Curriculum Vitae

Clare Rock, MB, BCh, BAO, MRCPI

December 2014 (anticipated) MS Clinical Research, University of Maryland, School of Medicine, Department of Epidemiology and Public Health, Baltimore, Maryland

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Current Appointment

2011- Present	Clinical Epidemiology Fellow, University of Maryland School of Medicine

Education and Training

Doctoral

2004	MB, BCh, BAO, Medical degree, University College Dublin, Dublin, Ireland Honors Degree

Postdoctoral

07/2004-06/2005	Intern in Internal Medicine St. Vincent's University Hospital, Dublin, Ireland
07/2005-06/2007	Resident in Internal Medicine Connolly Hospital and Beaumont Hospital, Dublin, Ireland

03/2007-Present	Member of the Royal College of Physicians of Ireland (MRCPI)
07/2007-06/2011	Infectious Diseases Fellow Royal College of Physicians of Ireland
07/2011-06/2013	Infectious Diseases Fellow University of Maryland Medical Center, Baltimore, MD, USA
07/2013-Present	Clinical Epidemiology Fellow and MPH candidate, University of Maryland School of Medicine

Professional Experience

2004-2005	Intern in Internal Medicine St. Vincent's University Hospital, Dublin, Ireland
2005-2007	Resident in Internal Medicine Connolly & Beaumont Hospital, Dublin, Ireland
2007-2011	Infectious Diseases Fellow, Royal College of Physicians of Ireland
2011-2013	Infectious Diseases Fellow, University of Maryland Medical Center, Baltimore, MD, USA
2013-present	Clinical Epidemiology Fellow, University of Maryland School of Medicine

Research Activities

Peer Reviewed Original Science Publications

1. Ryan S, Doherty LS, **Rock C,** Nolan GM, McNicholas WT. Effects of salmeterol on sleeping oxygen saturation in chronic obstructive pulmonary disease. Respiration. 2010;79(6):475-81
2. Feeney ER, McAuley N, O'Halloran JA, **Rock C**, Low J, Satchell CS, Lambert JS, Sheehan GJ, Mallon PW.J Infect Dis. 2013 Feb 15;207(4):628-37.
3. **Rock C**, Sadlier C, Fitzgerald J, Kelleher M, Dowling C, Kelly S, Bergin C. Epidemiology of invasive pneumococcal disease and vaccine provision in a tertiary referral center. Eur J Clin Microbiol Infect Dis. 2013 Sep;32(9):1135-41
4. **Rock C**, Harris AD, Reich NG et al Is hand hygiene before putting on nonsterile gloves in the intensive care unit a waste of health care worker time?-A randomized controlled trial. Am J Infect Control. 2013 Nov;41(11):994-6.
5. **Rock C,** de Barra E, Sadlier C, Kelly S, Dowling C, McNally C, Bergin C. Impact of a new vaccine clinic on hepatitis B vaccine completion and immunological response rates in an HIV-positive cohort. J Infect Public Health. 2013 Jun;6(3):173-8.
6. **Rock C**, Thom K, Masnick M Johnson JK, Harris AD, Morgan DJ. Frequency of contamination of Klebsiella pneumoniae carbapenemase (KPC)- and non-

KPC-producing Klebsiella from patients to healthcare workers and the environment. Infect Control Hosp Epidemiol. 2014 Apr;35(4):426-9.

7. **Rock, C**, Arnold R, Croft L, Gilliam BL, Morgan DJ. Factors associated with treatment failure in vertebral osteomyelitis requiring spinal instrumentation. Antimicrob Agents Chemother. 2014 ;58(2):880-4

Abstracts

1. **Rock C,** Harris D, Johnson JK, et al. Infrequent Air Contamination with Acinetobacter baumannii Surrounding Known Colonized or Infected Patients. 2014 ID™ Week Poster Presentation.
2. **Rock C,** Thom K, Masnick M et al Frequency of contamination of Klebsiella pneumoniae carbapenemase (KPC)- and non-KPC-producing Klebsiella from patients to healthcare workers and the environment
3. Flemming E, Thom KA, **Rock C** et al Risk factors for development of surgical site infection following renal transplantation 2013 ID Week Poster Presentation
4. Feeney ER, McAuley N, O'Halloran JA, **Rock C** et al. The Differential Expression of Cholesterol Metabolism Genes in Monocytes from Treated and Untreated HIV-Infected Subjects Compared to HIV-Negative Controls Suggests Impairment in Reverse Cholesterol Transport and Intracellular Cholesterol Accumulation. 13th European AIDS conference 2011: Poster presentation: PE9.2/1:
5. Cotter A, **Rock C**, Brady J et al.

