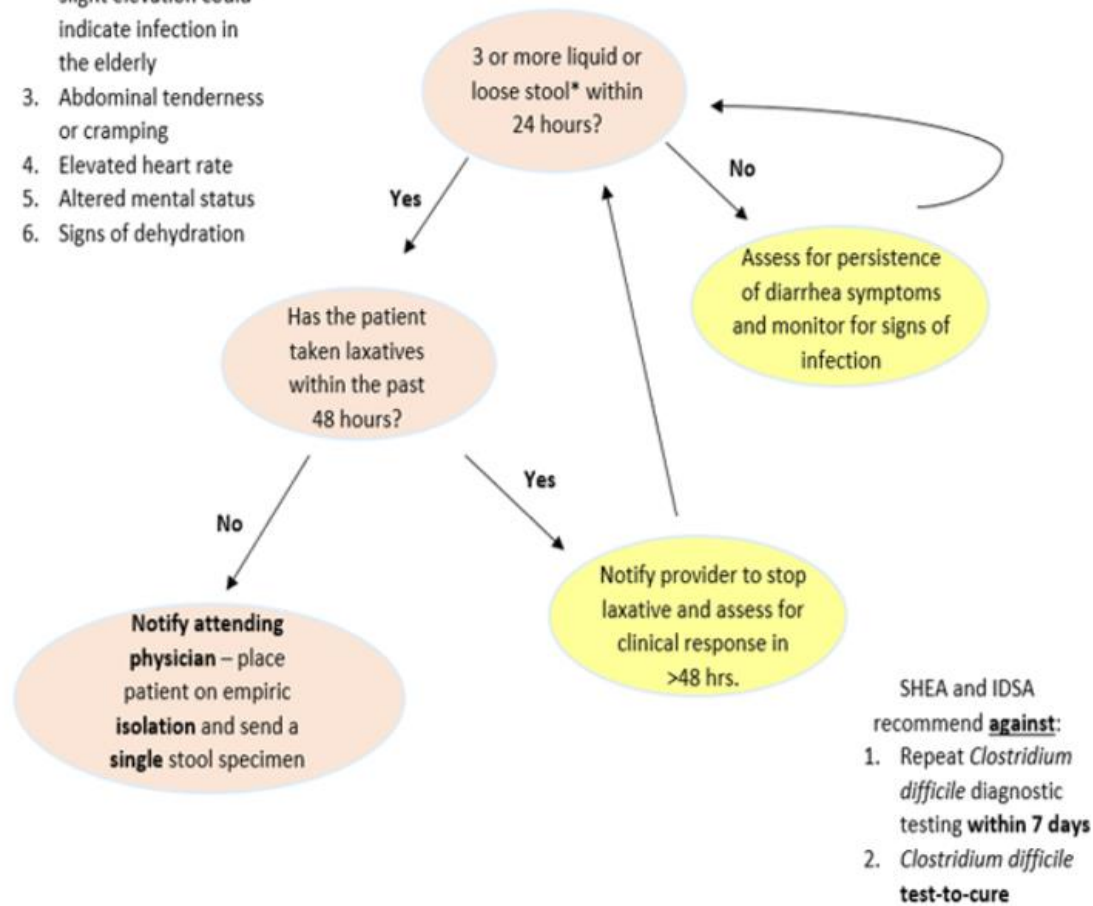
Potential Clinical Signs of CDI

in the Elderly Patient:

1. Elevated white blood cell
2. Elevation in temperature – even slight elevation could indicate infection in the elderly
3. Abdominal tenderness or cramping
4. Elevated heart rate
5. Altered mental status
6. Signs of dehydration

Liquid or loose stool \*

1. The stool should take the form of the container



Appendix E

On-line Education Slides

# Clostridium difficile Diagnostic Algorithm

DNP Study  
Laura Harrison

1

## Objectives

- To review relevant *Clostridium difficile* epidemiology, etiology, risk factors, and significance including unit-specific data regarding *Clostridium difficile* and hospital-occurring *Clostridium difficile* infection (HO-CDI)
- To explore the importance appropriate diagnostic testing
- To review the algorithm purpose, goal, and its application
- To Review the importance of accurate documentation in relation to *Clostridium difficile*

