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Unmasking the Hidden Hurdles in Outpatient Parenteral Antibiotic Therapy using a lean six-sigma approach

Vishakh C. Keri[1], Sajjad Ali[1], Ahmed Elattma[2], Sorabh Dhar[1], Lea M. Monday[1]

[1]Division of Infectious Diseases, Department of Medicine, Wayne State University, Detroit, Michigan, USA; [2]Wayne State University, School of Medicine, Detroit, Michigan, USA.

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SUMMARY

Background: Implementing Outpatient Parenteral Antimicrobial Therapy (OPAT) safely poses significant challenges, particularly in centers without a dedicated OPAT team, where monitoring by infectious diseases (ID) physicians can be difficult. We utilized a Lean 6-Sigma framework to evaluate our OPAT process and define opportunities for improvement.

Methods: In a retrospective cohort study, we screened 5 months of ID consult data for patients who left on OPAT from an urban hospital system. Primary outcome was incidence of adverse event (AE), a composite of either emergency department (ED) visit or all-cause 30-day readmission. Clinical characteristics and completeness of ID documentation were compared between patients with and without an AE. Complete documentation included antibiotic dose, duration, stop date, and a scheduled ID appointment. We simultaneously conducted a 6-sigma analysis involving stakeholders (physicians, case managers, nurses) in focus groups, to generate a process map, Ishikawa diagram, 5-Why's analysis, and identify heterogeneity in our OPAT process.

Results: Fifty of 441 patients (11.3%) were discharged on OPAT and incidence AE was 30%. Neither type of infection, nor demographics, clinical characteristics, or discharge location differed between groups. Only half (50%) of the patients had complete documentation. Median time from discharge to clinic was 21 days, however, AE's occurred in a median time of 12 days. Patients without an AE were more likely to have been seen in the clinic post-discharge (51% versus 20%, p=0.039). ID clinic appointments were made for 60% of patients, with a show rate of 63%. Two additional unscheduled patients initiated their own visit. The 6-Sigma analysis identified process heterogeneity at discharge location and over-reliance on human memory for complete documentation. Interestingly, focus groups revealed numerous assumptions not supported by the objective data.

Conclusions: Almost 1 in 3 patients leaving on OPAT experienced an adverse event. A 6 Sigma analysis identified heterogeneity in our process and incorrect assumptions among stakeholders. Next steps should focus on improving ID documentation and ensuring all patients leaving on OPAT have an ID clinic visit scheduled within 14 days after discharge.

Keywords: OPAT, Six sigma analysis, Quality improvement.

INTRODUCTION

Outpatient Parenteral Antimicrobial Therapy (OPAT) facilitates early discharge, improving patient comfort while simultaneously freeing up inpatient resources by allowing patients to finish their intravenous (IV) antibiotics in an outpatient setting. OPAT delivery generally occurs in one of four care models: home-based infusion therapy, infusion-center based therapy, delivery at a subacute nursing facility (SNFs), or delivery of antibiotics within a dialysis unit [1]. The logistics of the OPAT process vary significantly depending on the delivery model as well as the available infrastruc-

Corresponding author
Vishakh C. Keri
E-mail: vckeri@gmail.com

ture in the discharging institution. Outpatient monitoring of parenteral antibiotics varies significantly depending on the delivery model. Most home infusion companies employ clinical pharmacists that monitor therapy and alert ordering physicians about required dose changes or side effects. However, this process is less standardized at SNFs and dialysis centers where there may not be clinical pharmacists and the physicians on site are managing a variety of other non-infectious conditions [2, 3]. Regardless of delivery model, the ordering physician is ultimately responsible to manage and direct the patients OPAT care. This individual may be the discharging physician, a resident, a fellow, or an infectious diseases physician, depending on the discharge ordering practices of the institution. Patients without insurance benefits that cover home infusion may have to be discharged to a SNF in order to receive OPAT, and communication about the dosing, duration, and post-discharge appointments need to be communicated to that facility. This variety of patient factors, payer factors, delivery models, and available resources both pre- and post-discharge make monitoring and follow-up of OPAT patients a logistically heterogenous process that is prone to error.