Seasonal changes in 25-OH vitamin D and parathyroid hormone in HIV-infected subjects. 13th European AIDS conference 2011: Poster presentation: PE9.7/8: Infectious Diseases Society of Ireland annual meeting 2012: Oral presentation

6. **Rock C**, Kyithar P, Jackson V et al. Impaired glucose metabolism in HIV-1 seropositive pregnant women: a prospective analysis 7th Annual Conference of the British HIV Association 2011: Poster presentation P 55:HIV Medicine: 12 (1) 32-33.
7. Kyithar P, **Rock C**, Jackson V et al. Incidence of gestational diabetes mellitus (GDM) and gestational impaired glucose tolerance (GIGT) in HIV-1 seropositive women 6th International Symposium on Diabetes & Pregnancy, Austria, 2011: Abstract 587
8. **Rock C**, Levis J, Crowley B et al. Prevalence of hepatitis delta in a diverse hepatitis B population attending an Irish Clinic Infectious Diseases Society of Ireland Annual Scientific meeting 2010: PP12
9. **Rock C**, Coulter T, Rock K et al. Implications of universal childhood pneumococcal vaccination on invasive pneumococcal disease in HIV population – a review of current infecting serotypes 20th European Congress of Clinical Microbiology and Infectious Diseases (ECCMID) Austria 2010: Abstr. 3265
10. Brown A, **Rock C**, Ní Bhuachalla C et al. Variable serological response to PPV in HIV-positive patients – a need to review pneumococcal boost-prime strategies? 14th International Conference on Infectious Diseases, Florida, U.S.A. 2010. International Journal of Infectious Diseases 14(1)E 451-452 (Miami, Florida- March 9-12, 2010

11. **Rock C**, Dowling C, Kelly S et al. Strategies for management and optimization of vaccine uptake in an HIV positive cohort Infectious Diseases Society of Ireland Annual Scientific meeting 2009:
12. De Barra E, **Rock C**, Kiely B et al. Varicella vaccination in HIV-positive individuals – a time to act. Ninth International Congress on Drug Therapy in HIV Infection, UK 2008 Journal of the International AIDS Society 2008, 11(Suppl 1):293 doi:10.1186/1758-2652-11-S1-P293

Extramural Support

Current Research Support

2013-14 The use of all cause hospital-acquired bloodstream infection rate as an objective surrogate marker for central line associated bloodstream infection.
SHEA Epi Project Grant $20,000

Educational Activities

Educational Publications

Books, Textbooks.

1. **Rock C**, Thom K, Wright WF. Catheter associated urinary tract infections. In: Wright WF, ed. Essentials of Clinical Infectious Diseases. New York, NY: Demos Medical Publishing; 2013

2. **Rock C**, Leekha S. Basics of infection control and epidemiology. In: Wright WF, ed. Essentials of Clinical Infectious Diseases. New York, NY: Demos Medical Publishing; 2013
3. **Rock C**, Donnenberg M. Human pathogenic enterobacteriacae. In Encyclopedia of Human Biology. Editor: Bury-Moné , Stéphanie 2012
4. **Rock C**, Bergin C. Sexually Transmitted Infections. In: McKean SC, Ross JJ, Dressler DD., Brotman DJ, Ginsberg JJ, ed. Principles and Practices of Hospital Medicine. New York, NY: McGraw-Hill: 2012: 1680-1686
5. **Rock C**, Bergin C. Progressive multifocal leukoencephalopathy – Experimental options Eur J Intern Med. 2009 Oct;20(6)

Case Reports

1. **Rock C,** Thom KA Ecthyma gangrenosum caused by Pseudomonas aeruginosa. J Am Osteopath Assoc. 2012;112(4):240
2. **Rock C**, Brady D, Forde P, Lucey P, Horgan M. Leptospirosis – a globally increasing zoonotic disease BMJ Case Rep. 2010 Nov 5;2010
3. **Rock C,** Horgan M. Leptospirosis - on the increase due to global warming Ir Med J. 2010 Nov-Dec;103(10):317 PMID: 21563357

Letters, correspondence

1. **Rock C,** Bergin C Progressive multifocal leukoencephalopathy – experimental options. Eur J Intern Med. 2009 Oct;20(6):e142.

