American Journal of Infection Control 47 (2019) 558–564

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major Article

Evidence-based interventions to reduce obstetric-related infections at an army training facility

Edward R. McClellan MD [a,*], Andrew Hover APRN [b], Mehana Moore RN [a], Justin Spaleny LPN [a], Seema Singh MPH, M(ASCP), CIC [c], Ludrena Rodriguez APRN [a], Michael B. Lustik MS [d], Donald J. Gloeb DO, MPH [a]

[a] Department of Obstetrics and Gynecology, Tripler Army Medical Center, Honolulu, HI
[b] Center for Nursing Science and Clinical Inquiry, Tripler Army Medical Center, Honolulu, HI
[c] Infection Control and Epidemiology, Tripler Army Medical Center, Honolulu, HI
[d] Department of Clinical Investigation, Tripler Army Medical Center, Honolulu, HI

Key Words:
Chorioamnionitis
Endometritis
Surgical site infection

A B S T R A C T

Background:
Objective: Obstetric-related infections are a major cause of maternal morbidity and mortality worldwide. Our team implemented an evidence-based infection control bundle aimed at reducing obstetric-related infections at our facility.
Methods: A multidisciplinary team at Tripler Army Medical Center developed, implemented, and evaluated an evidence-based maternal safety infection control bundle (MSICB) on labor and delivery aimed at reducing the incidence of surgical site infections (SSI) and chorioamnionitis. Adenosine triphosphate testing of patient care–related surfaces was performed while behavioral and environmental interventions were implemented. Incidence rates for chorioamnionitis, SSI, and endometritis were compared between pre- and during-MSICB implementation using Fisher exact test and Poisson regression, adjusting for year and quarter. The decision science analysts at US Army Medical Command, Fort Sam Houston, Texas responsible for our facility utilized diagnosis-related group and ICD-10 Procedure Coding to determine infection-related costs.
Results: Prior to implementation of the MSICB, the rates of chorioamnionitis, SSI, and endometritis in the first half of 2016 were 6.3%, 3.4%, and 0.4%, respectively. After implementation of the MSICB, in the first 6 months of 2017, the rates of chorioamnionitis and SSI decreased to 1.7% and 1.0%, respectively, with no change in the rate of endometritis. The rate was significantly lower after implementation for chorioamnionitis ($P < .001$), and there was a statistically nonsignificant decrease for SSI ($P = .060$) and no difference for postpartum endometritis ($P = 1.00$). These reductions resulted in an estimated net cost savings of $671,218.
Conclusions: A multidisciplinary approach with evidence-based strategies resulted in a significant decrease ($P < .001$) in chorioamnionitis and a statistically nonsignificant decrease ($P = .060$) in the SSI rate, which resulted in a significant cost savings for the hospital. There was no change in our postpartum endometritis rate.

Obstetric-related infectious morbidity is a significant national and global problem.[1,2] Specifically, this preventable morbidity is attributed to chorioamnionitis, an infection of the chorion and amnion that can occur during labor; postpartum endometritis, an infection of the endometrial lining that occurs in the postpartum period; and cesarean delivery surgical site infections (SSI).[3,4] Currently, neonatal and maternal mortality and primary cesarean delivery rates are collected annually in the United States.[5,6] Recently, the American College of Obstetricians and Gynecologists and the American Society of Anesthesiologists created the Maternal Quality Improvement Program, which collects data for obstetric-related infections.[7] Evidence-based

* Address correspondence to Edward Russell McClellan, MD, Department of Obstetrics and Gynecology, Evans Army Community Hospital, 1650 Cochrane Circle, Fort Carson, CO 80913.
E-mail address: edward.r.mcclellan.mil@mail.mil (E.R. McClellan).
Previous presentation: Preliminary data were presented orally at the Asia-Pacific Military Health Exchange, Singapore, May 23-26, 2017. Completed data were presented orally at the ACOG Armed Forces District Meeting, San Antonio, TX, September 24-27, 2017. Poster presentations were made to the Pacific Coast Obstetrical and Gynecological Society, Palm Desert, CA, November 2-5, 2017, and the American Medical Association Scientific Assembly, Honolulu, HI, November 10, 2017.
Conflicts of interest: None to report.
The views expressed in this article are those of the author(s) and do not reflect the official policy or position of the Department of the Army, the Department of Defense, or the United States government.

https://doi.org/10.1016/j.ajic.2018.09.023
0196-6553/

infection prevention bundles have been shown to reduce obstetric SSI rates; however, we are unaware of bundles aimed at reducing all obstetric-related infections.[8]

The National Surgical Quality Improvement Program collects semiannual data on SSI; however, data are not collected for cesarean deliveries.[9] Although no specific interventions were reported, 82% of hospitals that participated in the National Surgical Quality Improvement Program had reduced morbidity and 66% had reduced mortality for the procedures tracked.[10] Additionally, there have been efforts to determine anticipated SSI rates based on patient-based risk stratification.[11] These programs suggest that tracking procedure-related infections and comparing local rates to national averages may result in decreased morbidity and mortality.

