Central Line Maintenance Bundles and CLABSIs in Ambulatory Oncology Patients

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KEY WORDS

oncology, central line–associated bloodstream infection, quality improvement, epidemiology, pediatric, central venous catheter/access device, outpatient management

ABBREVIATIONS

CDC—Centers for Disease Control and Prevention

CHA—Children's Hospital Association

CI—confidence interval

CLABSI—central line–associated bloodstream infection

IP—infection preventionist

IRR—incidence rate ratio

NHSN—National Healthcare Safety Network

Dr Rinke conceptualized and designed the study, assisted in data acquisition, co-led data analyses, and drafted the initial manuscript; Drs Bundy, Milstone, and Miller assisted in the design of the study, participated in data analyses and interpretation of data, and reviewed and revised the manuscript; Dr Chen assisted in the design of the study, participated in interpretation of data, and reviewed and revised the manuscript; Dr Colantuoni assisted in the design of the study, co-led data analyses, and reviewed and revised the manuscript; Ms Pehar assisted in the design of the study, participated in data acquisition, supervised data collection, and reviewed and revised the manuscript; Ms Herpst and Ms Fraterno assisted in the design of the study, participated in data acquisition, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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abstract

OBJECTIVE: Pediatric oncology patients are frequently managed with central lines as outpatients, and these lines confer significant morbidity in this immune-compromised population. We aimed to investigate whether a multidisciplinary, central line maintenance care bundle reduces central line–associated bloodstream infections (CLABSIs) and bacteremias in ambulatory pediatric oncology patients.

METHODS: We conducted an interrupted time-series study of a maintenance bundle concerning all areas of central line care. Each of 3 target groups (clinic staff, homecare agency nurses, and patient families) (1) received training on the bundle and its importance, (2) had their practice audited, and (3) were shown CLABSI rates through graphs, in-service training, and bulletin boards. CLABSI and bacteremia person-time incidence rates were collected for 23 months before and 24 months after beginning the intervention and were compared by using a Poisson regression model.

RESULTS: The mean CLABSI rate decreased by 48% from 0.63 CLABSIs per 1000 central line days at baseline to 0.32 CLABSIs per 1000 central line days during the intervention period ($P = .005$). The mean bacteremia rate decreased by 54% from 1.27 bacteremias per 1000 central line days at baseline to 0.59 bacteremias per 1000 central line days during the intervention period ($P < .001$).

CONCLUSIONS: Implementation of a multidisciplinary, central line maintenance care bundle significantly reduced CLABSI and bacteremia person-time incidence rates in ambulatory pediatric oncology patients with central lines. Further research is needed to determine if maintenance care bundles reduce ambulatory CLABSIs and bacteremia in other adult and pediatric populations. *Pediatrics* 2013;132:e1403–e1412

Exposure to vigorous chemotherapy regimens allows children with cancer to live longer and remain disease free for greater periods of time.^{1,2} To receive life-prolonging chemotherapy regimens, patients often require central lines, leaving them at risk of central line–associated bloodstream infections (CLABSI). CLABSI are positive blood cultures in patients with central lines where the infections are attributed to the central lines and not a secondary source (eg, pneumonia).³ Pediatric oncology patients are disproportionately affected by these harmful infections, because pediatric hematology/oncology patients and pediatric bone marrow transplant patients have higher CLABSI rates than almost all subsets of comparable adult oncology patients.⁴

Central line maintenance care bundles, based on Centers for Disease Control and Prevention (CDC) CLABSI prevention guidelines, reduced CLABSI in PICUs, NICUs, pediatric stem cell transplant recipients, and hospitalized pediatric oncology patients.^{5–12} Less attention has been paid to CLABSI in the ambulatory setting,^{7,13} despite the fact that most oncology patients are discharged with central lines.^{13–19} Additionally, no work has been done evaluating whether maintenance care bundles reduce positive blood cultures in ambulatory patients, an important cause for pediatric oncology patient admission. Evidence suggests that ambulatory pediatric oncology patients experience 2 to 3 times more CLABSI than hospitalized pediatric oncology patients.^{17,20} Furthermore, 8% of all ambulatory pediatric oncology central lines are removed due to CLABSI,²¹ 9.5% of ambulatory oncology patients in a polymicrobial-monomicrobial case-control study with a CLABSI were admitted to an ICU within 24 hours of

hospital admission, and 62% were hospitalized for ≥ 7 days.²²

It is unknown if central line maintenance care bundles can effectively translate to ambulatory pediatric patients with long-term central lines because these lines are maintained by a diverse group of caregivers, including clinic staff, homecare agencies, and families. We hypothesized that rigorous attention to central line maintenance practices using a multidisciplinary, central line maintenance care bundle can significantly reduce CLABSI and all-cause positive blood culture incidence rates in an ambulatory pediatric oncology population. We tested this hypothesis by using an interrupted time-series study in a tertiary care pediatric oncology center.