Educational Courses

2007-11	Infectious Diseases Weekly Teaching Sessions, RCPI
2010-11	Ethics in Medical Research – Four Part Course, RCPI
2011	Leadership Skills in Medicine, RCPI
2011	15th Annual SHEA Fellows Course in Hospital Epidemiology
2012	NIH Microbiology Course

Teaching

Classroom Instruction

2007-2011	Regular presentations for Infectious Diseases Fellowship Training sessions, Royal College of Physicians of Ireland (RCPI)
2007-2011	Regular teaching sessions for Residents rotating through Internal Medicine and Infectious Diseases, RCPI

Clinical Instruction

2004-2011	Regular clinical skills instruction for Trinity College, Dublin, University College Dublin, University College Cork medical students
2007-2010	Clinical Skills Instructor for candidates undertaking the Membership/Board Examinations of the RCPI
2011	Teaching course: Physicians as Trainers: Effective Teaching and Supervising Skills, RCPI

2012	Host defenses and Infectious diseases, small group lecturer, University of Maryland School of medicine.
2014	Host defenses and Infectious diseases, small group lecturer, University of Maryland School of medicine.

Clinical Activities

Board Certifications and Licenses

07/2004- Present	Medical Council of Ireland: Full Registration
03/2007- Present	Member of the Royal College of Physicians of Ireland (MRCPI)
06/2012	Certificate of Completion of Specialist Training in Infectious Diseases, RCPI, Ireland and European Union

Clinical (Service) Responsibilities

07/2011-06/2013	Infectious Diseases Clinic	(Two days per week)

Organizational Activities

Advisory Committees

2012-Present	Infection Control Committee, Department of Infectious Diseases, University of Maryland, Director – Anthony Harris, MD
2012-Present	Antimicrobial Subcommittee of the P&T committee, University of Maryland

Editorial Activities

Journal Peer Review Activities

Ad Hoc Reviewer

2013-Present	European Journal of Clinical Microbiology and Infectious Diseases
2012-Present	Invited Judge of oral session, 35th Annual Medical Student Research Day, University of Maryland School of Medicine
2012-Present	Epidemiology and Infection
2011-Present	The Obstetrician and Gynecologist: STI and Pregnancy

Membership of Professional Societies

2011-Present	Infectious Diseases Society of America
2011-Present	Society for Hospital Epidemiology of America
2014-present	American Society for Microbiology

Recognition

Awards, Honors

2007	Resident Grand Rounds Competition Winner, Connolly Hospital, Ireland
2008	University College Cork and South Tipperary General Hospital Outstanding Teaching Award, Ireland
2009	Infectious Diseases Society of Ireland Research Award, Ireland

2009 Infectious Diseases Society of Ireland Annual Scientific Meeting, Ireland

Fellows' Clinical Case presentation winner

2011 European Congress of Clinical Microbiology and Infectious Diseases (ECCMID) Award for high-quality abstract Milan, Italy

2012 Trainee Travel Grant for Excellence in Abstract Submission ID Week™

2013 SHEA Epi Project Grant Award Winner

2013 Jonathan Freeman Scholarship SHEA Conference Award

Invited Talks

1. **Rock C,** Ryan J Patients Perceptions and Expectations of Care Provided in the Emergency Department Royal Academy of Medicine Winter Meeting: Finalist for Watts Medal for outstanding undergraduate research St. Vincent's University Hospital Undergraduate Research Symposium 2003
2. **Rock C**, Loy A, McNally C HIV diagnoses in patients attending an urban Irish sexually transmitted infections walk-in clinic Society for the study of sexually transmitted infections in Ireland Autumn meeting 2008
3. **Rock C**. Experimental Options. Infectious Diseases Society of Ireland Annual Scientific meeting 2009: Fellows Clinical Case presentations (winner of case presentation).
4. **Rock C**, de Barra E, Dowling C et al. The Impact of a Structured Vaccine Programme of Care on Vaccine Uptake in the HIV Population attending an Urban

Clinic – a 5 year Review 19th European Congress of Clinical Microbiology and Infectious Diseases (ECCMID) Helsinki 2009