Health care–associated infections are costly, and infection control interventions could result in an annual cost savings to US hospitals of $5.7-$31.5 billion in 2007 US dollars.[12,13] Unfortunately, infection control programs continue to be underfunded and underresourced.[14] Research suggests that cesarean delivery SSI and postpartum endometritis result in additional costs related to inpatient and outpatient care, although the financial impact of a diagnosis of chorioamnionitis has not been well studied.[15-17]

In an effort to reduce obstetric-related infectious morbidity at our hospital, a quality improvement project was implemented using an evidence-based infection control bundle.

METHODS

Clinical data considerations

An evidence-based infection control bundle, the maternal safety infection control bundle (MSICB), was implemented at Tripler Army Medical Center, between January and June 2017, with the aim of reducing obstetric-related infectious morbidity, namely the rates of chorioamnionitis and SSI. In order to facilitate implementation, a multidisciplinary team at Tripler Army Medical Center was formed, consisting of an attending physician, a resident physician, an infection control specialist, clinical nurse specialists for both women's health and surgical services, an officer in charge and a noncommissioned officer in charge of labor and delivery (L&D), and representatives from environmental services.

The team used the Ruhof ATP Complete contamination monitoring system and the Ruhof Test swabs (Ruhof Corporation, Mineola, NY) to determine the effectiveness of a cleaning protocol on high-touch L&D areas.[18,19] The system and swabs are 2 of several tools recommended by the Centers for Disease Control and Prevention (CDC) to assess cleaning effectiveness. The system uses bioluminescence technology in conjunction with a luciferase/luciferin reagent in the test swabs to measure the concentration of adenosine triphosphate (ATP), reported as a relative light unit (RLU).[18] The manufacturer's recommended limit of less than 100 RLU was used to determine if particular surfaces had been appropriately cleaned following deliveries and to assess daily cleaning on L&D.[19]

Monthly ATP swab samples were taken in October and December 2016, prior to implementation of the MSICB, to assess effectiveness of baseline cleaning practices on L&D, as well as between January and June 2017, during implementation of the MSICB. Sampling was from patient high-touch areas and medical equipment routinely used in 19 rooms (11 L&D rooms, 2 L&D operating rooms, and 6 examination rooms in L&D triage). The sampling occurred within 30 minutes after each room had been cleaned. The patient high-touch areas and medical equipment in the 19 rooms included fetal scalp electrodes, intrauterine pressure catheters, blood pressure cuffs, neonatal stethoscopes, pulse oximetry devices, keyboards, intravenous pumps, bed rails, external fetal heart rate monitors, tocometers, operating room belts, and hair clipper bases. The team also implemented a CDC Level 1 cleaning program by creating a checklist with environmental services and with nursing staff that delineated cleaning responsibilities on L&D.[18] The cleanliness of each labor room was inspected by both the environmental services supervisor and a L&D staff member prior to rooming new patients. Rooms that contained items on the checklist that did not pass inspection by both the environmental services supervisor and a L&D staff member were cleaned again before rooming the next patient.

When selecting interventions to be included in our bundle, the team incorporated several evidence-based interventions that were not routinely being used at Tripler Army Medical Center. Use of chlorhexidine abdominal preparation and preoperative vaginal cleansing are both known to reduce cesarean delivery SSI.[20-25] The team also implemented standardization of hand hygiene and perineal care prior to cervical examinations, both of which are recommended by the World Health Organization.[26] Also, the team ensured the appropriate number of chlorhexidine abdominal preoperative applicators were used on each patient based on their abdominal surface area.[27] Finally, pressure dressings, silver-infused dressings, and negative pressure dressings were used on cesarean delivery incision sites, all of which have been utilized to reduce wound complications on nonobstetric incisions.[28,29] Subsequent to the conduct of this quality improvement project, systematic reviews and meta-analyses had shown conflicting results associated with the use of negative pressure dressings in obstetric patients.[30,31]