METHODS

Setting

The study site was a university-affiliated children's center within a tertiary care hospital. The pediatric oncology group sees ~200 new oncologic diagnoses, performs 35 stem cell transplants, and has 7000 clinic visits annually. The clinic only sees patients with primary oncologic diagnoses or stem cell transplant recipients.

Definitions and Data Sources

Our institution began prospectively tracking all positive blood cultures in pediatric oncology patients in January 2009. As described previously,^{10,20} positive blood cultures were identified by front-line nurses and case managers, and via active surveillance from infection preventionists (IPs). Ambulatory bacteremias were defined as any positive blood culture occurring >48 hours after discharge and until 48 hours after admission. This definition extrapolates from the National

Healthcare Safety Network (NHSN) guideline for inpatient CLABSI that occur up to 48 hours after discharge.³ Bacteremias with multiple organisms or repeated identical organisms required negative cultures between episodes of bacteremia to be counted as separate events. Ambulatory bacteremias are a clinically relevant outcome because they necessitate 48 hours of empirical antibiotics in pediatric oncology patients and may be an easier metric to track than CLABSI, which require trained IPs to adjudicate. The ambulatory bacteremia group necessarily includes all patients with CLABSI.

A trained IP (M.P.) independently adjudicated all bacteremias following the NHSN guidelines for CLABSI³ by using both chart and laboratory review. These guidelines define a CLABSI as any blood culture positive for a pathogenic organism or >1 blood culture positive for the same common skin contaminant organism not associated with another infectious source, such as a urinary tract infection or pneumonia.³ Ambulatory bacteremias were retrospectively adjudicated as potential CLABSI for the baseline period (January 2009 through November 2010) and prospectively adjudicated for the intervention period (December 2010 to November 2012).

Central line days were counted following CDC methodology.²³ As described previously, baseline central lines days were collected retrospectively via electronic and paper chart reviews of all patients seen in our oncology clinic ≥ 3 times during the baseline period ($N = 524$).²⁰ Patients seen <3 times in the baseline period were typically in remission or were seen in consultation only, and were thus excluded on the basis of the assumption that they were without a central line ($N = 448$). This assumption was

confirmed by completing full chart reviews on a 10% random sample of excluded patients ($n = 50$), and only 1 patient had a central line, which was removed in the second month of the baseline period. Three hundred thirty patients with central lines were included in the baseline period, and their central line days were recorded per CDC methodology. Three hundred thirty-nine patients with central lines were included in the intervention period, and their central line days were tracked prospectively via passive and active surveillance: ambulatory and inpatient nurses notified the study team of central line removals or placements, oncology fellows were queried quarterly for confirmation of their primary patients with central lines, and nurses were queried bi-annually for confirmation of their primary patients with central lines. CLABSI and bacteremia person-time incidence rates were defined as infections per 1000 central line days.

Intervention

We performed an interrupted time-series study comparing CLABSI and bacteremia incidence rates in the baseline period (January 2009 to November 2010) with the post-central line maintenance care bundle implementation period (December 2010 to November 2012). As previously described,¹⁰ our institution joined a national Children's Hospital Association (CHA) quality transformation effort in November 2009 and instituted a central line maintenance care bundle on our inpatient pediatric oncology unit. The maintenance care bundle, also previously described^{8,10} and based on CDC recommendations,²⁴ focuses attention on catheter care in all areas of central line maintenance (Supplemental Appendix 1).

After successes in our inpatient oncology unit,¹⁰ we initiated a similar

maintenance care bundle in our ambulatory clinic in December 2010. We targeted the 3 groups who most often access the central lines of ambulatory patients: clinic nurses, homecare nurses, and patient families. Johns Hopkins Pediatrics at Home, the home health agency for Johns Hopkins Medicine, cares for ~90% of our ambulatory oncology patients requiring homecare.