5. **Rock C,** Jackson V, Ciprike V et al Antenatal screening of syphilis in pregnant women and their partners – the importance of contact tracing Faculty of Public Health Medicine 2011 summer scientific meeting
6. **Rock C**, Fitzgerald J, Sadlier C et al. The associated mortality of invasive pneumococcal disease – Why are we not vaccinating? 21st European Congress of Clinical Microbiology and Infectious Diseases (ECCMID) Italy 2011: Oral presentation O423. Clinical Microbiology and Infection: Volume 17, Issue Supplement s4, pages S1–S107, May 2011
7. **Rock C**, Harris AD, Johnson JK et al. Utility of Hand Hygiene prior to donning non-sterile gloves - A randomized controlled Trial ID week/SHEA 2012 San Diego: Oral presentation 581.

Abstract

Title of Thesis: Comparing Hospital-Onset Bacteremia to Central Line Associated Bloodstream Infection as a Hospital Quality Measure

Clare Rock, Master of Science, 2014

Thesis directed by: Kerri A. Thom, Associate professor, Epidemiology and Public Health

Background

Central Line Associated Bloodstream Infections (CLABSI) rates are a benchmark for hospital quality despite problems with surveillance bias and inter-observer variability and subjectivity. The rate of Hospital-onset bacteremia (HOB) may offer significant advantages over CLABSI; including being more objective and un-biased.

Methods

We conducted a multisite cohort study via the Society for Healthcare Epidemiology of America (SHEA) research network to examine the relationship between HOB and CLABSI rates and compare ability of each to distinguish between hospitals. Hospitals reported total CLABSIs, central line days, HOBs, patient days, and total blood cultures performed for each ICU and completed a survey relating to CLABSI reporting. Mixed-effect Poisson regression was used to evaluate HOB as a predictor for CLABSI. Standardized infection ratios (SIR) for HOB and CLABSI for medical and neonatal ICUs were calculated using the pooled mean rates of the study sample as the benchmark.

Results

We obtained data for 79 ICUs from 15 hospitals within the US and Canada. From January 2012 to December 2013, 627 CLABSIs, 11 024 HOB, 464 224 central line days and 959 647 ICU patient days were reported. HOB was a strong predictor of CLABSI; a change in the rate of HOB of 1 predicted a relative change of 2.2% in CLABSI rate. Standardized infection ratios for HOB and CLABSI for medical and neonatal ICUs showed large confidence intervals that overlapped with each other for the CLABSI measure with 14 of 18 (77.7%) CLABSI 95% confidence intervals containing the null value of 1, compared to only 6 of 18 (33.3%) HOB 95% confidence intervals (p-value 0.02, fisher's exact test). CLABSI reporting requires 15.8 hours of nurse time per month.

Conclusions

In this multicenter study, HOB rates were strongly predictive of CLABSI rates. HOB can be collected automatically saving nurse time and provide better discrimination hospital quality than CLABSI.

Comparing Hospital-Onset Bacteremia to Central Line Associated Bloodstream Infection as a Hospital Quality Measure

by
Clare Rock

Thesis submitted to the faculty of the Graduate School
of the University of Maryland Baltimore in partial fulfillment
of the requirements for the degree of
Master of Science
2014

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List of Abbreviations

CLABSI	=	Central Line Associated Bloodstream Infection
CDC NHSN	=	Centers for Disease Control and Prevention National Healthcare Safety Network
CMS	=	Centers for Medicare and Medicaid Services
HOB	=	Hospital-onset Bacteremia
ICU	=	Intensive Care Unit
MICU	=	Medical Intensive Care Unit
NICU	=	Neonatal Intensive Care Unit
SIR	=	Standardized Infection Ratio

I. BACKGROUND

Central line-associated bloodstream infection (CLABSI) rate is a commonly used outcome measure of patient safety and quality of care. Most US states mandate hospitals to report CLABSI rates for each of their intensive care units to the Centers for Disease Control and Prevention National Healthcare Safety Network (CDC NHSN).[1] These data are available to the public through Hospital Compare and other consumer websites, and used by the Centers for Medicare and Medicaid Services (CMS)[1] to determine hospital reimbursement.[2] However, the CLABSI measure is believed by experts in the field to have significant flaws including surveillance bias, subjectivity, and inter-observer variability. [3, 4, 5, 6]