The multidisciplinary team reviewed, considered, and selected a list of interventions for reducing chorioamnionitis and SSI rates. The list of interventions included the following: (1) all staff on L&D should wash their hands with Avagard surgical scrub (3M Corporation, St. Paul, MN) prior to starting their shift; (2) all staff should remove their jacket or coats prior to entering a patient's room; (3) at the time of admission, all patients should have a chlorhexidine gluconate cloth wipe of their abdomen performed when changing into their gown, and a second wipe should be performed on all patients requiring a cesarean delivery within 1 hour of the surgical procedure; (4) prior to all cervical examinations and vaginal procedures, all staff should wash their hands with Purell waterless surgical scrub (GOJO Industries, Akron, OH), and the perineum should be cleaned with the Provon postinsertion Foley care wipes (GOJO Industries), with this step documented in the intrapartum progress note; (5) patients requiring a cesarean delivery should have vaginal cleansing performed in the operating room in addition to an abdominal preparation unless the nature of the delivery is too emergent to allow for an adequate preparation to be performed, and patients with an iodine allergy should be prepped with 4% chlorhexidine gluconate with 4% isopropyl alcohol per ACOG Committee Opinion 571;[32] (6) Traxi panniculus retractors (Clinical Innovations, Murray, UT) will be available to aid with proper exposure if desired by the surgeon; and (7) Aquacel Ag (ConvaTec, Reading, UK) or negative pressure dressings should be considered for all patients without contraindications. If the surgeon elects not to use 1 of these dressings, the alternative dressing should be secured only with adhesive tape rolls utilized for single patient use.

The multidisciplinary team implemented, supervised, and monitored the MSICB. The team met at regularly scheduled intervals to review the implementation of planned interventions and to review monthly chorioamnionitis and quarterly SSI rates. Prior to starting the project, mandatory training for all nursing and physician staff was held regarding the planned interventions. This training included training for all nursing staff on proper abdominal and vaginal preparation techniques. Measures to prospectively ensure compliance with the interventions were not put into place. Also, the team reviewed baseline data for rates of chorioamnionitis and cesarean delivery–related SSI collected between January and June 2016.

The Department of Infection Control tracks all obstetric-related infections at Tripler Army Medical Center. Patients with SSI were

identified using the CDC definition of SSI.[33] All patients given a clinical diagnosis of chorioamnionitis or postpartum endometritis were included in our analysis regardless of how that clinical diagnosis was made and were identified using the ICD-10-CM/PCS.[34] A diagnosis of chorioamnionitis included 1 or more clinical criteria, including maternal fever, tachycardia, leukocytosis, fundal tenderness, foul smelling or purulent vaginal discharge, and fetal tachycardia.

Cost data considerations

For this quality improvement project, we utilized available data obtained from the Military Health System Management Analysis and Reporting Tool (M2) for medical diagnoses and expense-related information for inpatient and outpatient care used by all Department of Defense medical facilities. Every inpatient disposition is assigned a Medicare Severity-Diagnosis Related Group (MS-DRG) based on the ICD-10-CM/PCS diagnoses and procedures assigned to a particular inpatient record. Each MS-DRG has an associated relative weighted product (RWP), which represents the relative cost of a given discharge diagnosis.[34] We obtained the following from the Military Health System Management Analysis and Reporting Tool (M2): MS-DRG, ICD-10-CM/PCS diagnoses, and RWP data.

Expense-related data were obtained from the Expense Assignment System IV. The Expense Assignment System IV is the Department of Defense database used to obtain cost-related data representing facility expenses incurred for personnel, supplies, equipment, travel, leases, maintenance, etc, across inpatient and outpatient facilities.

A base unit cost ($/RWP) was calculated by dividing each unique facility expense by each unique facility RWP. The base unit cost for the obstetric and gynecologic inpatient and newborn nursery (including the neonatal intensive care unit) at our facility was obtained by dividing total annual operating expenses for the obstetric and gynecologic inpatient and newborn nursery work centers by the total annual RWPs generated in those work centers, respectively.

The base unit cost was then multiplied by the average RWP per discharge diagnosis to determine the estimated cost per discharge diagnosis (cost per case). The average RWP per discharge diagnosis was determined using ICD-10-CM/PCS diagnoses for the relevant MS-DRGs. This methodology was applied to all categories of interest.