We initiated twice-weekly self-audits of the clinic nurses, which asked nurses to anonymously describe the maintenance central line care they delivered to 1 patient that day (Supplemental Appendix 1). Audits assessed the 3 main bundle elements: (1) Aseptic Entries (hand hygiene and an alcohol scrub/dry before all catheter entries), (2) Aseptic Central Line Component Change (changing caps/tubing/dressing/needles for prespecified criteria, an alcohol scrub/dry for cap/tubing changes, a chlorhexidine scrub for dressing/needle changes, sterile gloves/mask for dressing/needle changes, shielding the patient's face/tracheostomy for dressing/needle changes, and recording date/time for all new caps/tubing/dressings/needles), and (3) Family Assessment (assessing for central line problems at home and family central line education needs). An all-or-none measurement strategy was used for audits: nursing practice was recorded as compliant with one of the bundle elements only if every part of that bundle element was performed appropriately.^{10,25} In March of 2011, we began quarterly family

return-demonstrations of central line maintenance care for those patients who regularly flushed central lines or delivered medications at home. Return-demonstrations involved caregivers performing central line care in front of clinic nurses every 3 months. Caregiver audits were not collated at an institutional level because of difficulties in paper-chart data collection. In October 2011 our institution's homecare nurses began weekly self-audits and quarterly direct observations by nurse managers. Homecare nurse audits were assessed by homecare agency leadership but not the researchers directly involved in this project. Audit procedures are summarized in Table 1.

CLABSI and bacteremia incidence rates and audit compliance rates were displayed graphically in public clinic areas and updated and e-mailed monthly to key stakeholders, including the following: the oncology nurse manager; the director of oncology; oncology faculty; oncology fellows; clinic nurses; the director, nurse manager, and IP of our homecare agency; quality improvement specialists; and hospital IPs. A team of front-line nurses, the oncology nurse manager, physicians, pharmacists, quality improvement specialists, and IPs met monthly to complete mini-root cause analyses of bacteremias and CLABSIs (previously described¹⁰; Supplemental Appendix 2), discuss systems changes, and disseminate lessons learned to front-line staff. The inpatient CLABSI team and the ambulatory CLABSI team met quarterly with our homecare organization's director, nurse manager,

TABLE 1 Audit Strategy for the Central Line Maintenance Care Bundle

Group	Audit Procedure
Clinic nurses	Twice-weekly self-audits of central line maintenance practice
Homecare agency nurses	Weekly self-audits and quarterly direct practice observations of central line maintenance practice
Families who access central lines at home	Quarterly return-demonstrations of central line maintenance practice

and IP to share information, improve practices, and standardize education across all 3 areas.

One year after beginning our intervention, the CHA collaborative expanded its focus to include ambulatory CLABSI and bacteremias in November 2011. Team members participated in monthly CHA webinars on CLABSI and bacteremia prevention. Key members of the team attended semiannual, face-to-face national CHA learning sessions aimed at improving compliance with the maintenance care bundle and decreasing CLABSI and bacteremia incidence rates. Nursing and physician leadership in oncology and the children's center were supportive of this effort, protecting 10% of a clinic nurse's time to work on this project, funding participation in the CHA collaborative, and prioritizing the efforts with their personal involvement and interest.

To broaden the reach of our intervention and given the high level of family-centered care present in our clinic, we encouraged families to act as an additional check to ensure provider compliance both inside and outside our clinic. Families were provided with wallet cards describing maintenance central line care¹⁰ and were empowered by nursing staff to stop anyone accessing their child's central line in an inappropriate manner.

Statistical Analyses

Monthly CLABSI and bacteremia person-time incidence rates and compliance with the bundle elements were displayed graphically as a function of calendar time. The primary analyses estimated the differences between baseline and post-bundle implementation mean monthly CLABSI and bacteremia person-time incidence rates by using a standard Poisson regression model with a single covariate,

an indicator for bundle implementation. We assessed correlation in the infection rate over time by estimating the autocorrelation of the Pearson residuals from our model.²⁶ In addition, we added a robust variance estimate (Huber-White sandwich estimator) to assess the sensitivity of our results to potential under- or overdispersion in the data.^{27,28} Nelson's rules of process control charts^{12,29} were also used to determine if the infection rate statistically significantly decreased during the bundle implementation period. Before the start of the study, we estimated that the study would have 80% power ($\alpha = 0.05$) to detect a 40% decrease in the CLABSI person-time incidence rate⁸ and a 23% decrease in bacteremia person-time incidence rates over a predicted 33-month intervention period, assuming a baseline CLABSI rate of 0.6 and a baseline bacteremia rate of 1.7 per 1000 central line days.