Infection prevention and control in the hospital setting is a core aspect of patient safety. Hospital-associated infections are the outcome measures of infection prevention and control practices and may reflect inadequate staffing levels, inadequate systems, management failures and organizational stress.[7] An ideal outcome measure needs to be reliable, valid, objective with little inter-rater variability and have the ability to detect change over time. Hospital-onset bacteremia (HOB) rate has significant potential as a valid outcome measure of infection prevention efforts. HOB is a fully automated outcome measure, obtained from a microbiology database, without any requirement for chart review and thus is objective and not subject to inter-rater variability. Furthermore, it is a common event, with nosocomial bloodstream infection complicating 3 of every 100 Intensive care unit (ICU) admissions,[8 9] and therefore should have the ability to reflect changes in infection prevention practices over time.

We performed a multi-center study to evaluate the use of HOB rates as a quality measure in comparison to CLABSI rates. We hypothesized that 1) HOB rates would be predictive of CLABSI rates, and 2) compared to CLABSI, the HOB measure would provide greater discrimination when determining if a hospital's rate was significantly different (higher or lower) than average.

II. METHODS

Study Design and Location

In this multicenter, time trend longitudinal study, hospitals were recruited through the SHEA research network. The SHEA Research Network is a consortium of more than 200 hospitals conducting multicenter research projects in healthcare epidemiology. [10 11] Facilities within the US and Canada, with adult, pediatric or neonatal ICUs were invited to participate. Each medical center obtained approval from its respective institutional review board for human subject research.

Study Variables

Study variables were defined as follows: CLABSI was defined as a primary bloodstream infection in a patient with one or more central lines within the 48-hour period prior to the onset of the bloodstream infection and the bloodstream infection was not related to any infection at other foci[1]. CLABSI rate was the number of CLABSIs divided by the number of central line days. HOB was any positive blood culture for any organism (including contaminants and repeat positive blood cultures) from any cause sent from the ICU and taken 48 hours after admission to hospital. HOB rate was the number of HOBs divided by the number of ICU-patient days. Total number of blood cultures sent included positive and negative blood cultures sent from the ICU during the study month.

Data collection

Each participating hospital contributed monthly-aggregate data for each ICU with the number of CLABSIs, central line days, HOBs, ICU patient-days and total number of blood cultures taken from January 2012 to December 2013. CLABSIs were identified by

infection prevention staff at each hospital using CDC definitions.[1] The HOB outcome measure was attained in an automated fashion directly from microbiology databases without medical record review. The type of ICU was also collected using CDC-NHSN classification.[1]

Survey

Each participating hospital completed an on-line survey to assess hospital and ICU level factors. Questions included the number of infection preventionists at the hospital and estimated time spent by infection preventionists on CLABSI surveillance. (The survey is available as an appendix.)

Statistical Methods

A mixed effect Poisson regression model was fit to evaluate the effect of HOB on CLABSI, with ICU included as random effects and HOB rate and total number of blood cultures included as fixed effects. The nesting of CLABSIs within ICU was accounted for by the random effects in the model. The over-dispersed distribution of CLABSIs was adjusted by using additive over-dispersion. A backward selection for best fit model, using deviance information criterion, with CLABSI rates as an outcome was used. The candidate predictors include HOB rate, time period (month and year), hospital, ICU type and total number of blood cultures obtained. The best, most parsimonious model included HOB rate and total number of blood cultures obtained. These analyses were performed in R package using the MCMCglmm package.

Using a pooled mean of CLABSI and HOB (separately for all MICUs and all NICUs), an expected number of CLABSIs or HOB for each individual ICU was calculated. The expected rate was calculated by obtaining the pooled mean number of

CLABSIs for all NICUs or MICUs and then calculating for the number of central line days in each individual ICU what the expected number of CLABSIs should be. This expected number was then divided by the actual number of CLABSIs in that ICU, resulting in a SIR. The HOB SIR was calculated in a similar fashion. This is done in a similar way to the Hospital Compare CMS website [2] Poisson 95% confidence intervals around each SIR were calculated and interpreted as follows: an SIR 95% confidence interval that includes 1 means that the ICU is the same as the expected rate for that type of ICU, greater than 1 means that ICU has a higher than expected rate, and less than 1 means they have a lower than expected rate. These analyses were performed using SAS 9.3 (SAS Institute, Cary NC).