Statistical analysis

Fisher exact tests were used to compare incidence rates before and during MSICB implementation for chorioamnionitis, postpartum endometritis, and SSI. Rates for chorioamnionitis and postpartum endometritis were based on all deliveries in the first 2 quarters of 2016 and 2017 (n = 1,222 and n = 1,128, respectively), and rates for SSI were based on all cesarean deliveries during the same time period (n = 323 for 2016 and n = 290 for 2017). Poisson regression was used to estimate the relative risk of chorioamnionitis during implementation based on monthly rates of infection.

Wilcoxon signed-rank tests were used to compare ATP swab data (RLUs) collected from patient high-touch areas and medical equipment in each room before and during MSICB implementation. Pass rates based on a cut-point of 100 RLU were determined and compared pre-MSICB versus during MSICB implementation for each swabbed surface. Analysis of MSICB implementation swab data was characterized in 2 ways, the first based on the first 6 months of 2017 (January-June) and the second based on data obtained in May and June 2017. The second analysis was done to exclude data that may have been affected by any startup issues during implementation. A significance level of .05 was used for all analyses, which were performed using SAS Version 9.4 software (SAS Institute, Cary, NC).

This project was determined to be a quality improvement project and was approved by the Tripler Army Medical Center Department of Clinical Investigation and Quality Services Division on September 6, 2016.

RESULTS

Clinical data

Given the prevalence of chorioamnionitis at Tripler Army Medical Center, it was possible to report the rate of chorioamnionitis by month in each of the first 2 quarters of 2016 and 2017. Given the lower prevalence of SSI and postpartum endometritis, the rates of these conditions were reported for the first 6 months of 2016 and 2017.

Forty-one of 636 deliveries were diagnosed with chorioamnionitis (6.4%) in the first quarter of 2016. In the second quarter of 2016, 36 of 586 deliveries were diagnosed with chorioamnionitis (6.1%). Nine of 567 deliveries were diagnosed with chorioamnionitis (1.6%) in the first quarter of 2017, and in the second quarter of 2017, 10 of 561 deliveries were diagnosed with chorioamnionitis (1.8%). The overall incidence rate of chorioamnionitis was significantly lower during MSICB implementation in the first 6 months of 2017, compared with the same period in 2016 (1.7% vs 6.3%, $P < .001$). Rates were lower in each month of 2017, compared with the same month in 2016 (Table 1 and Fig 1). The relative risk of developing chorioamnionitis during MSICB implementation was 0.27 (95% confidence interval [CI], 0.16, 0.44, $P < .001$).

In the first half of 2016, 11 of 323 cesarean deliveries were diagnosed with SSI (3.4%). Five of these had been scheduled, and 6 were unscheduled. In the first half of 2017, 3 of 290 cesarean deliveries were diagnosed with SSI (1.0%). Two of these had been scheduled, and 1 was unscheduled. SSI incidence showed a statistically nonsignificant decrease in 2017, compared with 2016 (1.0% vs 3.4%, $P = .060$).

In the first half of 2016, 5 of 1,222 deliveries were diagnosed with postpartum endometritis (0.4%). In the first half of 2017, 5 of 1,128 deliveries were diagnosed with postpartum endometritis (0.4%). The rate of postpartum endometritis was the same for the first 6 months of 2017 and 2016 (0.4% vs 0.4%, $P = 1.00$).

Analysis of RLU levels found that, overall, levels were significantly lower for fetal scalp electrodes ($P = .005$), blood pressure cuffs ($P = .022$), keyboards ($P = .018$), bedrails ($P < .001$), and tocometers ($P = .031$) in the first 6 months of 2017, compared with October and December 2016 (Table 2). Prior to MSICB implementation, 14% of fetal scalp electrode samples, 19% of stethoscopes, and 30% of bedrails were less than 100 RLU. During implementation, pass rates at these 3 sampling locations rose to 90%, 88%, and 100%, respectively, in May and June 2017, and all other samples taken during these 2 months passed (RLU < 100). Table 3 contains data that reflect a summary of median RLUs with interquartile range (25%-75%) by surface before and during MSICB implementation, which demonstrates a clear