Student's *t* test and χ^2 tests were used to compare baseline and intervention period cohorts. The Wilcoxon rank-sum test and Fischer's exact test were calculated to assess if the intervention was associated with changes in demographic, infectious, and outcome characteristics of patients with CLABSIs. Stata 11.1 (StataCorp, College Station, TX) was used for all analyses. This study was approved by the Johns Hopkins University School of Medicine Institutional Review Board.

RESULTS

There were 520 unique patients in our cohort who had 763 central lines between January 2009 and December 2012. Comparisons of the baseline and intervention-period cohorts are presented in Table 2. During the 23-month baseline period, patients experienced 58 CLABSIs, 117 bacteremias, and 92 385 central line days. The baseline

CLABSI incidence rate was 0.63 CLABSIs per 1000 central line days (95% confidence interval [CI]: 0.48–0.81), and the baseline bacteremia incidence rate was 1.27 bacteremias per 1000 central line days (95% CI: 1.04–1.52). During the 24-month intervention period, patients experienced 27 CLABSIs, 49 bacteremias, and 83 317 central line days. The intervention CLABSI incidence rate was 0.32 CLABSIs per 1000 central line days (95% CI: 0.21–0.47), and the intervention bacteremia incidence rate was 0.59 bacteremias per 1000 central line days (95% CI: 0.44–0.78) (Figs 1 and 2).

The incidence rate ratio (IRR) comparing mean CLABSI incidence rates in the intervention with baseline periods was 0.52 (95% CI: 0.33–0.81; $P = .005$), and the IRR comparing mean bacteremia incidence rates in the intervention with baseline periods was 0.46 (95% CI: 0.33–0.65; $P < .001$) (Table 3). The estimated autocorrelation function of the Pearson residuals indicated zero correlation, and results were not sensitive to robust variances (data not shown). The intervention CLABSI and bacteremia incidence rates were also significantly different from baseline according to Nelson's rules for process control charts (Figs 1 and 2).

Compliance for all bundle elements improved during the intervention period except for Aseptic Entries, which started and remained at 100% for the entire period. In the final 3 months of the intervention period, mean clinic nurse-audited compliance with the 3 bundle elements was as follows: Aseptic Entries, 100%; Aseptic Central Line Component Change, 85%; and Family Assessment, 81%.

The demographic, microbiologic, and outcome characteristics of patients with CLABSIs before and after bundle implementation are presented in Table 4. Intervention-period patients

TABLE 2 Comparison of Baseline and Intervention Cohorts

	Baseline (January 2009 to November 2010)	Intervention (December 2010 to November 2012)	P
Unique patients ^a	330	339	
Total number of central lines	434	468	
Pediatric oncology clinic visits	13 645	14 050	
Line type, <i>n</i> (%)			.10
Totally implantable devices	253 (58)	267 (57)	
Tunneled, externalized catheters	126 (29)	119 (25)	
Peripherally inserted central catheters	54 (12)	78 (17)	
Other catheters	1 (0.2)	4 (1)	
Age at start of study period, mean (SD), y	9.78 (6.3)	9.96 (6.5)	.72
Male gender, <i>n</i> (%)	202 (61)	184 (54)	.07
Race, <i>n</i> (%)			.97
White	205 (62)	210 (62)	
African American	75 (23)	79 (23)	
Asian/Pacific Islander	12 (4)	14 (4)	
Other	38 (11)	36 (11)	
Ethnicity, <i>n</i> (%) not Hispanic ^b	325 (98)	334 (99)	.97
Total bone marrow transplants performed, no. (%)	74 (22)	56 (17)	.054 ^c
Diagnosis, <i>n</i> (%)			.29
Solid tumor	176 (53)	185 (55)	
Hematologic	149 (45)	143 (42)	
Nononcologic bone marrow transplant	5 (2)	11 (3)	
Mean pediatric oncology inpatient case mix index ^d	1.89	1.98	—

^a A total of 149 patients had central lines during both the baseline and intervention periods.