III. RESULTS

Demographics of the Participating Hospitals and Intensive Care Units

Sixteen hospitals in 11 states and Canada participated in the study and contributed data from 79 ICUs. See table one and figure 1 for hospital demographics and distribution of ICU types. Over the 2-year study period there were a total of 959,647 ICU patient days, 464,224 central line days and 154,502 blood cultures reported. For all ICUs over the 2 year study period there were 627 central line associated blood stream infections (CLABSIs) and 11,024 HOBs; CLABSIs represented approximately 6% of the overall HOB.

Table 1. Demographics, number of infection prevention staff and time required for completion of CLABSI surveillance of the Participating Hospitals

Hospital Study number	Hospital type *	Number of beds in hospital	Number of ICUs in the hospital **	Number of Infection preventionists (IP)	Number of hours per week spent by on CLABSI surveillance
1	A	>500	10	6	25
2	A	>500	8	5	11.5
3	A	>500	7	8	20
4	A	>500	10	5	20
5	A	>500	5	5	5
6	A	>500	8	14	30
7	A	>500	5	8	40
8	A	>500	7	4	5
9	A	300-500	3	3	7
10	A	>500	8	9	3
11	A	100-300	2	1.5	5
12	A	300-500	3	3.2	7
13	C	300-500	3	3	50
14	A	>500	6	5	15
15	C	300-500	1	1	5
16	C	100-300	1	1	5

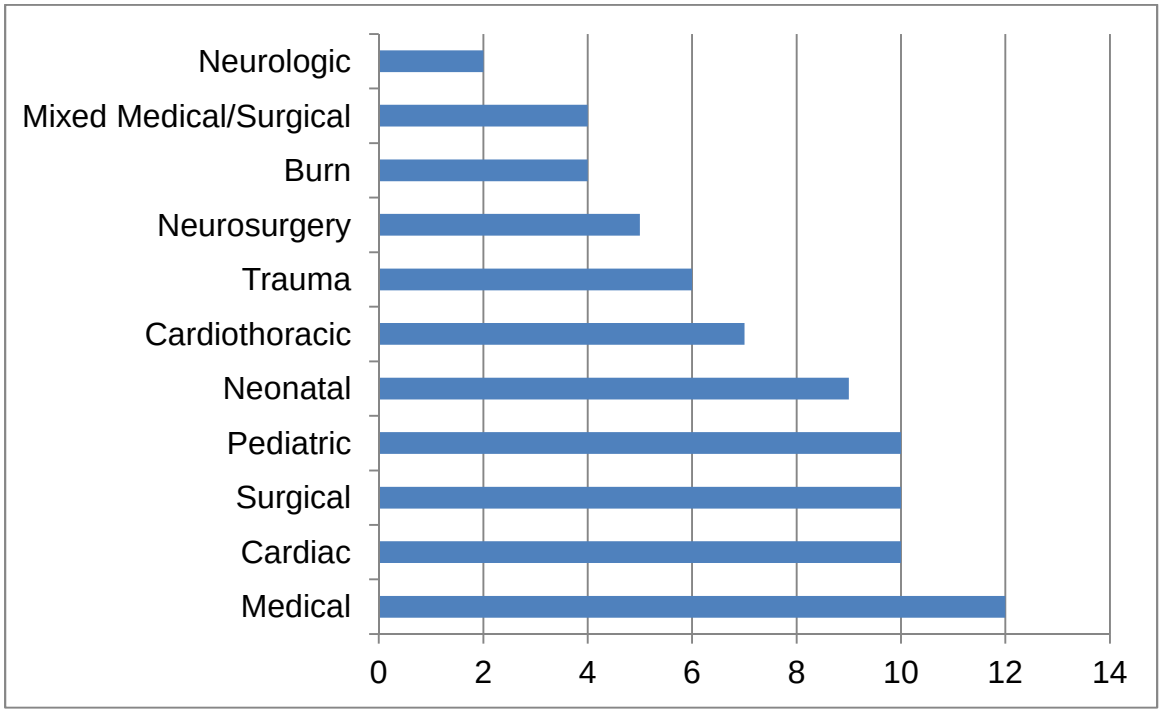

Figure 1: The number of ICUs for each ICU type (n=79)

Rates of Central Line Associated Bloodstream Infection and Hospital onset Bacteremia rates

There were many more (1,376 of 1,896, 72.6%) individual ICU-months without CLABSIs than months without a HOB (221 of 1,896, 11.7%) (chi square test P<0.001). Data from all ICUs from all hospitals was combined to form an overall CLABSI and overall HOB rate. Figure 2 shows the changes in the CLABSI and HOB rates by quarter. The median HOB rate was 11.62 per 1000 patient days, with an interquartile range (IQR) of 11.09 to 12.10. The median CLABSI rate was 1.35 per 1000 central line days, with an IQR of 1.26 to 1.50.