Multiple studies have shown that a dedicated OPAT team including members from vascular access, nursing, social work, and the pharmacy can significantly improve patient outcomes and reduce hospital readmissions [4, 5]. Unfortunately, many institutions lack a dedicated OPAT team to follow and manage these patients after discharge. Other initiatives have shown that being seen in the infectious diseases (ID) clinic soon after discharge is associated with a lower risk for readmission [6, 7]. The evolving landscape of infections requiring OPAT, along with the availability of newer drugs, necessitates continuously adapting strategies to enhance patient care [8]. Ideally, every patient leaving on IV antibiotics would have an appointment with the ID clinic arranged prior to discharge, however, consultants may not follow the patient daily for their entire stay and the discharge date may not be known if the consultant has signed-off prior to patient discharge. In medical centers without a dedicated OPAT note or order which can be queried, the ability to track which patients leave on IV antibiotics is difficult. Our center is an urban safety-net hospital employing both academic and private medical staff. We currently face a multitude of these challenges in the OPAT process including lack of an OPAT team or designated OPAT nurse or pharmacist in our outpatient infectious diseases clinic. We have no dedicated OPAT note or order which is able to be queried to track such patients. Given these constraints, we sought to devise a model for evaluating and improving our OPAT process.

Lean Six Sigma is a quality improvement (QI) model which merges the concepts of Six Sigma production analysis with "Lean" practices to standardize production and reduce waste [9, 10]. Six Sigma concepts were applied in the 1980s by engineer Bill Smith and Bob Galvin to reduce process variation at Toyota and Motorola [11]. "Lean" production also originates from Toyota, and includes aspects of Japanese culture and Zen Buddhism designed to improve efficiency and deliver a standardized product by eliminating waste in the production process [9]. The overarching theme of merging these concepts into Lean Six Sigma is to apply a set of principles that will ultimately result in a more consistent process that produces a desired outcome. The process analysis tool used in Lean Six Sigma is called DMAIC, which stands for Define, Measure, Analyze, Improve and Control [11, 12]. The healthcare system is more dynamic and complex than most production lines. However, the utility of DMAIC in healthcare has been shown to be successful in several studies. In the realm of ID, previous studies have investigated the Lean Six Sigma DMAIC framework as a methodology to reduce healthcare-associated infection and decrease duration of pneumonia overtreatment. However, no OPAT initiatives using this methodology have been described [13, 14]. We aim to utilize a Lean Six Sigma framework to evaluate our OPAT process and define opportunities for improvement in patient care.

METHODS

According to institutional policy, this quality improvement project was exempt from ethical approval and informed consent was not required. The manuscript was prepared according to the SQUIRE standard reporting guidelines [15].

Study Setting and Design

This QI initiative was undertaken by the division of infectious diseases at Wayne State University in

Detroit, Michigan. "Wayne Health" physicians' groups hires infectious diseases physicians into the division. Our center (the Detroit Medical Center) encompasses over 2,000 licensed beds and serves as the primary healthcare safety net hospital for our community in affiliation with the Wayne State University School of Medicine. We used the DMAIC problem solving tool of the lean six-sigma process to evaluate our OPAT process, starting with a strategy to, "Define" and "Measure" a cohort of patients discharged on OPAT.

Data Collection and Analysis

We retrospectively analyzed all consults to the academic infectious diseases service over five-month period (August 2022 to December 2022) and identified patients who were discharged on intravenous antibiotics. Patients were included if they were aged 18 years and older and were discharged on OPAT. Patients were excluded if they completed their IV antibiotics in the hospital or expired prior to discharge. Data on demographics, infection source, micro-organism, discharge antibiotic regimen, discharge location, and readmission were systematically recorded. We also collected data on the completeness of documentation in our ID sign-off notes. We defined complete documentation as that which included the antibiotic dose, duration, stop date, and indicated that an outpatient ID appointment was scheduled after discharge. ID clinic show-rate and duration from discharge date to ID clinic visit were also noted.