2

## Facts about *Clostridium difficile*

1. *Clostridium difficile* (*C. difficile*) is a gram-positive anaerobic spore-forming bacterium that causes a variety symptomatic *Clostridium difficile* infections (CDI) including uncomplicated diarrhea, pseudomembranous colitis, and toxic megacolon that could lead to sepsis and potentially death (Centers for Disease Control (CDC), 2018).
2. There were approximately 223,900 CDI cases with an estimated 12,800 deaths from CDI in 2017, with annual healthcare costs estimated between one to five billion dollars (CDC, 2018)

**Risk factors for *C. difficile* infections:**

- Taking antibiotics for more than 1 week – particular antibiotics like fluorquinolones
- Age 65 or older – Nearly 80% of deaths due to *C. difficile*
- Complicated medical care and extended stays in healthcare settings, including long-term care facilities and hospitals
- Weakened immune system
- Previous infection or exposure of *C. difficile*
- Enteral Tube Feedings

3

## *C. difficile* and the Acute Care Elderly unit

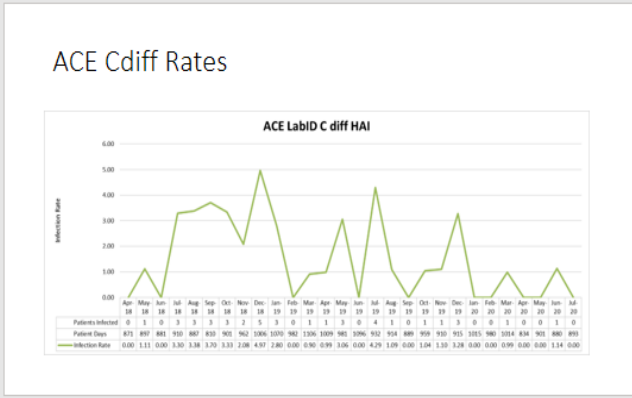
- The ACE unit patient population has all the risk factors for *C. difficile* infections
- The unit averages 2 hospital-onset CDI's (HO-CDI) per 1000 patient days per month – the benchmark is zero per 1000 patient days

The ACE nursing staff compliance with proper PPE/handwashing and has been high. Also, ACE has been cleaning all discharge rooms with bleach.

So, where this this coming from?

Need for improvement for appropriate CDI diagnostic samples

Need for improving antibiotic stewardship program



## Testing and results

We wear PPE, wash our hands, isolate and clean with bleach.

Why are we still seeing increased rates?

Healthcare providers have been found to be **over diligent in ordering the tests**, which now requires only attending physicians to order the *C. difficile* tests.

Nursing staff are also **over diligent in reporting loose stool** and requesting testing.

3

Over testing or choice of test

**TESTING ISSUES**

- Hospitals switched from toxin testing to molecular polymerase chain reaction (PCR) testing because worried they missing a significant number of *Cdiff* infections.
- After this switch, hospitals had found a 50 to 100 percent increase in their *Cdiff* rates.
- WHY?** The PCR was so sensitive detecting microbial DNA, rather than the toxin which distinguishes disease from colonization. So, this means the PCR was detecting those who were colonized without active infection and those who had CDI.
- Among adults in acute care hospitals 1 to 20% asymptotically colonized with *Cdiff*.

**REPORTING & SURVEILLANCE DEFINITIONS**

CMS requires all acute care hospitals to submit all positive *Cdiff* results into a database.

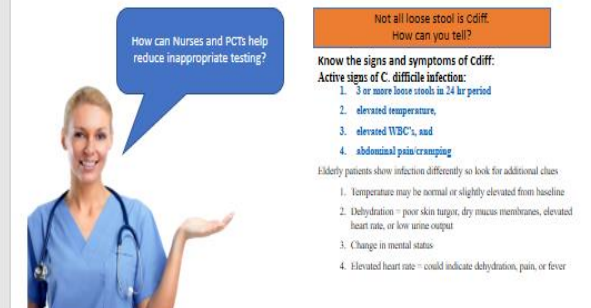
- LabID definition neglects to incorporate clinical assessment of CDI, which has been found to **increase false positive**.
- Any positive test > day 4 is considered hospital-onset.
- There are **financial penalties** if their SIR are above **benchmark of 0.01 SIR**.



Negative outcomes with over testing



The *C. difficile* Diagnostic Algorithm



7

8

9

How loose is loose?