^b Fischer's exact test was used for this variable.

^c Difference likely due to decreased transplantation in acute and chronic myeloid leukemia patients after 2011 protocols and imatinib introduction. During the intervention, 3.6% of transplant patients had CLABSI, resulting in potentially 1 less CLABSI in the intervention period (18×0.036).

^d Case mix index is based on relative weight at the time of discharge.

with CLABSI had proportionally more mucositis (15% versus 1.7% in the intervention and baseline cohorts, respectively; $P = .03$), longer lengths of

stay (median length of stay: 10 versus 6 days in the intervention and baseline cohorts, respectively; $P = .006$), and a decreased proportion of Gram-negative

organisms (30% versus 55% in the intervention and baseline cohorts, respectively; $P = .02$) than did baseline-period cases.

FIGURE 1

Monthly CLABSI rates in the baseline and intervention periods. The IRR comparing mean CLABSI rates in the intervention period with those in baseline periods was 0.52 (95% CI: 0.33–0.81; $P = .005$). The intervention CLABSI rate was significantly different from baseline according to Nelson's rules because ≥ 9 consecutive months had CLABSI rates less than the mean baseline CLABSI rate (December 2010 to September 2011 and November 2011 to August 2012).

FIGURE 2

Monthly bacteremia rates in the baseline and intervention periods. The IRR comparing mean bacteremia rates in the intervention with baseline periods was 0.46 (95% CI: 0.33–0.65; $P < .001$). The intervention bacteremia rate was significantly different from baseline according to Nelson's rules because ≥ 9 consecutive months had bacteremia rates less than the mean baseline bacteremia rate (December 2010 to November 2012).

TABLE 3 CLABSI and Bacteremias in the Baseline and Intervention Periods

	Baseline (January 2009 to November 2010)	Intervention (December 2010 to November 2012)	Person-Time IRR (95% CI)
Total central line days	92 385	83 317	
CLABSI	58	27	
CLABSI per 1000 central line days	0.63	0.32	0.52 (0.33–0.81)
Bacteremias	117	49	
Bacteremias per 1000 central line days	1.27	0.59	0.46 (0.33–0.65)

DISCUSSION

With the use of continuous quality improvement methodology, a multidisciplinary central line maintenance care bundle reduced CLABSI incidence rates by 48% and bacteremia incidence rates by 54% in an ambulatory pediatric oncology population over 24 months. To our knowledge, this is the first study to target an entire ambulatory oncology population with a maintenance care bundle. On average, 5 children were admitted monthly for bacteremia during the baseline period compared with 2 children admitted monthly during the intervention period. Despite 2 years of rigorous quality improvement

methodologies, almost 1 of 5 line care encounters were not completely in compliance with the maintenance care bundle.

Central line maintenance care bundles have been shown to reduce CLABSI in many pediatric inpatient settings.^{5–11} Ambulatory central line care interventions are complicated because multiple caregiver groups access ambulatory central lines and each group must be targeted in interventions. This study suggests that interventions involving clinic staff, homecare nurses, and home caregivers can reduce CLABSI and bacteremia incidence rates. Multidisciplinary methods,

targeting both medically trained and non-medically trained caregivers,⁵⁰ should be a focus for future interventions to reduce ambulatory health care–associated infections. Furthermore, continuous quality improvement methodologies must be vigorously applied and sustained because almost 20% of line care encounters by clinic nurses did not completely comply with all bundle elements after 2 years. Finally, the application of this bundle reduced the percentage of Gram-negative CLABSI in our cohort, suggesting that future bundle modifications and research should focus on methods to reduce Gram-positive

TABLE 4 Demographic, Microbiologic, and Outcome Characteristics of Patients With CLABSI in the Baseline and Intervention Periods