In the analysis phase, we identified adverse outcomes and opportunities for error in our OPAT process. Primary outcome was a composite of any adverse event (AE) which encompassed any issue for which patients required emergency department (ED) visit or hospital readmission within 30 days. Outcomes were compared between the OPAT patients who had and had not experienced an AE, respectively. Descriptive statistics included median and interquartile range (IQR). Binary variables were compared using odds ratios and ordinal variables were compared with the Wilcoxon rank sum (Mann-Whitney U) test for nonparametric data. Statistical analysis was done using SPSS version 26 (IBM). Effects were considered significant if the p-value was less

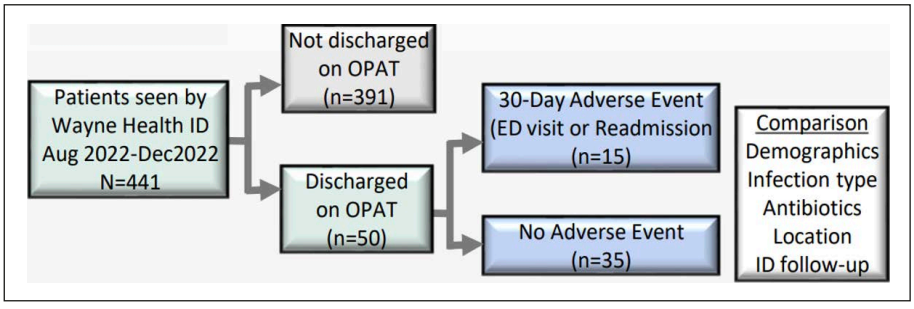

Figure 1
Study design. Abbreviations: ID: Infectious Diseases, ED: Emergency Department.

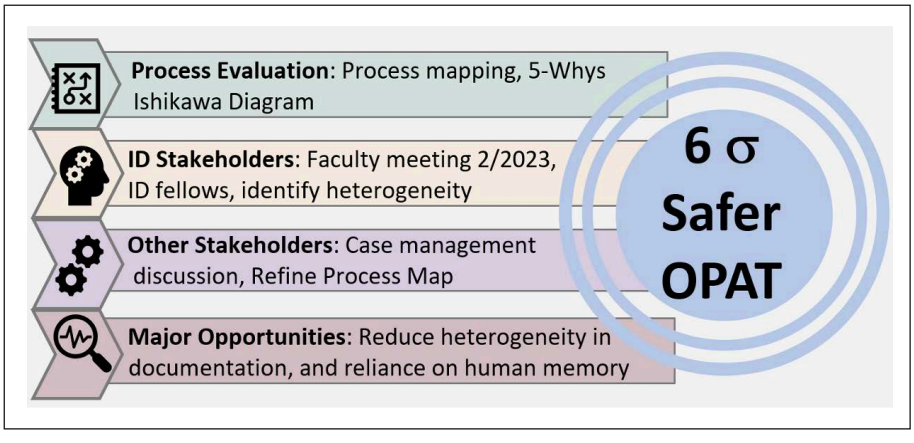

Figure 2
Six-Sigma Process Evaluation and Stakeholder Engagement. Abbreviations: ID: Infectious Diseases, OPAT: Outpatient Parenteral Antibiotic Therapy.

than 0.05. AEs were evaluated through 30 days after discharge. Through-out this period, first and the last authors conducted focussed group discussions with process stakeholders included ID attendings, ID fellows, ID clinic nurses, and case managers to gain insights through group conversations and observations post-discharge OPAT appointment scheduling. Ishikawa diagrams, 5-Why's analysis, and process maps were created for assessing the scope of errors and the process for prescribing OPAT. Stakeholder anecdotes were challenged with data from the study. Study design and six sigma process evaluation with stake holder engagement has been illustrated in Figure 1 and 2.

RESULTS

During the five months study period 50 out of 441 patients (11.3%) were discharged on IV antibiotics. The study population constituted of 74% men with a median age of 61 years and 14% with intravenous drug use. Bone and joint infections including septic arthritis (32%) and cardiac infections (18%) were the most common indications for which patients were discharged on IV antibiotics (Figure 3). *Staphylococcus aureus* infection occurred in 30% of the patients with 22% being discharged on vancomycin-based regimen. On discharge, equal proportion of patients went to skilled nursing facility as they did on home IV infusion (40%). Only 50% of the ID sign off notes had complete

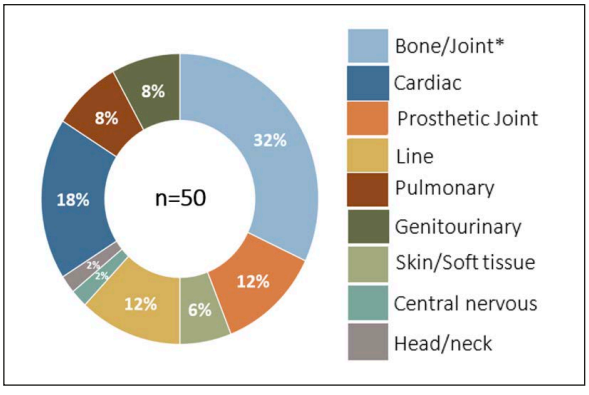

Figure 3 - Infection types. Legend: *native joint, Interpretation: No difference in infection type were seen between the group who had an adverse event (n=15) and the group that did not (n=35), (p>0.05 for all comparisons).

