Original Article

Postoperative Infection in Developing World Congenital Heart Surgery Programs

Data From the International Quality Improvement Collaborative

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Background—Postoperative infections contribute substantially to morbidity and mortality after congenital heart disease surgery and are often preventable. We sought to identify risk factors for postoperative infection and the impact on outcomes after congenital heart surgery, using data from the International Quality Improvement Collaborative for Congenital Heart Surgery in Developing World Countries.

Methods and Results—Pediatric cardiac surgical cases performed between 2010 and 2012 at 27 participating sites in 16 developing countries were included. Key variables were audited during site visits. Demographics, preoperative, procedural, surgical complexity, and outcome data were analyzed. Univariate and multivariable logistic regression were used to identify risk factors for infection, including bacterial sepsis and surgical site infection, and other clinical outcomes. Standardized infection ratios were computed to track progress over time. Of 14 545 cases, 793 (5.5%) had bacterial sepsis and 306 (2.1%) had surgical site infection. In-hospital mortality was significantly higher among cases with infection than among those without infection (16.7% versus 5.3%; $P<0.001$), as were postoperative ventilation duration (80 versus 14 hours; $P<0.001$) and intensive care unit stay (216 versus 68 hours; $P<0.001$). Younger age at surgery, higher surgical complexity, lower oxygen saturation, and major medical illness were independent risk factors for infection. The overall standardized infection ratio was 0.65 (95% confidence interval, 0.58–0.73) in 2011 and 0.59 (95% confidence interval, 0.54–0.64) in 2012, compared with that in 2010.

Conclusions—Postoperative infections contribute to mortality and morbidity after congenital heart surgery. Younger, more complex patients are at particular risk. Quality improvement targeted at infection risk may reduce morbidity and mortality in the developing world. **(*Circ Cardiovasc Qual Outcomes*. 2017;10:e002935. DOI: 10.1161/CIRCOUTCOMES.116.002935.)**

Key Words: congenital heart disease ■ developing world ■ infection ■ intensive care unit ■ outcome

Congenital heart defects are a growing public health concern worldwide. As the world population continues to rise, surpassing 7 billion, so does the need for pediatric congenital heart surgery centers across the globe. Newly emerging centers in developing countries face a unique predicament; they encounter large numbers of uncorrected congenital heart disease in children alongside significant limitations in human and material resources, inadequate state funding, and a virtual absence of health insurance in addition to low incomes.

See Editorial by Gaies and MacLaren

The pediatric age group constitutes a large percentage of the developing world population. The burden of congenital heart disease in this population still remains undefined.[1] In addition to the aforementioned problems, postoperative infections hinder the goal of excellent care in constrained environments. Infection is a common association with pediatric cardiac surgery, with a reported incidence as high as 15% to 30%[2–5]; the percentage may be higher in the developing world because most data go unaudited.[6] The impact of infection in the postoperative period is enormous because it is associated with increases in morbidity, as well as mortality, greater

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WHAT IS KNOWN

- Risk factors for postoperative infections after congenital heart surgery include age at surgery and complexity of the procedure.
- Postoperative infections contribute substantially to the mortality, morbidity, and costs after congenital heart surgery.

WHAT THE STUDY ADDS

- We identified risk factors for postoperative infections after congenital heart surgery from a large multicentral registry in 16 low- and middle-income countries.
- Simple and standardized quality improvement initiatives that use knowledge from developed world programs may reduce postoperative infections as well as costs in low.
- Transfer of knowledge from developed world programs to low- and middle-income countries may enhance care in these high-risk patients.

antibiotic usage, and increased length of intensive care unit (ICU) stay.[7–9]

In an attempt to address the challenges that emerging congenital heart surgery centers in developing countries encounter, a group of physicians attending the 2007 Global Forum on Humanitarian Medicine in Cardiology and Cardiac Surgery in Geneva, Switzerland, formed the International Quality Improvement Collaborative for Congenital Heart Surgery in Developing World Countries (IQIC). These individuals sought to facilitate improvement in outcomes at developing world congenital heart surgery centers with the belief that benchmarking data at these institutions were missing, significantly hindering progress.

In 2008, the IQIC began its pilot year with 5 participating centers. Boston Children's Hospital served as the data coordinating center, providing both data collection and analysis resources. In addition, quality improvement mentorship was incorporated through a series of monthly instructional webinars. The webinars used a telemedicine platform to encourage and guide participating centers in interpreting individual data reports as a starting point for making necessary team-based and clinical improvements.

