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The investment case for preventing NICU-associated infections

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Abstract

Nosocomial (hospital-associated or NICU-associated) infections occur in as many as 10–36% of very low birth weight infants cared for in newborn intensive care units (NICU).

Objective—To determine the potentially avoidable, incremental costs of care associated with NICU-associated bloodstream infections.

Study Design—This is a retrospective study that included all NICU admissions of infants 401–1500 grams birth weight in the greater Cincinnati region from January 1, 2005 through December 31, 2007. Non-physician costs of care were compared between infants who developed at least one bacterial bloodstream infection prior to NICU discharge or death and infants who did not. Costs were adjusted for clinical and demographic characteristics that are present in the first three days of life and are known associates of infection.

Results—Among 900 study infants with no congenital anomaly and no major surgery, 82 (9.1%) developed at least one bacterial bloodstream infection. On average, the cost of NICU care was \$16,800 greater per infant who experienced NICU-associated bloodstream infection.

Conclusions—Potentially avoidable costs of care associated with bloodstream infection can be used to justify investments in the reliable implementation of evidence-based interventions designed to prevent these infections.

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Keywords

quality improvement; investment case; nosocomial infection

Introduction

The Ohio Perinatal Quality Collaborative (OPQC) is a network that comprises 24 Ohio neonatal intensive care units (NICU) including all NICUs that have been designated by the Ohio Department of Health as Level 3 or tertiary. OPQC is conducting collaborative quality improvement (QI) interventions to eliminate neonatal intensive care unit (NICU) associated infections [1]. In this study, we begin to address the return on investment of collaborative QI by estimating the incremental, or potentially avoidable, costs of care associated with these infections [2].

Infection may be the most frequently occurring hospital-acquired condition [3]. For adults and older children receiving care in a hospital intensive care unit, 7–16% may develop infection during their stay [4, 5]. In intensive care units for adults, such infections are associated with prolonged hospital stays, long lasting morbidity, death and increased costs of care [6–17]. In a multicenter study of infants 401–1500 grams birth weight, 20–25% of infants developed a late-onset, thus NICU-associated, infection [18]. Among infants 22–28 gestation, late-onset infection may occur in as many as 36% of infants [19]

Systematic use of QI methods to improve patient care and outcomes necessarily requires an investment of resources, thus theoretically increasing the cost of health care. Among all Level 3 NICU's in Ohio, the Ohio Perinatal Quality Collaborative reported a 20% decrease in NICU-associated infections associated with application of collaborative quality improvement methods [20]. Some have argued that improving care and outcomes may lead to reduced costs. In this study, we estimate the incremental, directly measured, costs of care associated with bacterial bloodstream infections identified 72 hours or more after NICU admission among infants 401–1500 grams birth weight. Previously published studies of NICU-acquired infection used billed charges or self-reported survey to estimate infection-associated costs [10, 21–23]. Converting reported charges for care to costs may distort cost estimates gathered directly from the individual components of cost such as clinical effort, laboratory, radiology and respiratory care [24]. Provider self-reported costs of care have not been validated. The current study sought to better enumerate the additional costs associated with NICU-associated infections and estimate the potential return on investments to prevent such infection using collaborative quality improvement methods.

Design and methods

This retrospective study reviewed clinical and cost data for all 401–1500 gram birth weight infants (VLBW) admitted before 72 hours of age to any of the three greater Cincinnati NICUs between January 1, 2005 and December 31, 2007. The study population includes all VLBW infants receiving NICU care in the greater Cincinnati region over a three year period.

The primary study outcomes were mean, per-patient, adjusted, in-hospital costs of care and duration of NICU stay for infants who had no late-onset, bloodstream infections compared to those who had at least one late-onset, bloodstream infection. Actual, non-inflation-adjusted costs were used (see Discussion). An episode of infection was defined as a positive culture of blood, obtained in the presence of compatible clinical signs of septicemia, occurring after 72 hours of age. In order to increase the precision and generalizability of the infection-related cost estimates, eligible patients were selected from the Cincinnati

Children's, University and Good Samaritan NICUs that together provide care for all newborn infants receiving NICU care in the greater Cincinnati region. Cincinnati Children's Hospital Medical Center is a referral center for newborns requiring sub-specialty medical services, major surgical procedures or highly technical care such as extracorporeal membrane oxygenation. Good Samaritan Hospital and University Hospital are the only tertiary maternity hospitals with NICUs that provide mechanical ventilation for newborns in the greater Cincinnati region. Greater Cincinnati has approximately 29,000 births each year.