	Baseline (January 2009 to November 2010)	Intervention (December 2010 to November 2012)	P
<i>n</i>	58	27	
Demographic characteristics			
Unique patients, <i>n</i>	45	19	
Age at infection, median (IQR), y	9 (2–16)	5.5 (3–20)	.99
Male gender, <i>n</i> (%)	42 (72)	20 (74)	.55
Race, <i>n</i> (%)			.30
White	35 (60)	15 (56)	
African American	19 (33)	8 (29)	
Asian/Pacific Islander	2 (3)	—	
Other	2 (3)	4 (15)	
Ethnicity, <i>n</i> (%) not Hispanic	57 (98)	25 (93)	.24
Clinical characteristics, <i>n</i> (%)			
Malignancy type			.47
Hematologic	31 (53)	12 (44)	
Solid	25 (43)	15 (56)	
Nononcologic Bone Marrow Transplantation	2 (3)	—	
Neutropenic (Absolute Neutrophil Count <500)	18 (31)	5 (19)	.30
Mucositis	1 (2)	4 (15)	.03
Active graft-versus-host disease	5 (9)	1 (4)	.66
Bone marrow transplant within 100 days of infection	11 (19)	2 (7)	.21
Central line type			.10
Totally implantable devices	12 (21)	7 (26)	
Tunneled, externalized catheters	46 (79)	18 (67)	
Peripherally inserted central catheters	—	2 (7)	
Microbiology, <i>n</i> (%)			
Polymicrobial	18 (31)	6 (22)	0.45
Total organisms ^a	81	33	
Gram-positive organisms	34 (42)	23 (70)	.02 ^b
<i>Staphylococcus</i> , coagulase-negative	18 (22)	12 (36)	
<i>Enterococcus</i> spp.	7 (9)	1 (3)	
<i>Streptococcus</i> spp.	3 (4)	1 (3)	
<i>Staphylococcus aureus</i>	3 (4)	4 (12)	
<i>Corynebacterium</i>	—	3 (9)	
Gram-negative organisms	45 (55)	10 (30)	.02
<i>Enterobacter</i> spp.	10 (12)	2 (6)	
<i>Escherichia coli</i>	8 (10)	2 (6)	
<i>Klebsiella</i> spp.	7 (9)	3 (9)	
<i>Pseudomonas</i> spp.	5 (6)	1 (3)	
<i>Acinetobacter</i> spp.	5 (6)	1 (3)	
<i>Stenotrophomonas maltophilia</i>	4 (5)	1 (3)	
<i>Pantoea agglomerans</i>	2 (2)	—	
Fungal	2 (2)	—	.02
<i>Candida albicans</i>	2 (2)	—	
Outcomes			
Admitted to PICU within 72 hours, <i>n</i> (%)	8 (14)	7 (26)	.22
Died during hospitalization, <i>n</i> (%)	1 (2)	—	1.0
Length of stay, median (IQR), d	6 (4–10)	10 (7–15)	.006
Central line removed because of infection, <i>n</i> (%)	26 (45)	17 (63)	.16

IQR, interquartile range.

^a Single organisms not mentioned for baseline were as follows: *Achromobacter*, *Bacillus circulans*, *Citrobacter freundii*, *Gordonia* spp., *Micrococcus luteus*, *Moraxella osloensis*, and *Ochrobactrum anthropi*. Single organisms not mentioned for intervention were as follows: *Clostridium* spp. and *Sporosarcina* spp.

^b Compares total Gram-positive, Gram-negative, and fungal organisms for baseline versus intervention periods.

infections and/or alter CLABSI definitions to account for patients with mucositis and other skin flora organisms.

Previous work suggests that ambulatory pediatric oncology patients have a 2 to 3 times higher absolute burden of CLABSI than inpatients, likely due to the larger number of central line days at risk of CLABSI in the ambulatory setting.^{17,20} If we extrapolate the baseline bacteremia incidence rate in this study to the 24 months of the intervention period, the intervention may have prevented 73 hospital admissions for bacteremia in a pediatric oncology population that averaged 114 patients with central lines. Similarly, the intervention may have prevented 33 CLABSI. At an estimated cost of \$16 550 to \$45 000 per CLABSI,^{4,31,32} the intervention may have saved between \$546 150 and \$1 485 000 in health care costs. This potential savings on CLABSI, in addition to the uncalculated savings from preventing bacteremias, likely outweighs intervention costs for a clinic nurse's time, monthly hour-long group meetings, time for an IP, and institutional participation in a national collaborative. Because the project demonstrated 2 years of sustainable infection reduction and national CLABSI reduction efforts have been sustained for at least 6 years,⁹ we believe the potential for sustainability is high. We urge similar maintenance care bundles be investigated in all pediatric and adult patients with ambulatory central lines and that attention to ambulatory CLABSI be prioritized.