Achieving an overall decrease in postoperative mortality in children undergoing congenital heart surgery in developing countries is the overarching goal of the collaborative, and reductions in risk-adjusted mortality have been previously published.[10] This article focuses on an important key driver of mortality, namely, postoperative infection and, in particular, on bacterial sepsis and surgical site infection (SSI). Of particular interest is the impact of these infections on risk for death after congenital heart surgery in developing countries. This article also examines risk factors for infection and describes measures taken by the IQIC to reduce infection.

Table 1. Participating Sites and Locations

Name of Institution	Location
Amrita Institute of Medical Science (AIMS)	Kochi, India
Armed Forces Institute of Cardiology (AFIC), National Institute of Heart Disease	Rawalpindi, Pakistan
Care Hospital	Hyderabad, India
Clinica Infantil Colsubsidio	Bogota, Colombia
Federal State Budgetary Institution, Siberian Branch Russian Academy of Medical Sciences	Kemerovo, Russia
First Hospital of Lanzhou University	Lanzhou, Gansu Province, China
Frontier Lifeline Hospital	Chennai, India
Fundacion Cardioinfantil de Bogota	Bogota, Colombia
Fundacion Cardiovascular Adulto-Pediatrica Clinica San Rafael	Bogota, Colombia
Hospital Arturo Grullon	Santiago de los Caballeros, Dominican Republic
Hospital de Base	Sao Jose do Rio Preto, Brazil
Hospital de Ninos	Cordoba, Argentina
Hospital Garrahan	Buenos Aires, Argentina
Innova Children's Heart Hospital	Hyderabad, India
Institute of General & Urgent Surgery, Academy of Medical Sciences	Kharkov, Ukraine
Instituto do Coracao (InCor)	Sao Paolo, Brazil
Instituto Nacional de Pediatria	Mexico City, Mexico
Instituto Nacional del Corazon (INCOR)	Lima, Peru
KJ Hospital	Chennai, India
Kokilaben Dhirubhai Ambani Hospital & Medical Research Center	Mumbai, India
National Children's Cardiac Medical Center	Minsk, Belarus
Nhi Dong 1 (Children's Hospital No 1)	Ho Chi Minh City, Vietnam
Shanghai Children's Medical Center (SCMC)	Shanghai, China
Star Hospital	Hyderabad, India
Uganda Heart Institute, Mulago Hospital	Kampala, Uganda
Unidad de Cirugia Cardiovascular de Guatemala (UNICAR)	Guatemala City, Guatemala
United Hospital	Dhaka, Bangladesh

Methods

Study Population

Data were obtained from 28 sites in 17 countries enrolled in IQIC between January 2010 and December 2012 (Table 1). A total of 28 sites had joined IQIC at that time: 15 by 2010, 7 in 2011, and 6 in 2012. Analyzed data included all cases of congenital heart surgery in patients <18 years of age at participating sites that passed a data audit. All except 1 site satisfied data audit requirements in at least 1 calendar year, and therefore, data from 27 sites were included in the analyses (Table 1). Patients ≥18 years of age at surgery and neonates or premature infants undergoing patent ductus arteriosus ligation only were excluded from the study cohort because the IQIC did not require collection of these cases. Patients for whom information about infection status was not available were also excluded.

Data Collection Process

The data collection process differed at various sites, but generally was accomplished manually. Appropriate individuals verified the data, after which deidentified information was entered into the central data repository using a web-based platform, in accordance with the IQIC data protocol.

The following information was collected for each patient: demographics, surgical history, surgical procedure(s) performed, preoperative status, and clinical outcomes. Data were source-verified during a series of monitoring trips conducted from 2010 to 2013. Multidisciplinary teams from Boston Children's Hospital, as well as nongovernmental organization representatives and volunteers, performed data source verification using a minimum 10% sample of each site's cases. Key variables audited included type of procedure, Risk Adjustment for Congenital Heart Surgery (RACHS-1) risk category,[11] age, weight, prematurity, major noncardiac structural anomaly, and postoperative outcomes. Data audit results determined whether data were sufficiently complete and accurate for inclusion in aggregate results. The audit specifically included variables that measured infection rates, including bloodstream infections, sepsis, and SSI. Definitions for bloodstream infections, SSI, and other major preventable infections were reinforced through webinars conducted by IQIC. The Boston Children's Hospital Institutional Review Board has approved use of this deidentified database for research purposes, such as this study.