The data source used to identify infections and other clinical characteristics was the Cincinnati component of the Eunice Kennedy Shriver National Institute for Child Health and Human Development Neonatal Research Network registry. Patient-level cost data were obtained from the cost accounting databases of the three participating hospitals and linked, by medical record number, to the clinical registry'. We used actual costs rather than charges because actual costs are considered a more reliable estimate of financial burden [25]. Costs for each departmental category were summed for the entire NICU stay. Costs included both direct costs (wages, supplies and other costs of care) and indirect costs (capital building, shared service, insurance, maintenance and patient care administrative costs). Only hospital costs were included, not physician costs. Study eligible infants are sometimes transferred among the three NICUs prior to death or discharge home. For the purposes of this study, costs and duration of NICU stay were summed across NICUs at the infant level.

Using each hospital's existing cost accounting system, estimates of the costs of care for all eligible infants from NICU admission to discharge home or death, whichever occurred first, were used to estimate mean, adjusted, total NICU costs, excluding physician fees, for infants with and without at least one late-onset bacterial bloodstream infection. Proprietary cost accounting procedures at the three participating hospitals varied and could not be reconciled for the purposes of this study.

To account for the likelihood that sicker infants, with necessarily higher costs, are at greater risk of infection, all analyses were adjusted using multivariable regression for factors present in the first days of life that are either known associates of infection or could potentially modify these associates: gestational age at birth, birth weight, use of mechanical ventilation, use of parenteral nutrition, exposure to maternal antibiotics and prolonged rupture of membranes. Because they have unique infection risks, the primary analysis excluded infants with major congenital anomalies and infants who underwent major surgical procedures. We estimated the risk-adjusted effects of at least one late-onset infection on total NICU costs of care as well as duration of NICU stay prior to discharge, death or transfer to another health care facility. The primary independent variable was presence or absence of at least one bloodstream infection identified after 72 hours of life and prior to NICU discharge, death or age 120 days.

Because mortality rates are high for preterm infants and because incurred costs are truncated at the time of death, we performed separate regression analyses for infants who survived to discharge from the NICU and those who died during their initial NICU stay. To account, in the least biased way, for the effect of death to truncate costs of care, for infants who died, we made two cost estimates that bound likely minimum and maximum costs. One estimate (lower boundary) included the actual costs of care of the infants who died. As care improves, the types of infants who die today due to infection may survive with infection-associated morbidities and thus incur higher costs in the future. Thus, the second estimate (upper boundary) substituted the actual costs of care for infants who died with the mean adjusted cost for survivors. This analysis design assumed that future costs of care for infants dying with today's care practices will be at least as high as the mean cost for today's

survivors. This may be an under-estimate of the upper boundary because infants who die may be the highest risk infants and thus are likely to incur greater than average costs of care.

To estimate trade-offs between increased daily costs of care and increased duration of NICU stay, survival curves for these two outcomes, adjusted for the same variables included in the multivariable regression models, were developed and qualitatively compared.

To explore possible biases associated with excluding these infants from the primary analysis, separate multivariable analyses were performed that included infants with major congenital anomalies and infants who had a major surgical procedure.

The study was approved by the Cincinnati Children's Hospital Medical Center, University Hospital and Good Samaritan Hospital Institutional Review Boards. Because all study data were de-identified, these IRBs agreed that parent consent was not required. All analyses were performed using SAS software, version 9.1.

Results

During the three year study period, 1173 infants 401 to 1500 grams birth weight were cared for in the three participating NICUs. One hundred sixty-one (161) infants were excluded from the study data set including 6 with missing birth weight, 117 who died prior to 72 hours of life, 24 with missing transfer dates, 9 with missing cost data and 5 with uncertain medical record numbers. Among the remaining 1,012 infants in the study data set, 45 had a major congenital anomaly and 67 had a major surgical procedure (Figure 1).