Table 1
Chorioamnionitis rates by month, quarter, and year

	2017 %	2017 # cases/total	2016 %	2016 # cases/total
January	2.2%	4/184	7.2%	15/208
February	0.6%	1/169	3.9%	7/181
March	1.9%	4/214	7.7%	19/247
Quarter 1	1.6%	9/567	6.4%	41/636
April	1.1%	2/188	6.4%	13/203
May	2.1%	4/192	3.6%	7/195
June	2.2%	4/181	8.5%	16/188
Quarter 2	1.8%	10/561	6.1%	36/586

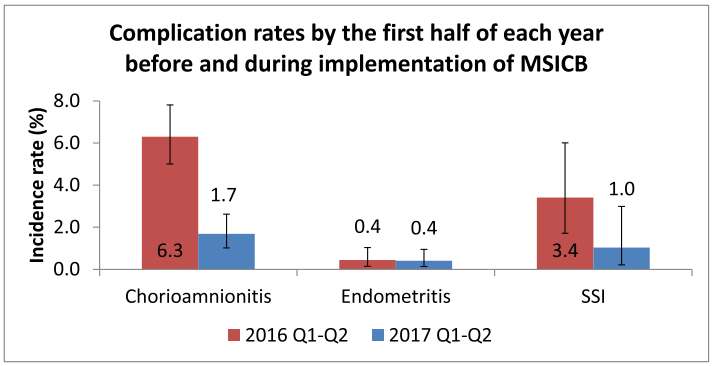

Fig 1. Comparison of complication rates by year before and during implementation of the maternal safety infection control bundle (MSICB). *SSI*, surgical site infection.

decrease in median RLUs during implantation of the MSICB and is suggestive of its efficacy.

Cost data

Observed costs

MS-DRG and ICD-10-CM/PCS codes were used to calculate the chorioamnionitis-related inpatient costs for 2016 at Tripler Army Medical Center. All costs were rounded to the nearest dollar. Results (cost per case) showed average additional costs of $5,342 for maternal care after a vaginal delivery complicated by chorioamnionitis, average additional costs of $3,469 for maternal care after a cesarean delivery complicated by chorioamnionitis, and average additional costs of $7,817 for newborn care complicated by chorioamnionitis (Fig 2). The team did not determine additional costs for postpartum endometritis.

The total cost for chorioamnionitis in the first half of 2016 was calculated on a quarterly basis. In the first quarter of 2016, there were 29 vaginal deliveries and 12 cesarean deliveries whose intrapartum courses were affected by chorioamnionitis. These deliveries were productive of 41 newborn infants. The total additional chorioamnionitis-related inpatient cost for these 41 patients and their newborns was $517,043.

In the second quarter of 2016, there were 26 vaginal deliveries and 10 cesarean deliveries whose intrapartum courses were affected by chorioamnionitis. These deliveries were productive of 36 newborn infants. The total additional chorioamnionitis-related inpatient cost for these 36 patients and their newborns was $454,994.

In the first quarter of 2017, there were 3 vaginal deliveries and 6 cesarean deliveries whose intrapartum courses were affected by chorioamnionitis. These deliveries were productive of 9 newborn infants. The total additional chorioamnionitis-related inpatient cost for these 9 patients and their newborns was $107,193.

In the second quarter of 2017, there were 6 vaginal deliveries and 4 cesarean deliveries whose intrapartum courses were affected by chorioamnionitis. These deliveries were productive of 10 newborn infants. The total additional chorioamnionitis-related inpatient cost for these 10 patients and their newborns was $124,098.

SSI-related inpatient costs were also calculated for 2016 at Tripler Army Medical Center. MS-DRG and ICD-10-CM/PCS codes were used to calculate the average additional cost for 1 SSI ($7,900). In the first half of 2016, 11 of 323 cesarean deliveries were diagnosed with SSI, with a rate of 3.4%. SSI-related inpatient costs during this time frame totaled $86,900. In the first half of 2017, 3 of 290 cesarean deliveries were diagnosed with SSI, with a rate of 1.0%. SSI-related inpatient costs during this time frame totaled $23,700.

Expected costs

Several assumptions were made to calculate expected costs. The first assumption was based on the 10.8% decrease in the number of all deliveries in the first quarter of 2017, compared with the first quarter of 2016. One would expect that the chorioamnionitis-related inpatient costs in the first quarter of 2017 would have decreased by 10.8%, which would be an expected cost of $461,202. However, the actual cost was $107,193, resulting in a cost savings of $354,009.