Educational Program

The quality improvement component of IQIC began in 2010. Individuals at different sites were able to participate in monthly webinars, which focused on 3 change strategies, ranging from beginner- to advanced-level content. The learning modules included educational videos and web content related to the 3 key drivers of the IQIC quality improvement framework: safe perioperative practice, reduction of bacterial sepsis and SSI, and team-based practice. In 2011, additional curricula with advanced nursing content were added.

Infection reduction learning modules focused on strategies to improve hand hygiene compliance; to reduce bloodstream infections by improving care of central venous catheters; to reduce urinary tract infections and ventilator-associated pneumonia; and to reduce SSI through correct antibiotic timing, preoperative skin disinfection, and postoperative wound management. Infection prevention practices were adopted by individual centers and tailored to their specific environments, in consultation with local infection prevention and control programs.

Surgical Case Complexity

To quantify complexity of surgical procedures, each case of congenital heart surgery was assigned to 1 of 6 risk categories used in the RACHS-1 risk adjustment method.[11] Risk category 1 reflects a procedure that is low in risk for in-hospital death, such as an atrial septal defect repair, while risk category 6 reflects a procedure with the highest degree of complexity, such as a Norwood operation.

World Health Organization Weight- and Body Mass Index-for-Age Percentiles

Using World Health Organization (WHO) algorithms,[12] patient age in months, weight in kilograms, and sex were used to calculate weight-for-age percentiles for subjects <10 years of age, separately for males and females. For subjects between 10 and 17 years of age, weight and height were used to calculate body mass index (BMI), and BMI, age in years, and sex were used to compute BMI-for-age percentiles, separately for males and females. Patients in both age groups and both sex were then categorized as being <5th percentile, ≥5th but <15th percentile, or ≥15th percentile for age and combined for analysis.

Clinical Outcomes

The primary outcome for this analysis was major infection, which included any postoperative occurrence of bacterial sepsis or SSI during the hospital admission. Bacterial sepsis was defined as known culture-positive bacterial sepsis or clinical evidence of fever or hypothermia, tachycardia, hypotension, tachypnea, leukocytosis, or leucopenia, based on the assessment of the physicians at the participating site. SSI was defined as an infection that could be subclassified as a deep incisional SSI, superficial incisional SSI, or mediastinitis. Formal Centers for Disease Control and Prevention definitions of all 3 subclassifications[13] were used, and positive cultures were not required if all other clinical indicators suggested significant infection. Secondary outcomes were length of ICU stay and ventilation time. In-hospital mortality, defined as any death occurring during a patient's hospital stay prior to postoperative discharge, was a primary outcome for IQIC, but a secondary outcome in this analysis.

Statistical Analysis

Categorical variables are summarized using frequencies and percentages and continuous variables using medians and interquartile ranges. Major infection rates were compared across patient subgroups using Fisher exact test. A multivariable generalized estimating equations model identifying patient factors associated with major infection was derived. Variables significant at the 0.10 level in univariate analysis were considered for inclusion in the final model. Odds ratios and 95% confidence intervals (CIs) were estimated. Duration of ventilation and length of stay in the ICU were compared for patients who did and did not experience a major infection using the Wilcoxon rank-sum test. To examine the impact of major infection on in-hospital mortality, occurrence of a major infection was added to the full RACHS-1 risk adjustment model, including both RACHS-1 category and other clinical variables.[11] To determine the effectiveness of the IQIC to reduce infections, risk-adjusted outcomes for 2011 and 2012 were compared with outcomes for 2010 using the model developed for major infection. Standardized infection ratios (SIRs) and their 95% CIs were calculated for calendar years 2011 and 2012, using 2010 as the reference population. An SIR is defined as the observed infection rate in a calendar year divided by the infection rate expected in that year based on patient case mix; an SIR >1.0 suggests higher than expected infections relative to the reference population, whereas an SIR <1.0 indicates lower than expected infections. If a 95% CI for the SIR does not contain the value 1.0, then risk-adjusted infections are significantly different from the reference population (P<0.05). Because different institutions contributed data in different years, SIRs for 2011 and 2012 relative to 2010 were also generated for the 7 sites contributing data for the entire time period, using these 7 sites' 2010 data as the reference population rather than the entire collaborative. Similarly, SIRs for 2012 relative to 2011 were generated for the 14 sites contributing data in both 2011 and 2012. Statistical analyses were conducted using SAS version 9.2.