Among 900 study infants with no congenital anomaly and no major surgery, 82 (9.1%) developed at least one bacterial bloodstream infection. Of these, 7 (8.5%) had more than one late-onset, bacterial bloodstream infection during their NICU stay. The mortality rate prior to NICU discharge for infants with no congenital anomaly and no major surgery and infection was 30% compared to 7% for similar infants with no infection (chi square, $p < 0.0001$). The distributions of variables included in the multivariable regression models are displayed in Table 1.

For infants with no congenital anomaly and no major surgery, who survived to NICU discharge or transfer ($n=819$), the presence of at least one late-onset, bloodstream infection was associated with higher, risk-adjusted overall costs of care (\$116,305 vs \$97,033) and longer adjusted length of stay (54 vs 46 days, Table 2). Similarly, among infants with no congenital malformation and no major surgery, who died prior to NICU discharge, the presence of at least one, late-onset bloodstream infection was associated with higher, adjusted overall costs of care (\$142,673 vs \$84,158) and longer adjusted length of stay (53 vs 25 days, Table 3). In regression models that included all infants regardless of survival status, substituting mean costs of survivors for actual costs among infants who died (Table 4) resulted in a similar adjusted cost difference compared to the difference observed when actual costs of those who died were used (\$13,659 vs \$16,800, Table 5). The differences in adjusted length of stay comparing infants with and without infection were the same when mean length of stay for survivors was substituted for actual length of stay among infants who died (4 vs 4 days, Tables 4 and 5). Adjusted survival curves for costs and duration of NICU stay were consistent with the multivariable regression models. Among infants with no malformations and requiring no surgery, infants with sepsis who survived had the highest cost (Figure 2, Panel A) and longest length of stay (Figure 2, Panel B). Comparing infants with and without infection, differences in length of stay were somewhat greater when infants with major congenital anomalies or major surgery were included in the model data set (Table 6).

Discussion

In a prior study, the authors have shown that collaborative quality improvement can prevent hospital-associated infections [20]. In the current study, we have shown that prevention of such infections is associated with reduced costs. Although it was not apparent in the multivariable regression models, the adjusted survival analyses indicate that length of stay is not the only driver of increased costs associated with infection. This is the only study, that we were able to identify, that used direct measures of costs of care. Because this study includes all eligible infants in a geographically defined population, the conclusions are not biased by uncertain referral patterns. Forty-five otherwise eligible infants (4%) were excluded from the analyses; eight of which had congenital malformations or major surgery. Rates of late onset sepsis were higher in the excluded group of 36 infants (30.6% vs. 9.1%, $p < 0.0001$), but mortality was no different. Though the excluded population was significantly smaller with earlier gestational ages than the population included in the analysis, no differences were seen regarding cost or length of stay between the groups.

The purpose of this study was to determine the incremental cost of care and financial impact associated with late onset, bacterial, bloodstream infection during the first NICU admission for preterm infants 401–1500 grams and, using this information, discuss the investment case for preventing such infections. An investment case is said to exist if “the entity that invests in the intervention realizes a financial return on its investment in a reasonable time frame, using a reasonable rate of discounting.” [26]. Because sicker infants both cost more and are at higher risk for infection, cost estimates were adjusted for baseline risk of infection and higher costs of care, in general, for sicker infants.

The current study included all bloodstream infections among all infants with birth weights 401–1500 grams. Thus, risks of associated morbidities, mortality and cost would vary by infant maturity, organism and infection source, for example indwelling catheter versus necrotizing enterocolitis. Because our study infants include all NICU infants, inborn and outborn, from a population of approximately 90,000 births over a three year period, we believe that our cost and mortality estimates can be used to consider the impact of reductions in overall NICU infections rates for other NICU populations.