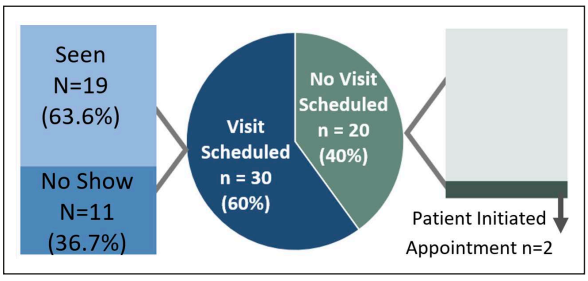

Figure 4 - Flow of infectious diseases clinic follow up.

documentation. Only 60% were scheduled for ID clinic follow-up. Overall clinic, show rate was 42% with a median duration of 21 days after hospital discharge. The show rate in the ID clinic for patients scheduled was 63%, and two patients not scheduled initiated their own appointments (Figure 4).

Fifteen patients (30%) had met the criteria for primary outcome of adverse event, requiring emergency department (ED) visit or readmission within 30 days. Analysis of the various factors revealed that OPAT patients who had no adverse events were more likely to have been seen in the clinic after discharge (51% versus 20%, p=0.039) (Table 1). The median time to an adverse event was 12 days. Stakeholder statements and its clarification with the data has been depicted in Figure 5.

DISCUSSION

The DMAIC model of the six-sigma process illuminated aspects of our process that were previously unknown to us. On an average we discharged ten patients per month on IV antibiotics and 30% were readmitted for adverse events. The anecdotal beliefs of our stakeholders was that a majority of patients completed OPAT in SNFs or other facilities, however, this was not the case. In our study, 40% of the patients were discharged on IV antibiotics to be administered through home infusion companies. It is difficult to assess these patients for therapeutic response or any medication related toxicities unless they follow up in the ID clinic. This requires co-ordination between in-patient care teams and ambulatory clinic staff to ensure prompt follow up of these patients. As evidenced in our study those patients who had a clinic follow up were less likely to have an ED visit or readmission. In a large retrospective study of

Table 1 - Characteristics and Outcomes of OPAT Patients treated by Wayne Health.

Characteristics	*Total (n=50)*	*No Adverse Event (n=35)*	*Adverse Event (n=15)*	*p-value*
Age, median (IQR) years	61 (50-67)	62 (49-68)	57 (52-65)	0.575
Male, n (%)	37 (74.0)	26 (74.3)	11 (73.3)	0.944
PWID, n (%)	7 (14.0)	6 (17.1)	1 (6.7)	0.328
Infection Type, n (%)				
Bone/Joint*	16 (32.0)	10 (28.6)	6 (40.0)	0.427
Cardiac	9 (18.0)	6 (17.1)	3 (20.0)	0.810
Prosthetic Joint Infection	6 (12.0)	6 (17.1)	0 (0)	0.087
Line infection	6 (12.0)	3 (8.6)	3 (20.0)	0.254
Pulmonary	4 (8.0)	3 (8.6)	1 (6.7)	0.820
Genitourinary / Pelvic	4 (8.0)	2 (5.7)	2 (13.3)	0.363
Skin and Soft Tissue Infection	3 (6.0)	3 (8.6))	0 (0)	0.242
Central Nervous System	1 (2.0)	1 (2.9)	0 (0)	0.508
Head and Neck	1 (2.0)	1 (2.9)	0 (0)	0.508
Hospital				
Harper University Hospital	23 (46.0)	16 (45.7)	7 (46.7)	0.577
Detroit Receiving Hospital	23 (46.0)	17 (48.6)	6 (40.0)	0.951
Karmanos Cancer Center	4 (8.0)	2 (5.7)	2 (13.3)	0.363
Microbiology and Antibiotics, n (%)				
Staphylococcus aureus infection	15 (30.0)	11 (31.4)	4 (26.7)	0.736
Vancomycin Regimen	11 (22.0)	7 (20.0)	4 (26.7)	0.602
OPAT Location				
Home Infusion, n (%)	20 (40.0)	13 (37.1)	7 (46.7)	0.529
Inpatient Rehabilitation, n (%)	3 (6.0)	3 (8.6)	0 (0)	0.242
Long Term Acute Care, n (%)	4 (8.0)	3 (8.6)	1 (6.7)	0.820
Skilled Nursing Facility, n (%)	20(40.0)	14 (40.0)	6 (40.0)	1.00
Dialysis, n (%)	3 (6.0)	2 (5.7)	1 (6.7)	0.897
Discharge Outcomes				
Complete Documentation[¥]	25 (50.0)	19 (54.3)	6 (40.0)	0.355
No ID clinic visit scheduled, n (%)	20 (40.0)	13 (37.4)	7 (46.7)	0.529
ID clinic visit scheduled, n (%)	30 (60.0)	22 (62.9)	8 (53.3)	0.529
ID clinic show (Any), n (%)[#]	21 (42.0)	18 (51.4)	3 (20.0)	0.039
ID clinic show within 14 days, n (%)	4 (8.0)	4 (11.4)	0 (0)	0.172
ID clinic show within 28 days, n (%)	15 (30.0)	13 (37.1)	2 (13.3)	0.092
Time to ID clinic visit, median (IQR) days	21 (17-31)	18.5 (15.3-22.8)	21 (16.3-30)	0.920
Scheduled, but no show, n (%)	10 (20.0)	5 (14.3)	5 (33.3)	0.123