Results

A total of 14 545 surgical cases met inclusion criteria and are described in Table 2. Of these, 55.8% were male and 6.2% were ≤30 days old. The median weight, height, hematocrit, and oxygen saturation were 8.3 kg, 74 cm, 37%, and 95%, respectively. More than half (54.2%) of the cases were below the fifth percentile of weight- or BMI-for-age based on WHO standards. The case mix spanned all 6 of the RACHS-1 risk categories, although >90% of the cases were in risk categories 1 to 3. The Figure shows the breakdown for each category, along with infection rates by category.

In the postoperative period, 5.5% (793) of cases developed bacterial sepsis and 2.1% (306) developed SSI. The rate of any major infection was 6.9% (1010). Univariate risk factors associated with major infection are shown in Table 2. Multivariable risk factors are shown in Table 3 and include younger age at

Table 2. Patient and Preoperative Characteristics and Associations With Major Infection (n=14 545)

	Total Cases	Major Infections	Infection Rate	*P* Value
Sex				
Female	6423 (44.2%)	430	6.7%	0.29
Male	8113 (55.8%)	580	7.1%	
Age at surgery				
≤30 d	897 (6.2%)	227	25.3%	<0.001
31 d to <1 y	5783 (39.8%)	508	8.8%	
1–17 y	7865 (54.1%)	275	3.5%	
Weight, kg				
<2.5	276 (1.9%)	63	22.8%	<0.001
2.5–4.9	3107 (21.47%)	488	15.7%	
5.0–9.9	5039 (34.83%)	265	5.3%	
≥10.0	6046 (41.80%)	186	3.1%	
Nutritional appearance				
Normal	9003 (62.0%)	631	7.0%	<0.001
Overweight	83 (0.6%)	3	3.6%	
Malnourished	3665 (25.3%)	350	9.6%	
Emaciated	1760 (12.1%)	24	1.4%	
WHO weight or BMI for age percentile				
<5th	7776 (54.16%)	604	7.8%	<0.001
≥5th, <15th	1826 (12.72%)	129	7.1%	
≥15th	4756 (33.12%)	262	5.5%	
Any preoperative procedure				
Yes	766* (5.27%)	203	26.5%	<0.001
No	13 779 (94.73%)	807	5.9%	
Prematurity				
Yes	704 (4.9%)	85	12.1%	<0.001
No	13 841 (95.1%)	925	6.7%	
Major noncardiac structural anomaly				
Yes	408 (2.8%)	68	16.7%	<0.001
No	14 137 (97.2%)	942	6.7%	
Major chromosomal abnormality				
Yes	812 (5.6%)	122	15.0%	<0.001
No	13 733 (94.4%)	888	6.5%	
Major medical illness				
Yes	761 (5.2%)	149	19.6%	<0.001
No	13 784 (94.8%)	861	6.3%	
Hematocrit, %				
<30	861 (6.10%)	74	8.6%	0.05
≥30	13 256 (93.90%)	906	6.8%	
Oxygen saturation, %				
<85	3212 (22.74%)	373	11.6%	<0.001

(*Continued*)

Table 2. Continued

	Total Cases	Major Infections	Infection Rate	*P* Value
85–94	3719 (26.33%)	266	7.2%	
≥95	7194 (50.93%)	324	4.5%	
RACHS-1 Risk Category				
1	2701 (18.6%)	62	2.3%	<0.001
2	7241 (49.8%)	400	5.5%	
3	3344 (23.0%)	375	11.2%	
4	749 (5.2%)	140	18.7%	
5	9 (0.1%)	3	33.3%	
6	77 (0.5%)	23	29.9%	
Unassigned	424 (2.9%)	7	1.7%	

BMI indicates body mass index; RACHS, Risk Adjustment for Congenital Heart Surgery; and WHO, World Health Organization.

*Preoperative procedures include 117 balloon atrioseptostomy, 44 resuscitation, 122 inotrope therapy, and 483 preoperative ventilation.

surgery (≤30 days or 31 days to <1 year of age), RACHS-1 risk categories 2 to 6, any preoperative procedure, major noncardiac structural anomaly, major chromosomal anomaly, major medical illness, oxygen saturation <85%, and WHO weight- or BMI-for-age (<5th percentile or ≥5th, <15th).

Postoperative ventilation duration (80 versus 14 hours; *P*<0.001) and ICU stay (216 versus 68 hours; *P*<0.001) were longer in cases with major infection; these cases were also more likely to have additional surgery for bleeding (5.3% versus 1.2%; *P*<0.001).