The Ohio Perinatal Quality Collaborative (www.OPQC.net) invested approximately \$600,000 over two years to reduce infection risk in all 24 Ohio, Level III NICUs, including administration (30%), data management (40%) and quality improvement consultation (30%). These funds were provided by a contract from Ohio Medicaid via a CMS Neonatal Transformation Grant. In addition, the participating NICUs each invested time and effort for data collection and transmission, education and conduct of improvement interventions. In the two year period, September 2008 through August 2010, OPQC participating NICUs cared for 2,862 infants 22–29 weeks gestational age. In this group, the infection rate decreased from 18.1% (April 2006 to August 2008) to 14.7% or 97 fewer infections and 19 fewer infection-related deaths than expected [20]. Using the actual differences in costs for survivors and non-survivors in the current study and applying these to the OPQC experience, we calculate an overall cost avoided for the 24 participating OPQC NICUs of \$2,343,592. The amounts invested by OPQC to effect collaborative quality improvement are rough estimates; however the total avoided costs per year (\$1,171,796 or \$1,268,389 in 2010 dollars according to Bureau of Labor Statistics, medical care inflation, 2006–2010, http://www.bls.gov/spotlight/2009/health_care/) represent the maximum size of the investment in collaborative quality improvement that could have been recouped and thus result in a positive return. In addition to the costs avoided, OPQC avoided 929 days of NICU care [27]. The cost savings from NICU infection prevention can be estimated quantitatively. The cost benefits of the documented lives saved by infection prevention are incalculable [20].

NICU-associated infections result in large increases in resource use, hospital costs and duration of NICU stay. The current study provides estimates of the potential savings that could accrue to hospitals and payors if such infections are prevented. There is a convincing argument to be made for investments that increase the reliable implementation of evidence-based interventions to prevent such infections.

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Abbreviations

NICU	neonatal intensive care unit
OPQC	Ohio Perinatal Quality Collaborative
QI	quality improvement
VLBW	very low birth weight

References

1. Ohio Perinatal Quality Collaborative Writing Committee. Collaborative improvement of population perinatal health in Ohio: study design, methods and provider site participation. Jul 5. 2010 Available from: <http://www.opqc.net/sites/bmidrupalpopqc.chmcres.cchmc.org/files/docs/articles/EdManuscript.pdf>
2. Finkler, S.; Ward, D. Cost accounting for health care organizations: concepts and applications. 2. Aspen Publications; 1999.
3. Saleh SS, et al. The cost impact of hospital-acquired conditions among critical care patients. *Med Care*. 48(6):518–26. [PubMed: 20473198]
4. Ramritu P, et al. Catheter-related bloodstream infections in intensive care units: a systematic review with meta-analysis. *J Adv Nurs*. 2008; 62(1):3–21. [PubMed: 18352960]
5. Stockwell J. Nosocomial infections in the pediatric intensive care unit: affecting the impact on safety and outcome. *Pediatr Crit Care Med*. 2007; 8(2 Suppl):S21–S37. [PubMed: 17496829]
6. Piacevoli Q, Palazzo F, Azzeri F. Cost evaluation of patients with severe sepsis in intensive care units. *Minerva Anesthesiol*. 2004; 70(6):453–471. [PubMed: 15235553]
7. Chen YY, Chou YC, Chou P. Impact of nosocomial infection on cost of illness and length of stay in intensive care units. *Infect Control Hosp Epidemiol*. 2005; 26(3):281–7. [PubMed: 15796281]
8. Kilgore M, Brossette S. Cost of bloodstream infections. *Am J Infect Control*. 2008; 36(10):S172 e1–3. [PubMed: 19084149]