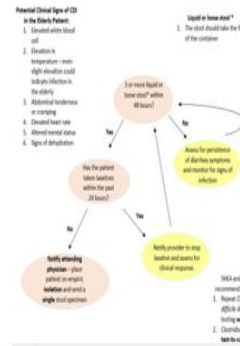
- 3 or more liquid stool without alternative cause. This requires further investigation.
  - Did they have a **loaxative within 24 hours** and that's why they have loose stools?
  - Is the stool even **liquid**? It should take the shape of the container to be considered liquid.
  - Stool sample for *C. difficile* should be a "7" on the **Bristol Stool Scale**.
- No repeat *C. difficile* testing within 7 days - although there are always circumstance when this is necessary.
- No test-of-cure: if a patient has received or is receiving treatment for an active CDI, it is not recommended that a repeat test be performed to see if they are cured from the infection.

Bristol Stool Scale



The Algorithm

- Follow the algorithm with each stool sample (take a mental picture of the algorithm you'll need this for the quiz)
  - Cheat sheets will be available on each computer and in each patient bathroom.
- Goal = 100% of the *Cdiff* diagnostic stool samples will be considered appropriate
  - To increase true positive results
  - To decrease false positive results
  - Eliminate inappropriate treatment for colonized patients
  - Decrease HO-CDI related to inappropriate diagnostic testing
  - Improve patient outcomes




If it's Not Documented, It Didn't Happen

- We are always told how important documentation is, well here it is again.
- If we aren't accurately documenting the number of times a patient has stoolled, that would be missing a critical indicator of *Cdiff* infection.
- Not only is the **number** important, but so is the **description** of the stool.
- Example:
  - So, if a patient has 3 liquid bowel movements in 1 hour, document 3 in the I&O section, describe the consistency, and the size.



### Summary

- 1. Risk factors for *C. difficile* infections:**
  - Taking antibiotics for more than 1 week – particular antibiotics like fluoroquinolones
  - Age 65 or older – Nearly 80% of deaths due to *C. difficile*
  - Complicated medical care and extended stays in healthcare settings, including long-term care facilities and hospitals
  - Weakened immune system
  - Previous infection or exposure of *C. difficile*
- 2. Appropriate Diagnostic Testing**
  1. Active signs of infection
  2. 3 or more liquid stools in 24 hours without alternative cause
  3. No repeat testing within 7 days
- 3. Documentation = Important!**
  1. Number
  2. Description
  3. Size



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Appendix F

*Clostridium difficile* Pocket Reference Template

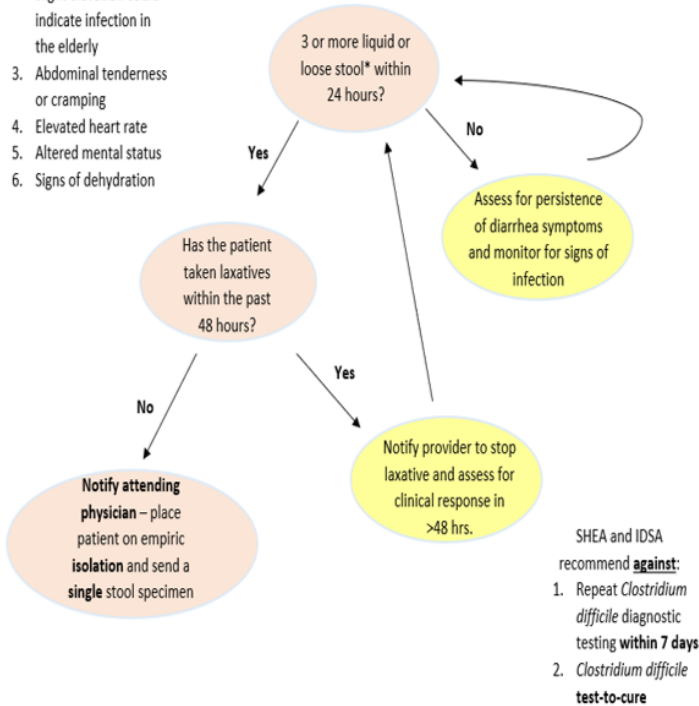
Potential Clinical Signs of CDI

in the Elderly Patient:

1. Elevated white blood cell
2. Elevation in temperature – even slight elevation could indicate infection in the elderly
3. Abdominal tenderness or cramping
4. Elevated heart rate
5. Altered mental status
6. Signs of dehydration

Liquid or loose stool \*

1. The stool should take the form of the container



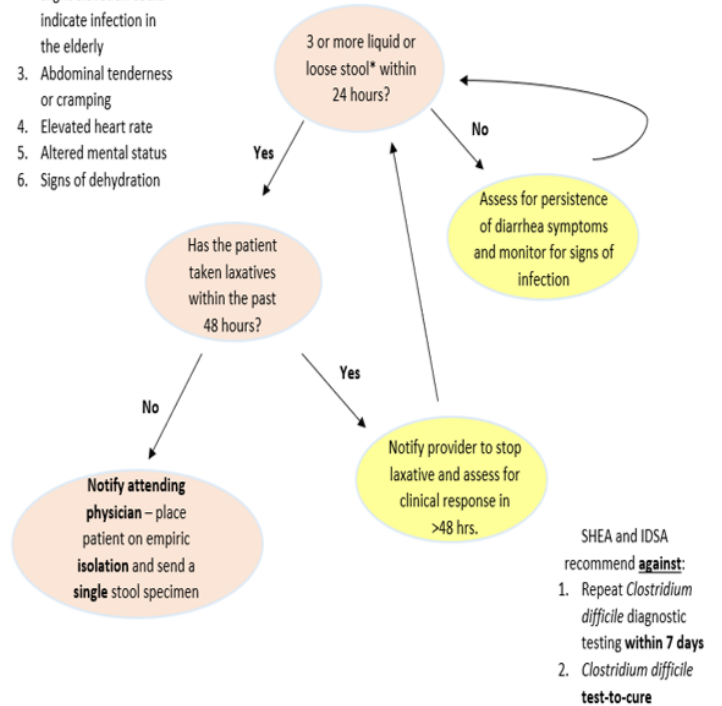
Potential Clinical Signs of CDI

in the Elderly Patient:

1. Elevated white blood cell
2. Elevation in temperature – even slight elevation could indicate infection in the elderly
3. Abdominal tenderness or cramping
4. Elevated heart rate
5. Altered mental status
6. Signs of dehydration