In-hospital mortality among cases with infections was significantly higher than in cases without infections (16.7% versus 5.3%; *P*<0.001). When added to the RACHS-1 model for in-hospital death, the risk-adjusted odds of death remained higher for cases with a major infection (odds ratio, 1.9; 95% CI, 1.6–2.3).

Table 4 shows SIRs in 2011 and 2012 relative to 2010 for the aggregate and for 7 sites contributing data for all 3 years. For the 7 sites, the SIR was 0.58 (95% CI, 0.50–0.66) in 2011 and 0.47 (95% CI, 0.40–0.55) in 2012, both significantly lower

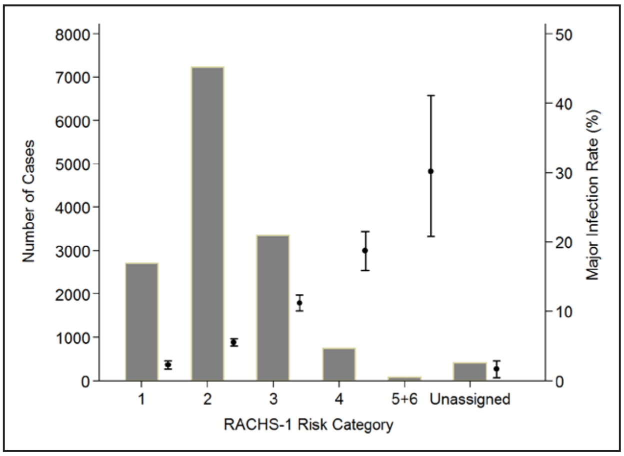

Figure. Risk Adjustment for Congenital Heart Surgery (RACHS-1) risk categories and corresponding infection rates.

Table 3. Multivariable Associations With Major Infection

	Odds Ratio	95% Confidence Interval	*P* Value
Age at surgery			
≤30 d	5.0	2.5–10.0	<0.001
31 d to <1 y	2.0	1.4–2.8	<0.001
1–17 y	1.0	…	…
RACHS-1 Risk Category			
1	1.0	…	…
2	2.1	1.4–3.0	<0.001
3	3.2	1.9–5.3	<0.001
4	4.1	2.7–6.3	<0.001
5+6	6.0	2.7–13.4	<0.001
Unassigned	0.6	0.2–1.5	0.27
Any preoperative procedure	2.0	1.5–2.7	<0.001
Major noncardiac structural anomaly	2.0	1.3–3.0	0.002
Major chromosomal abnormality	2.0	1.2–3.2	0.007
Major medical illness	2.1	1.5–2.8	<0.001
Oxygen saturation <85%	1.5	1.2–1.9	<0.001
WHO weight or BMI for age percentile			
<5th	1.7	0.9–2.9	0.07
≥5th, <15th	1.3	0.9–1.9	0.08
≥15th	1.0	…	…

One hundred eighty-seven cases missing WHO weight or BMI-for-age percentile are excluded. C statistic =0.769. BMI indicates body mass index; RACHS, Risk Adjustment for Congenital Heart Surgery; and WHO, World Health Organization.

than 1.0. For the 14 sites contributing data in 2011 to 2012, the SIR for 2012 relative to 2011 was 0.74 (95% CI, 0.65–0.84).

Discussion

This study reported data from nearly 15000 cases of congenital heart surgery, verified by audit, from 27 sites in 16 low- and middle-income countries (LMIC) to examine postoperative infections after congenital heart surgery in children. Postoperative bacterial sepsis and SSIs remain common after congenital heart surgery in LMICs and contribute substantially to postoperative mortality, morbidity, and resource consumption. Infants and children who experienced a postoperative infection were nearly twice as likely to die than those who did not experience an infection, even after adjusting for other risk factors. Postoperative ventilation time and ICU stay were also significantly longer among patients who had an infection. Younger age, prematurity, higher surgical complexity, under nutrition, baseline desaturation, and associated noncardiac anomalies were all identified as risk factors in the multivariable analysis. Preoperative procedures, medical illness, and repeat surgery for bleeding also contributed independently to risk for postoperative infections.

Table 4. Risk-Adjusted Standardized Infection Ratios

	Standardized Infection Ratios		
	2010	2011	2012
Aggregate data	1.00	0.65 (0.58–0.73)	0.59 (0.54–0.64)
7 sites contributing data 2010–2012	1.00	0.58 (0.50–0.66)	0.47 (0.40–0.55)
14 sites contributing data 2011–2012	…	1.00	0.74 (0.65–0.84)

Standardized ratios are shown with 95% confidence intervals.