An additional challenge in reducing ambulatory health care-associated infections, such as CLABSI, is the cost and scarcity of trained IPs and the lack of an NHSN consensus ambulatory CLABSI definition.³ The use of bacteremias as an outcome, as in previous

inpatient health care–associated infection studies,³³ does not require an IP and allows important quality improvement work on health care–associated infections to proceed while awaiting a consensus ambulatory CLABSI definition. The ability of a maintenance care bundle to reduce bacteremias in the ambulatory setting suggests that bacteremias could serve as a more feasible and objective surrogate marker for CLABSIs in outpatients. A disadvantage of using bacteremia as a surrogate marker in the current pay-for-performance³⁴ and public reporting³⁵ framework is that some bacteremias may not constitute preventable health care–associated infections. Additional studies should investigate whether bacteremias can effectively provide a marker for ambulatory CLABSIs in other outpatient settings.

There are a number of limitations to this study. National studies suggest that CLABSI rates have decreased over the past decade.³² We cannot determine if secular factors such as an increased national focus on CLABSIs and public CLABSI reporting efforts contributed to the reduction in CLABSI and bacteremia incidence rates in our study.³⁵ Furthermore, it is unclear if our inpatient CLABSI reduction effort, beginning in November 2009, affected our ambulatory CLABSI rates. Our inpatient CLABSI rates did not appreciably change during the first year of the inpatient intervention (November 2009 to October 2010),¹⁰ suggesting little impact on our baseline ambulatory CLABSI rates. Alternatively, the ramp-up period for our ambulatory intervention was considerably shorter than our inpatient intervention, suggesting that the inpatient intervention may have provided meaningful preparation for our patients and clinic nurses in accepting and implementing the central line maintenance care bundle. Due to the scope of the project, we were unable to

collect time-varying covariates, such as rates of neutropenia, intensity of chemotherapy and rates of mucositis, comparing our baseline with intervention cohorts. We cannot comment on whether these factors decreased the risk of CLABSIs and bacteremia in the intervention period and therefore biased our results. This is an important limitation for all ambulatory studies given the difficulty of assessing a patient's illness severity, and therefore susceptibility to infectious diseases, while they are not hospitalized. Non-significantly fewer bone marrow transplants were performed during the intervention period, likely due to decreased transplantation in patients with acute and chronic myeloid leukemia after 2011 protocols and imatinib introduction. In the intervention period, 18 fewer transplantations were performed and 3.6% of transplant patients had CLABSIs (Table 4). If the intervention period had equal numbers of transplantations to the baseline period, it would translate into one more CLABSI in the intervention period (18×0.036) and the results would still be significant (data not shown). It is also impossible to know if the results from our single-institution study can be generalized to non-tertiary care ambulatory pediatric oncology clinics, which may not care for a large number of bone marrow transplant patients and therefore may have lower baseline CLABSI and bacteremia incidence rates. Given that 1 of 5 nursing central line encounters were not in full compliance with the bundle, additional CLABSI and bacteremia rate reduction may occur with further improved compliance.³⁶ Data from homecare nurse audits and family return-demonstrations were not available for this analysis, and it is unclear how effectively these groups implemented the bundle. Because audits function both as metrics for leadership to understand process improvement and as

educational tools to directly instruct caregivers on recommended practices, we are confident they functioned as instructional aides for caregivers and homecare nurses. Whereas all bacteremias were identified prospectively, central line days and CLABSI adjudications were performed retrospectively for our baseline period. It is possible that the different methods used in the baseline and intervention periods led to decreased central line day counts and/or increased numbers of CLABSI events identified in the baseline period and artificially increased our baseline CLABSI rates. We performed a sensitivity analysis assuming a 20% increase in baseline central line days and the IRR remained significant (IRR: 0.62; 95% CI: 0.39–0.98). Additionally, IPs were not blinded to the time period of the intervention, creating the potential for CLABSI misclassification bias.³ We believe the risk of bias due to retrospective CLABSI adjudication and misclassification bias is low because rates of bacteremia, a more objective and prospectively collected outcome, significantly decreased after implementation of the maintenance care bundle.

CONCLUSIONS

A maintenance central line care bundle involving a multidisciplinary care group of clinic nurses, homecare nurses, and patient families significantly reduced CLABSIs and bacteremias in an ambulatory pediatric oncology population over 24 months. Further research should focus on spreading maintenance central line care bundles to other ambulatory pediatric oncology sites and other pediatric and adult populations with central lines.

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