The second assumption was based on the 4.3% decrease in the number of all deliveries in the second quarter of 2017, compared with the second quarter of 2016. One would expect that the chorioamnionitis-related inpatient costs in the second quarter of 2017 would have decreased by 4.3%, which would be an expected cost of $435,429. However, the actual cost was $124,098, resulting in a cost savings of $311,331.

Table 2
ATP swab percentage pass rate by surface

	FSE % pass (N)	IUPC % pass (N)	BP cuff % pass (N)	Stethoscope % pass (N)	Pulse ox % pass (N)	Keyboard % pass (N)	IV pump % pass (N)	Bedrails % pass (N)	EFHR % pass (N)	Toco % pass (N)	OR belt % pass (N)	Clipper base % pass (N)
Pre-MSICB												
October	0 (11)	73 (11)	79 (19)	23 (13)	92 (13)	89 (19)	100 (11)	24 (17)	78 (8)	83 (6)	50 (2)	100 (2)
December	30 (10)	91 (11)	84 (19)	15 (13)	92 (13)	89 (19)	100 (11)	35 (17)	80 (5)	75 (4)	50 (2)	100 (2)
During MSICB												
January	67 (9)	80 (10)	100 (17)	75 (12)	78 (18)	100 (18)	90 (10)	88 (16)	89 (9)	100 (8)	50 (2)	100 (2)
February	40 (10)	70 (10)	94 (18)	50 (12)	94 (18)	100 (18)	100 (8)	67 (15)	100 (8)	100 (7)	100 (2)	100 (2)
March	50 (10)	100 (8)	100 (18)	46 (13)	100 (18)	95 (19)	100 (10)	71 (17)	83 (6)	100 (6)	50 (2)	100 (2)
April	70 (10)	80 (10)	89 (18)	42 (12)	89 (18)	100 (18)	80 (10)	88 (16)	71 (7)	100 (5)	50 (2)	100 (2)
May	82 (11)	100 (11)	100 (19)	85 (13)	100 (19)	100 (19)	100 (9)	100 (15)	100 (6)	100 (6)	N/A (0)	N/A (0)
June	100 (10)	100 (11)	100 (19)	92 (13)	100 (18)	100 (19)	100 (13)	100 (17)	100 (6)	100 (6)	100 (2)	100 (2)

NOTE. N = total number of samples.
ATP, adenosine triphosphate; *BP*, blood pressure; *EFHR*, electronic fetal heart rate; *FSE*, fetal scalp electrode; *IUPC*, intrauterine pressure catheter; *IV*, intravenous; *MSICB*, maternal safety infection control bundle; *N/A*, not applicable; *OR*, operating room; *ox*, oximetry; *toco*, tocometer.

Table 3
ATP swab median RLUs pre- and during MSICB implementation by surface

	Pre-MSICB		During MSICB	
	n	Median (IQR)	n	Median (IQR)
FSE	21	491 (220-979)	60	18 (5-147)
IUPC	22	12 (3-76)	60	4 (2-18)
BP cuff	38	15 (7-48)	109	4 (2-11)
Stethoscope	26	367 (161-798)	75	42 (7-275)
Pulse ox	26	17 (10-35)	109	4 (2-20)
Keyboard	38	13 (5-21)	111	7 (3-16)
IV pump	22	12 (6-28)	60	5 (2-15)
Bedrails	34	128 (77-235)	96	30 (5-67)
EFHR	13	14 (6-27)	42	7 (3-15)
Toco	10	31 (6-67)	38	7 (2-13)
OR belt	4	104 (60-118)	10	27 (8-129)
Clipper base	4	21 (13-48)	10	6 (2-33)

ATP, adenosine triphosphate; *BP*, blood pressure; *EFHR*, electronic fetal heart rate; *FSE*, fetal scalp electrode; *IUPC*, intrauterine pressure catheter; *IQR*, interquartile range; *IV*, intravenous; *MSICB*, maternal safety infection control bundle; *OR*, operating room; *ox*, oximetry; *RLU*, relative light units; *toco*, tocometer.

The third assumption was based on the 10.2% decrease in the number of cesarean deliveries in the first half of 2017, compared with the first half of 2016. One would expect that the SSI-related inpatient costs in the first half of 2017 would have decreased by 10.2%, which would be an expected cost of $78,036. However, the actual cost was $23,700, resulting in a cost savings of $54,336.

The implementation costs of the MSICB were $34,989. In the second quarter of 2017, $13,469 was spent on sustaining the MSICB. The savings in chorioamnionitis- and SSI-related additional costs was $719,676. Minus the implementation and sustainment costs of the MSICB, the net cost savings was $671,218.