The risk factors for infections that were identified through this study in the resource-poor healthcare environments of LMICs are similar to those identified after pediatric cardiac surgery in high-income countries.[3,14,15] However, the specific implications of these risk factors in resource-poor environments may be even greater. For example, newborns in this study were found to be at a 5-fold greater risk for infections after congenital heart disease. In the coming decades, a substantial increase in absolute numbers and relative proportion of newborns undergoing congenital heart surgery can be expected with improving human development index and access to primary healthcare in many parts of the world. Simultaneously, surgical complexity can also be expected to increase as congenital heart surgery programs mature. Programs seeking to deliver comprehensive pediatric heart care will need to assign highest priority to the establishment of robust infection prevention and control systems.

Hospital infection prevention and control programs play a vital role in surveillance and reduction in infection. Huskins and Soule[16] have shown improvements in prevention and control of infections in economies with limited resources, and beneficial effects of these improvements can be extended to other hospitals as well. Similarly, Singh et al[17] have shown that the standardization of infection prevention and control training and practices is a cost-effective way to reduce healthcare-associated infections and related outcomes after heart surgery.

Nosocomial infection is a significant problem in all healthcare environments, but the consequences are likely to have serious impacts in the limited resource environments of the developing world, where, because of budgetary constraints, the greater cost of care for surviving patients with infection may limit access to surgery for other patients with congenital heart disease. With the emergence of multidrug-resistant bacteria, the cost of newer broad-spectrum antibiotics is likely to become a major contributor to costs of care. The impact of healthcare-associated infections on individual families is also likely to be substantial in LMICs, where the majority of healthcare costs are not covered by health insurance.

Given the significant impact of postoperative infections on congenital heart surgery clinical outcomes and resource consumption, efforts such as IQIC participation are particularly important. The IQIC seeks to provide a platform for a robust data collection system, data reports for self-evaluation, and an educational program for quality improvement. The IQIC facilitates collaborative learning to spread good practices from one center to another, for infection reduction, as well as team-based practice and communication. Specific infection prevention practices included learning modules focused on strategies to improve hand-hygiene compliance, as well as practice bundles to reduce blood stream infections, SSIs, ventilator-associated pneumonia, and urinary tract infections.

Sites were also able to share successful strategies and challenges with each other and to track their own progress over time. While it is difficult to prove for certain that reductions in infections were because of IQIC activities, the temporal association and focus on implementation of evidence-based strategies to reduce infection makes a causal relationship plausible and offers a potential dissemination strategy to other resource-poor environments.

Limitations

Because the database was specifically designed to capture nosocomial infections that are listed as hospital-acquired infections, it is possible that some infections may not have been captured. In addition, data audits were based on only a 10% audit sample, and only key variables were audited. Other predictors of infection may have been missed. Another limitation is that while IQIC attempted to teach standardized definitions to all participating sites, we are not confident that all sites applied infection definitions consistently. We are, thus, significantly limited in our ability to attribute success to IQIC because the implementation of practices varied across the sites, and we did not measure any process or implementation steps. Additionally, we lack a control group to show and compare the decline in infection rates.

Conclusions

In this large multicenter database of congenital heart surgeries in 16 LMICs, postoperative infections were shown to be common and to contribute substantially to morbidity and mortality. Risk factors, both modifiable and nonmodifiable, were identified. A temporal trend in reduced infection rates suggests that collaborative learning to disseminate information on how to implement practice changes through quality improvement may allow rapid improvements in quality of care in resource-poor environments.

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Dr Sen oversaw data collection, conducted literature search, interpreted data, and wrote the article. D.F. Morrow provided infection data definitions, designed infection reduction educational program, and revised the article. Dr Balachandran oversaw data collection, interpreted data, and assisted in drafting the article. Dr Du oversaw data collection and drafted and critically revised initial article. K. Gauvreau analyzed and interpreted data, created figures, and wrote the article. B.R. Jagannath oversaw data collection, and drafted and critically revised initial article. R.K. Kumar interpreted data and wrote the article. J.K. Kupiec assisted in data interpretation, and wrote the article. Dr Melgar conducted literature search, assisted in data collection and interpretation, and wrote the article. Dr Chau oversaw data collection, and drafted and critically revised initial article. G. Potter-Bynoe provided infection data definitions, designed infection reduction educational program, and revised the article. Dr Tamariz-Cruz oversaw data collection and drafted and critically revised initial article. Dr Jenkins conceptualized and designed the International Quality Improvement Collaborative and this study, interpreted data, and wrote the article.

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Disclosures

None.

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