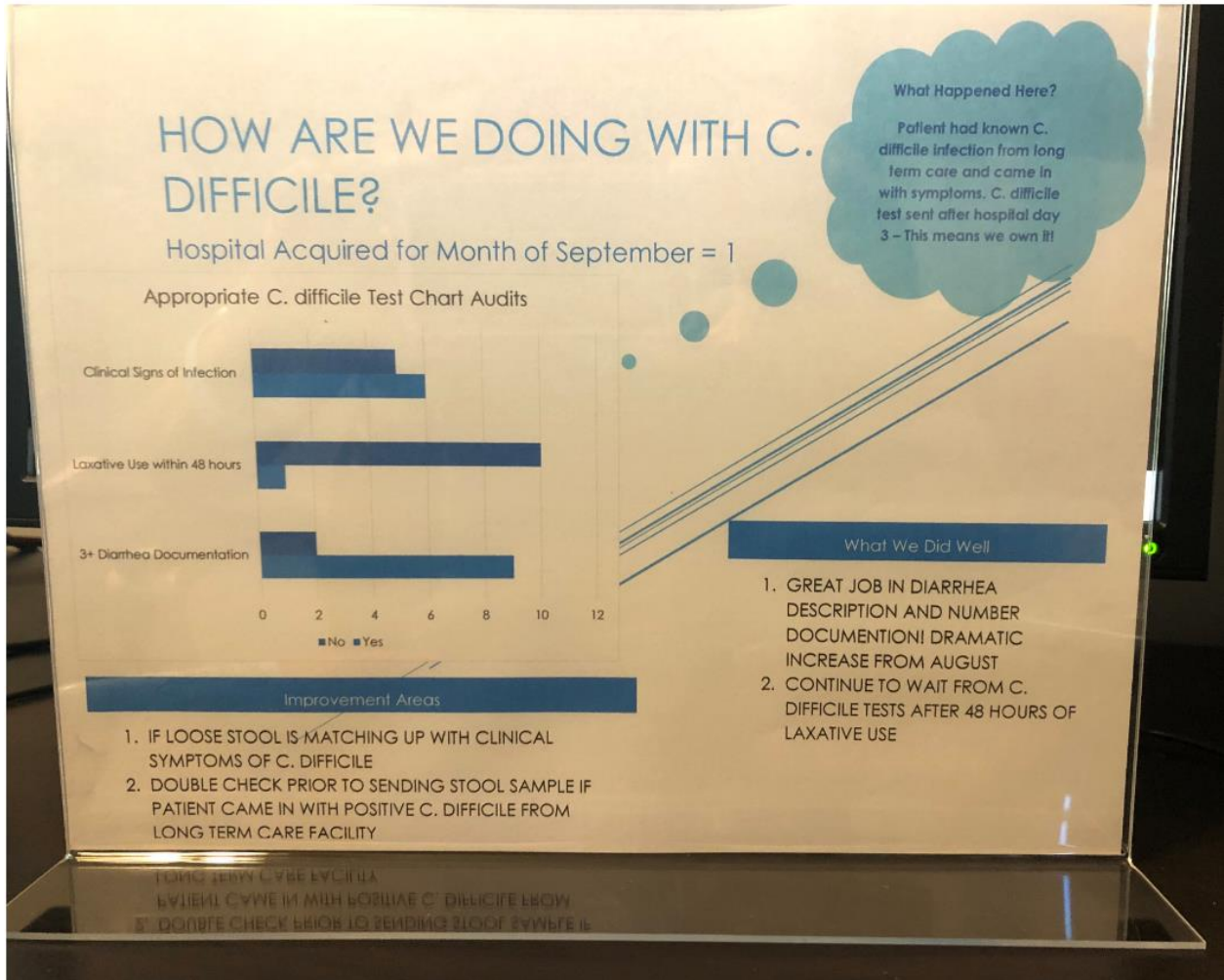
Liquid or loose stool \*

1. The stool should take the form of the container



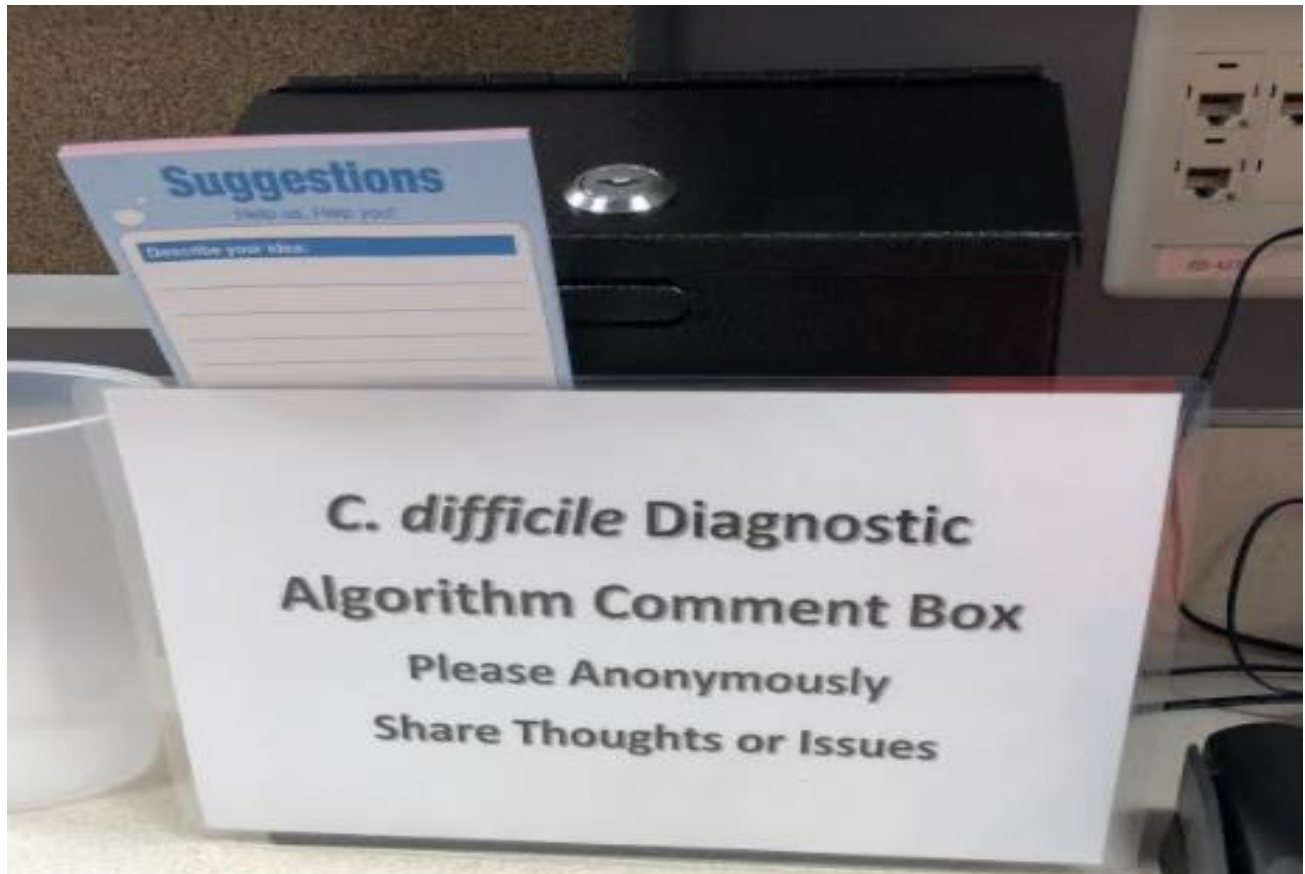
### Appendix G

#### Weekly *C. difficile* Bulletin Board



**Appendix H**

Suggestion Box



**Appendix I***Clostridium difficile* Post - Education Test

A 75% is required to pass this test.

1. A 78-year-old female is admitted from a long-term care facility to the ACE unit for healthcare-associated pneumonia. She has a past medication history of hypertension. She has not had antibiotics in the past month. What are her risk factors?
  - a. Age of 65 or greater
  - b. Age of 65 or greater and past antibiotic use
  - c. Past antibiotic use and coming from long-term care facility
  - d. Age of 65 or greater and coming from long-term care facility**
2. You come on to your shift and find that your patient has had 5 loose stools the past 24 hours, you notice she has been on Dulcolax, what is the next step?
  - a. Call the healthcare provider to stop the laxative, assess for clinical response.**
  - b. Call the attending to get an order for a *C. difficile* sample
  - c. Give the next dose
  - d. Do nothing, it is normal
3. Its 0900, you've gotten the subsequent Dulcolax orders discontinued, but your patient just had 2 loose stools within the past hour. How are you going to document this stool number in intake and output for that hour?
  - a. Leave blank – who documents intake and output anyway
  - b. 2**
  - c. 1
  - d. 0
4. True or false: The guidelines recommend to do a test-for-cure after a patient has completed their treatment for *C. difficile*?