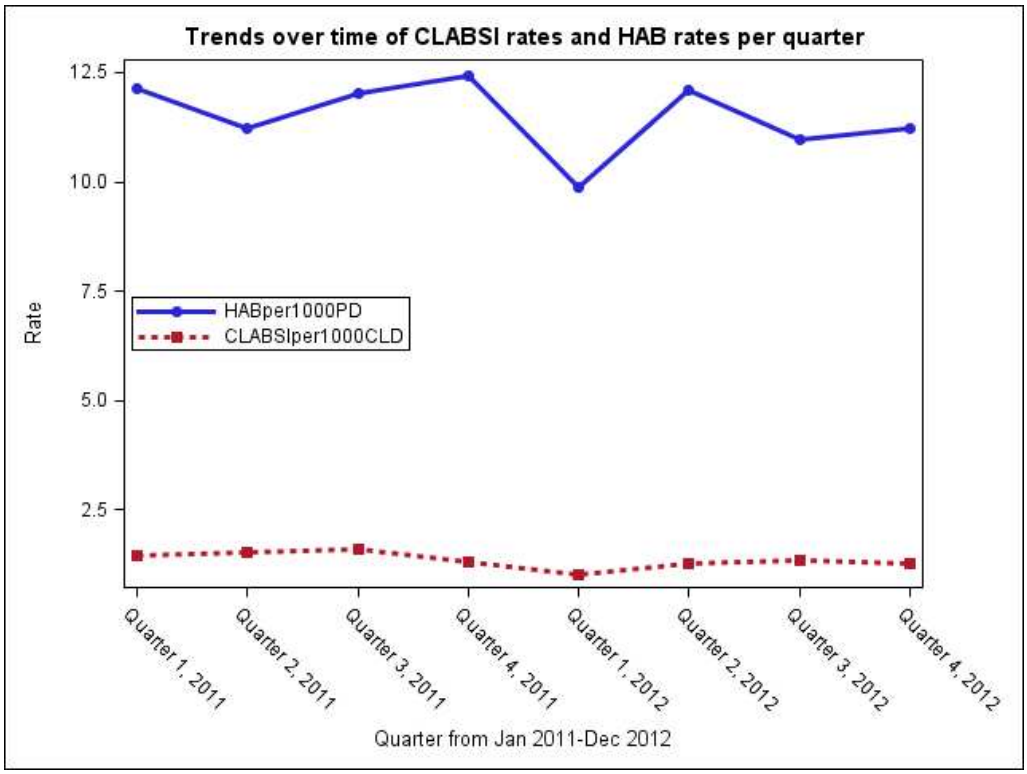

Figure 2: Trends over time of CLABSI rates and HOB rates per quarter

Using a model with CLABSI rate as the outcome and HOB rate and total blood culture taken as the dependent variables we found that HOB was a strong predictor of CLABSI, an increase in the absolute rate of HOB of 1 predicted a relative increase of 2.2% in CLABSI rate. ($p<0.001$)

Standardized Infection Ratio for Medical and Neonatal ICUs

The ability to discriminate between ICUs was evaluated for both CLABSI and HOB rates. The normal rate for the study group was calculated with an SIR. Figure 3 (a) and (b) show the standardized infection ratios (SIR) for CLABSI and HOB rates in the ICUs (MICU and NICU were the most frequent adult and non-adult ICUs in the study). An SIR with a lower limit that is greater than 1.0 means that there were more CLABSIs or HOB in the ICU than were predicted, and the hospital is classified as

"Worse than the Study Benchmark" and colored in red. If the SIR has an upper limit that is less than 1, then the ICU had fewer CLABSI or HOBs than were predicted and is classified as "Better than the Study Benchmark" and colored in green. If the confidence interval includes the value of 1, then there is no statistical difference between the actual numbers of CLABSI or HOBs and the number predicted the hospital is classified as "No Different than Study Benchmark" and colored in orange. Only 4 of 18 (22.3%) of ICUs had CLABSI rates that could be distinguished from the average ICU (SIR with 95% CI that doesn't overlap 1) while 12 of 18 (66.7%) of ICUS had HOB rates that were different from average (p=0.02, Fisher's exact test) Examining all ICUs (MICUs and NICUs) 14 of 18 (77.7%) CLABSI 95% confidence intervals that contain the null value of 1 meaning they are no different from the study benchmark. In contrast, 6 of 18 (33.3%) HOB 95% confidence intervals contained the null value (p-value 0.02, fisher's exact test).