Abbreviations: IQR: Interquartile Range; ID: Infectious Diseases; OPAT: Outpatient Parenteral Antibiotic Therapy; PWID: People who inject drugs
*Indicates native joint infection; [¥]Defined as having the drug, dose, duration, and end date documented, and an appointment scheduled in the ID clinic; [#]Included any patient seen post discharge including 2 who self-scheduled follow-up.

755 patients, follow up OPAT clinic visit was associated with lower readmission (odds ratio, 0.10 [95% confidence interval, 0.06-0.17]) [16]. It was also observed in our study that median duration for development of an adverse event was 12 days. Early outpatient infectious diseases follow up within two weeks was associated with lower risk of all-cause 30-day readmission (adjusted odds ratio, 0.33; P=.0001) [17]. Indicating that patients must be seen early in the clinic within the first two weeks of discharge, irrespective of the total duration of antibiotics. This helps in clinical assessment to take necessary corrective actions and establish ambulatory care.

We identified defects in our OPAT discharge process which was hampering the goal for early and close outpatient ID follow up to reduce readmission rates. Process mapping revealed process het-

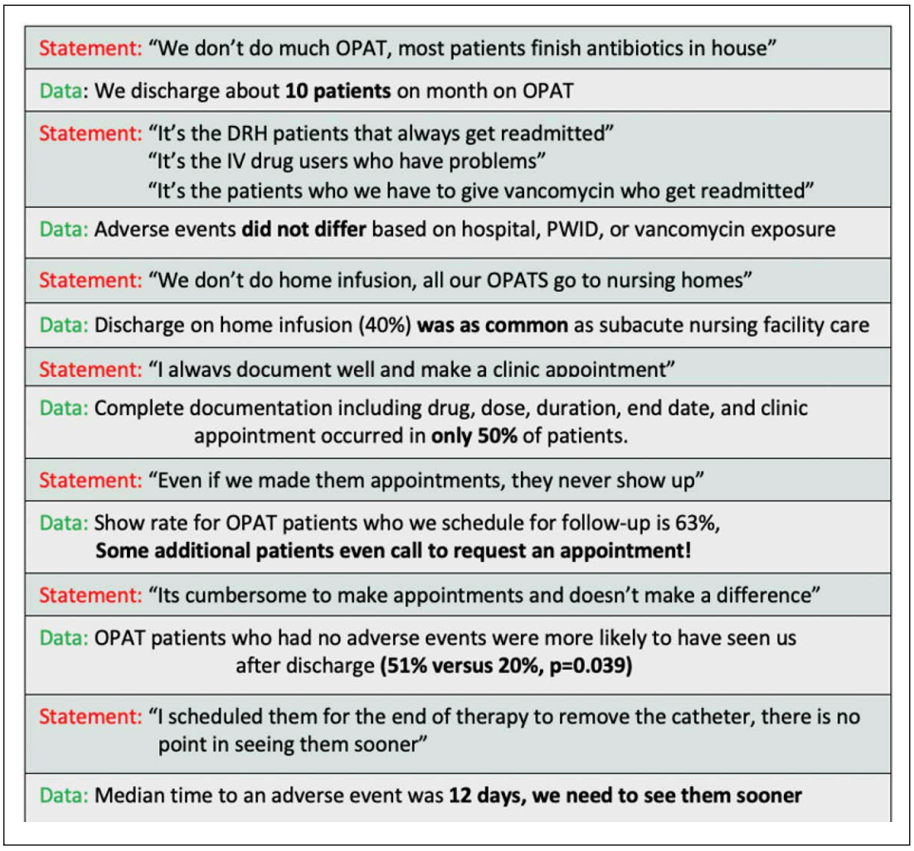

Figure 5
Stakeholder anecdotes versus the data.

erogeneity depending on patient discharge location and a high reliance on human memory. An Ishikawa diagram also identified numerous factors contributing to OPAT related adverse events. Focus groups with various stakeholders revealed common assumptions which were not supported by the data. The completeness of documentation for an ID follow-up visits in our ID sign off note was as low as 50% and only 60% were scheduled for a clinic visit. Among those who were scheduled, our median time to ID follow-up was 21days. The next steps in our DMAIC approach includes efforts at developing improvement strategies. We will plan to develop a system to standardize our documentation for patients leaving on IV antibiotics. An electronic ID sign off note with predetermined mandatory variables for dose, duration, stop date, monitoring labs and scheduled ID clinic follow up date will be designed with the help of our IT department. We will engage ID physician assistant in helping us schedule appointments to reduce heterogeneity. We will further ensure scheduling appointments within 14 days of discharge. With the implementation of these strategies, our process will be reassessed to see if there was any change in readmission rates and look for additional opportunities for improvement.