The results of planned, regularly collected ATP swabs showed an improvement in environmental cleaning processes throughout the project (Table 3), and this is reflected in the cost savings. ATP swab data were regularly collected, although not all rooms were available for sampling every month because they were either occupied or being repaired.

DISCUSSION

We found that implementation of the MSICB at Tripler Army Medical Center in 2017 was associated with a statistically significant decrease in the chorioamnionitis rate and a statistically nonsignificant decrease ($P = .060$) in the SSI rate compared with the same time periods in 2016, and that it did not affect the postpartum endometritis rate. We also noted that environmental cleaning dramatically improved during implementation of the MSICB. These reductions in infections resulted in an estimated cost savings of $671,218 in the first 6 months of 2017, compared with the first 6 months of 2016.

Chorioamnionitis is a very difficult diagnosis to study because there is no uniformity among obstetric providers in applying diagnostic criteria. Historically, to make the clinical diagnosis of chorioamnionitis, many obstetric providers have used the presence of a maternal fever (>100.4°F persistently for 1 hour or more or 101.0°F transiently) and 2 of the following: uterine fundal tenderness, maternal tachycardia (rate >100), fetal tachycardia (baseline >160), and purulent or foul-smelling amniotic fluid.[35] In 2016, the Chorioamnionitis Workshop Executive Summary was published by the American College of Obstetricians and Gynecologists.[36] This article recommends using a transient maternal temperature of 102.2°F or greater or persistent temperatures of 100.4°F for 30 minutes or more and any of the following: fetal tachycardia (baseline >160), maternal white blood cell count greater than 15,000 per mm^3, and purulent fluid from the cervical os.[36] Adoption of these new criteria are not uniform among obstetric providers. Using different criteria could affect the prevalence of the diagnosis of chorioamnionitis.

The chorioamnionitis workshop executive summary was published in March 2016, so analyzing the second quarter of 2016 and 2017 allows for analysis of the effectiveness of the MSICB after these new criteria were published. The American College of Obstetricians and Gynecologists published new recommendations in August 2017 for the definition of chorioamnionitis; however, these guidelines were not published until after the conclusion of our project and had no effect on our results.[4] This Committee Opinion recommended diagnosing a suspected intra-amniotic infection with a maternal temperature ≥39°C or "when the maternal temperature is 38.0°C-38.9°C and 1 additional clinical risk factor is present," including "maternal leukocytosis, purulent cervical drainage, or fetal tachycardia."[4] We believe a strength of our quality improvement project was including all patients with a diagnosis of chorioamnionitis regardless of the diagnostic criteria utilized because this most closely reflects clinical practice.

Postpartum endometritis is a clinical diagnosis made based on a combination of clinical findings, vital signs, and results of laboratory

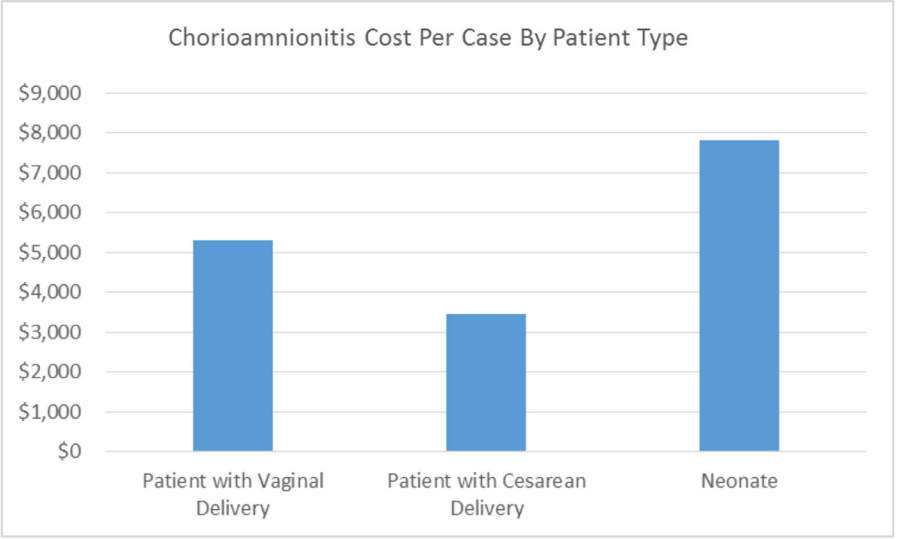

Fig 2. Chorioamnionitis cost per case by patient type.