  - a. True
  - b. False**
5. True or false: In order to be diagnostically appropriate stool sample, the stool consistency must take the form of the container?
  - a. True**
  - b. False
6. You come back to your shift after 24 hours of much needed time off, you see your patient's laxative has been still discontinued for those 24 hours, she has had 4 loose stools the past 24 hours, and her WBC's increased from 9,000 to 12,000. What is your next step?
  - a. Notify the attending physician for a *C. difficile* diagnostic test and place the patient on empiric isolation precautions**
  - b. Notify the attending physician for a *C. difficile* diagnostic test and wait until the test is positive before placing the patient on isolation
  - c. Reassess in a few hours
  - d. Reorder her Dulcolax
7. True or false: Elderly patients always have a high fever when they have *C. difficile*.
  - a. True
  - b. False**

**Appendix J**

## On-line Education Competition of Training Audit Tool

Total of Nurses Who Completed the Educational Training	Total Number of Nurses on ACE unit



### Appendix L

#### *C. difficile* Testing Audit Form

<i>C. difficile</i> Diagnostic Tests on ACE unit on ACE Unit			
Week	Total Number of <i>C. difficile</i> Tests	Total Number of Positive <i>C. difficile</i> Tests	Total Number of Hospital-Occurring Positive <i>C. difficile</i> Tests
8/16/2020			
8/23/2020			
8/30/2020			
9/6/2020			
9/13/2020			
9/20/2020			
9/27/2020			
10/4/2020			
10/11/2020			
10/18/2020			
10/25/2020			
11/1/2020			
11/8/2020			
11/15/2020			
11/22/2020			
11/29/2020			
12/6/2020			