In summary, to optimize OPAT performance and reduce readmissions, key strategies include ensuring early outpatient follow-up within 14 days, standardizing the discharge process to minimize variability, and enhancing documentation with a structured electronic ID sign-off note. Additionally, streamlining appointment scheduling with the support of an ID physician assistant and continuously reassessing outcomes will help identify further improvements. Implementing these measures can enhance patient safety and OPAT efficiency.

Our study has limitations inherent to any retrospective study including but not limited to misclassification, missing data and loss to follow up. We have consciously tried to minimize these biases. Although we screened over 400 patients during a 5-month period, we could find only 50 patients

discharged on IV antibiotics. This number is small to derive any meaningful statistical results. Most of our patients were homeless without much access to healthcare facility. As a result, a smaller number of patients were discharged on IV antibiotics due to ID physician preference to discharge them on oral antibiotics. Moreover, our study does not report on the changes following development of improvement strategies. Given our patient population, we recognize that payor type (insured vs. uninsured) and/or underlying IV drug use may have influenced the outcomes. However, we do not have specific data to quantitatively support this claim.

CONCLUSIONS

An infectious diseases physician-driven quality improvement analysis designed with the Lean Six Sigma DMAIC methodology revealed heterogeneity in our process, inconsistent discharge documentation, and incorrect assumptions about OPAT among process stakeholders. Almost a third of our patients experienced an adverse event after discharge; most within two weeks. We are currently integrating the insights gained from our DMAIC analysis in a QI initiative to enhance our documentation practice and standardize OPAT follow-up to ensure that all patients discharged on OPAT receive timely follow-up care.

Ethical clearance
Given the nature of our study as a Quality Improvement initiative, it was exempt from Institutional Review Board (IRB) clearance. The focus on enhancing practices and procedures within our own institution negated the need for external ethical review.

Declaration
the research findings were presented at ID week 2023, Boston as an oral presentation and the abstract was published in Open Forum Infectious Diseases on Nov 27th, 2023. DOI: 10.1093/ofid/ofad500.407. This was presented as a poster at the Michigan Infectious Diseases Society annual meeting, 2023 and was awarded as the "best poster". It was also selected as the "best oral abstract presentation" at the Southeast Michigan QI Summit 2023. It was presented at the Detroit Medical Center annual QuESST meeting 2023.

Conflict of interest
No conflict of interest to declare.

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None.

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