9. Laupland KB, et al. Cost of intensive care unit-acquired bloodstream infections. *J Hosp Infect.* 2006; 63(2):124–32. [PubMed: 16621137]
10. Mahieu LM, et al. Additional hospital stay and charges due to hospital-acquired infections in a neonatal intensive care unit. *J Hosp Infect.* 2001; 47(3):223–9. [PubMed: 11247683]
11. Pirson M, et al. Financial consequences of hospital-acquired bacteraemia in three Belgian hospitals in 2003 and 2004. *J Hosp Infect.* 2008; 68(1):9–16. [PubMed: 18055065]
12. Roberts RR, et al. The use of economic modeling to determine the hospital costs associated with nosocomial infections. *Clin Infect Dis.* 2003; 36(11):1424–32. [PubMed: 12766838]
13. Sanchez-Velazquez LD, Ponce de Leon Rosales S, Rangel Frausto MS. The burden of nosocomial infection in the intensive care unit: Effects on organ failure, mortality and costs. A nested case-control study. *Arch Med Res.* 2006; 37(3):370–5. [PubMed: 16513487]
14. Shannon RP, et al. Economics of central line--associated bloodstream infections. *Am J Med Qual.* 2006; 21(6 Suppl):7S–16S. [PubMed: 17077414]
15. Tarricone R, et al. Hospital costs of central line-associated bloodstream infections and cost-effectiveness of closed vs. open infusion containers. The case of Intensive Care Units in Italy. *Cost Eff Resour Alloc.* 8:8. [PubMed: 20459753]
16. Warren DK, et al. Attributable cost of catheter-associated bloodstream infections among intensive care patients in a nonteaching hospital. *Crit Care Med.* 2006; 34(8):2084–9. [PubMed: 16763511]
17. Orsi GB, Di Stefano L, Noah N. Hospital-acquired, laboratory-confirmed bloodstream infection: increased hospital stay and direct costs. *Infect Control Hosp Epidemiol.* 2002; 23(4):190–7. [PubMed: 12002233]
18. Stoll BJ, Hansen N. Infections in VLBW infants: studies from the NICHD Neonatal Research Network. *Semin Perinatol.* 2003; 27(4):293–301. [PubMed: 14510320]
19. Stoll B, et al. Late-onset sepsis in very low birth weight neonates: the experience of the NICHD Neonatal Research Network. *Pediatrics.* 2002; 110(2 Pt 1):285–291. [PubMed: 12165580]
20. Kaplan H, et al. Ohio statewide quality-improvement collaborative to reduce late-onset sepsis in preterm infants. *Pediatrics.* 2011; 127(3):427–435. [PubMed: 21339274]
21. Leroyer A, et al. Prolongation of hospital stay and extra costs due to hospital-acquired infection in a neonatal unit. *J Hosp Infect.* 1997; 35(1):37–45. [PubMed: 9032634]
22. Payne NR, et al. Marginal increase in cost and excess length of stay associated with nosocomial bloodstream infections in surviving very low birth weight infants. *Pediatrics.* 2004; 114(2):348–55. [PubMed: 15286215]
23. Rogowski JA, et al. Economic implications of neonatal intensive care unit collaborative quality improvement. *Pediatrics.* 2001; 107(1):23–9. [PubMed: 11134429]
24. Data Assistance Center, U.o.M., Minneapolis, MN. Technical Brief ResDAC Publication Number TN-008. Nov. 2005 Using Medicare Hospital Cost Reports Cost-to-Charge Ratios in Research. updated August 2009
25. Warren D, et al. Outcome and attributable cost of ventilator-associated pneumonia among intensive care unit patients in a suburban medical center. *Crit Care Med.* 2003; 31:1312–1317. [PubMed: 12771596]
26. Leatherman S, et al. The business case for quality: case studies and an analysis. *Health Affairs (Millwood).* 2003; 22(2):17–30.
27. Donovan, E., et al. Building the investment case for quality improvement in Ohio. *Pediatric Academic Societies; Vancouver, BC:* 2010.

Figure 1.
Study population

Figure 2.
Survival curves for adjusted cost (Panel A) and adjusted duration of NICU stay (Panel B)

Panel A: Adjusted cost (\$) for survivors with and without infection and infants who died with and without infection

Panel B: Adjusted length of NICU stay (days) for survivors with and without infection and infants who died with and without infection

Table 1

Study population characteristics, means and standard deviations (SD), for infants without a major anomaly or major surgery:

Characteristic	All infants (n= 900)	Infection (n=82)	No infection (n=818)
Gestational age, weeks (SD)	28.5 (2.5)	27 (2.3)	28.7 (2.5)
Birth weight, grams (SD)	1103 (266)	961 (262)	1117 (262)
Mechanical ventilation [*] , n (%)	234 (26)	35 (42.7)	199 (24.3)
Parenteral nutrition, n (%)	887 (98.5)	82 (100)	805 (98.4)
Maternal antibiotics, n (%)	432 (48)	43 (52.4)	389 (47.6)
PROM ^{**} , n (%)	158 (17.6)	16 (19.5)	142 (17.4)
Died, n (%)	81 (9.0)	25 (30.5)	56 (6.9)