studies.[37] Postpartum endometritis "occurs after about 1%-3% of vaginal births, and up to 27% of cesarean births" and usually presents with fever, abdominal and pelvic tenderness, and foul-smelling vaginal discharge.[37]

Regarding SSI, prior to implementation of the bundle, it was standard practice to administer prophylactic antibiotic therapy to patients undergoing a cesarean delivery.[38] Our facility uses cefazolin in nonpenicillin-allergic patients and clindamycin and gentamicin in penicillin-allergic patients. In January 2017, obstetricians were encouraged to consider adding azithromycin to preoperative antibiotic therapy for patients undergoing cesarean delivery that had undergone a trial of labor or had rupture of membranes. This recommendation was based on a single randomized clinical trial published in 2016.[39] Although this intervention was not part of the MSICB, it was implemented by some obstetricians during the period of our study and is a potential confounding variable when considering our statistically nonsignificant reduced SSI rate.

Vaginal cleansing is an evidence-based intervention known to reduce the risk of postoperative SSI after cesarean delivery. Additionally, as we observed reductions in SSI among both labored patients who received azithromycin and planned cesarean delivery patients who did not receive azithromycin, our results cannot be explained solely by the use of azithromycin. A recently published systematic review and meta-analysis found that evidence-based bundles reduced cesarean delivery SSI rates.[8] We believe that emphasis on hand hygiene, intrapartum perineal care, and improved environmental cleaning, coupled with vaginal cleansing, proper abdominal preparation technique, and the recommendation that obstetricians use negative pressure dressings or silver-infused dressings on cesarean delivery incisions, are primarily responsible for our results.[8,40] This bundle developed for use in our hospital has been proven effective, and most of these interventions have been continued after completion of this project. Other hospitals should consider developing a bundle unique to their own institution's environment and practices.

We recognize that an inherent limitation of quality improvement projects is the inability to address causality. Additionally, because demographic data were not collected in our quality improvement project, potential confounders of the effects of our interventions could not be identified. Another limitation of our quality improvement project is the use of ICD-10-CM/PCS because of the potential for coding error. Historically, the Department of Infection Control cross references the queried ICD-10-CM/PCS diagnoses with the antibiotic administration recorded in the delivery summary. This practice continued during the MSICB and reduced the likelihood of significant coding error accounting for our results. Furthermore, chorioamnionitis does not change the MS-DRG classification for a patient, and we utilized the presence or absence of an ICD-10-CM/PCS diagnosis of chorioamnionitis to determine additional costs accrued for patients based on the route of delivery. Any change in the MS-DRG for a patient with chorioamnionitis occurred based on additional comorbidities or complicating conditions that may or may not have been affected by the clinical diagnosis of chorioamnionitis but would affect the cost associated with that patient's care. Therefore, it is possible that some of the increased costs in our paper attributed to the diagnosis of chorioamnionitis are secondary to another comorbidity or complicating condition, but because our team did not have access to this information, we identify this as another limitation to our cost data. Also, the accounting methodology used by the military health system is unique to the Department of Defense and does not reflect accounting practices in the civilian sector. This latter limitation could affect the reproducibility of our cost savings in a civilian institution. Finally, the assumptions made in calculating expected costs are based on the decreased number of deliveries at Tripler Army Medical Center during the first half of 2017 during the implementation of our bundle. We do not believe this decrease in the number of deliveries resulted in a healthier delivering population.

CONCLUSIONS

Future research should address the sustainability of the interventions we have implemented. Additionally, a randomized controlled trial to evaluate the effectiveness of the MSICB and to control for observer bias is needed to determine causality. Such a study should include validated, objective measures of compliance that were not collected for this project.

Acknowledgments

The MSICB team is grateful to the decision science analysts assigned to Tripler Army Medical Center. Mr. Darrin E. Powers and Ms. Bertha M. Smith provided invaluable assistance throughout this project. The team would also like to thank SPC Recquita Y. Miller for her assistance with room surveillance. The team is also grateful for the support of COL Alan P. Gehrich, MD, COL Charles S. Dietrich, MD, and LTC Gary Levy, MD, who were invaluable in ensuring successful implementation of the MSICB. Finally, the team is appreciative of all members of the L&D 'ohana at Tripler Army Medical Center who participated in this quality improvement project.

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