* Mechanical ventilation in first 24 hours of life

** Rupture of membranes more than 24 hours prior to delivery

Table 2

Adjusted costs and duration of NICU stay for study infants, without a major anomaly or major surgery, who **survived** to NICU discharge *

	No bloodstream infection	Bloodstream infection
n	762	57
Total costs	\$97,033	\$116,305
95% CI for costs	\$81,056, \$113,010	\$95,336, \$137, 274
p value for costs		P=0.01
NICU stay (days)	46	54
95% CI for NICU stay (days)	41, 52	46, 61
p value for NICU stay		P=0.006

* Multivariable regression adjusting for factors known in the first 72 hours of life including gestational age at birth, birth weight, mechanical ventilation, use of an umbilical catheter, use of parenteral nutrition, exposure to maternal antibiotics and prolonged rupture of membranes.

Table 3

Adjusted costs and duration of NICU stay for infants, without a major anomaly or major surgery, who **died** prior to NICU discharge *

	No bloodstream infection	Bloodstream infection
n	56	25
Total costs (\$)	\$84,158	\$142,673
95% CI for costs (\$)	\$52,860, \$115,457	\$102,116, \$183,230
p value for costs		P=0.004
NICU stay (days)	25	53
95% CI for NICU stay (days)	14, 43	35, 72
p value for NICU stay		P=0.008

* Multivariable regression adjusting for factors known in the first 72 hours of life including gestational age at birth, birth weight, mechanical ventilation, use of an umbilical catheter, use of parenteral nutrition, exposure to maternal antibiotics and prolonged rupture of membranes.

Table 4

Adjusted costs and duration of NICU stay for **survivors and non-survivors**, without a major anomaly or major surgery, assigning mean costs and duration of NICU stay of survivors with and without infection to those who died with or without infection, respectively^{*}

	No bloodstream infection	Bloodstream infection
n	818	82
Total costs (\$)	\$91,634	\$105, 293
95% CI for costs (\$)	\$75,584, \$107, 684	\$85,548, \$125,038
p value for costs		P=0.036
NICU stay (days)	44	48
95% CI for NICU stay (days)	38, 50	40, 55
p value for NICU stay		P=0.14

^{*} Multivariable regression adjusting for factors known in the first 72 hours of life including gestational age at birth, birth weight, mechanical ventilation, use of an umbilical catheter, use of parenteral nutrition, exposure to maternal antibiotics and prolonged rupture of membranes.

Table 5

Adjusted costs and duration of NICU stay for **survivors and non-survivors**, without a major anomaly or major surgery, using actual costs for infants who died *

	No bloodstream infection	Bloodstream infection
n	818	82
Total costs (\$)	\$89,582	\$106,462
95% CI for costs (\$)	\$71,585, \$107,579	\$84,322, \$128,602
p value for costs		P=0.02
NICU stay (days)	42	46
95% CI for NICU stay (days)	34, 49	37, 55
p value for NICU stay		P=0.18

* Multivariable regression adjusting for factors known in the first 72 hours of life including gestational age at birth, birth weight, mechanical ventilation, use of an umbilical catheter, use of parenteral nutrition, exposure to maternal antibiotics and prolonged rupture of membranes.

Table 6

Adjusted costs and duration of NICU stay for all infants, **including those with malformations or surgery**, using actual costs for infants who died^{*}

	No bloodstream infection	Bloodstream infection
n	903	109
Total costs (\$)	\$106,621	\$158,672
95% CI for costs (\$)	\$76,197, \$137,045	\$122,777, \$ 194,567
p value for costs		P<0.0001
NICU stay (days)	46	56
95% CI for NICU stay (days)	36, 56	44, 68
p value for NICU stay		P=0.008

^{*} Multivariable regression adjusting for factors known in the first 72 hours of life including gestational age at birth, birth weight, mechanical ventilation, use of an umbilical catheter, use of parenteral nutrition, exposure to maternal antibiotics and prolonged rupture of membranes.