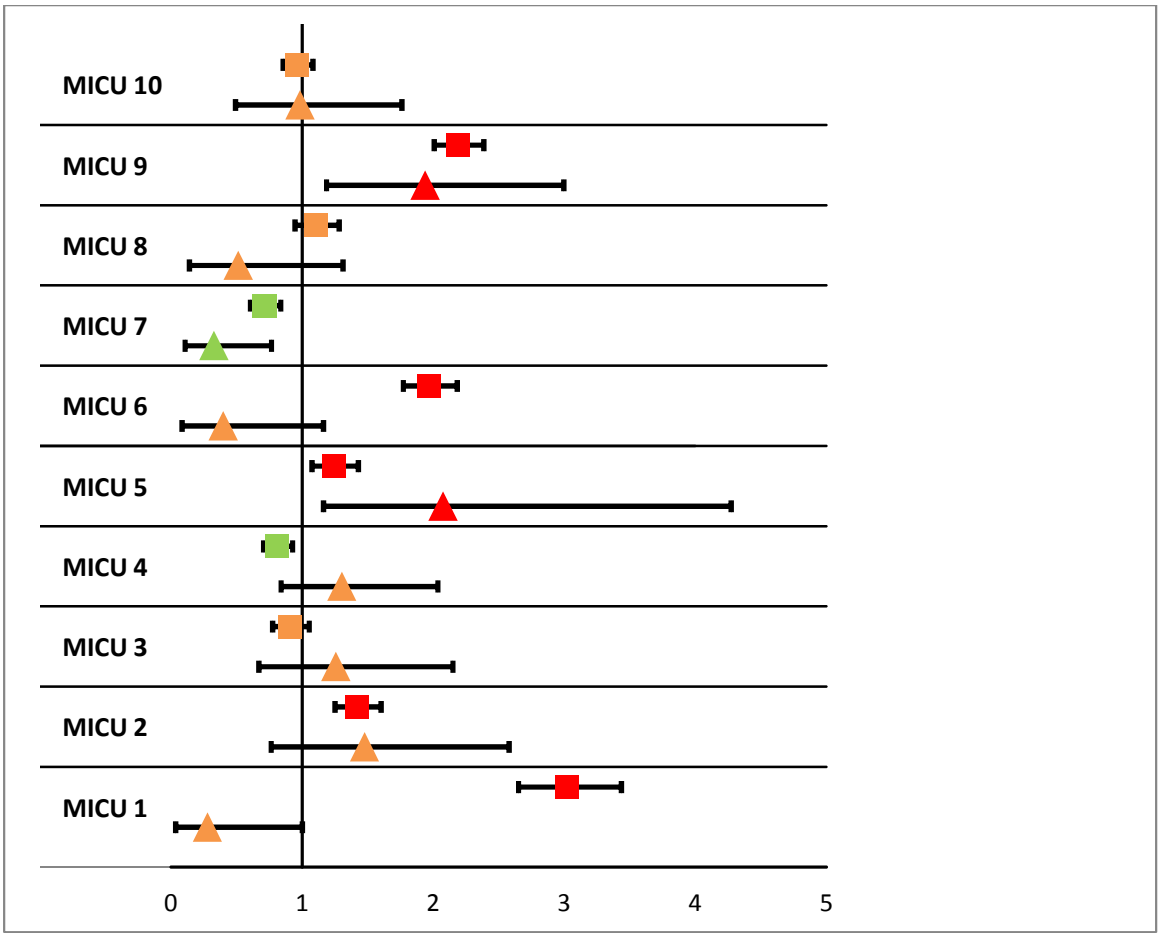

Figure 3 A: Standardized Infection Ratios (SIR) for CLABSI and HOB for each of the MICUs

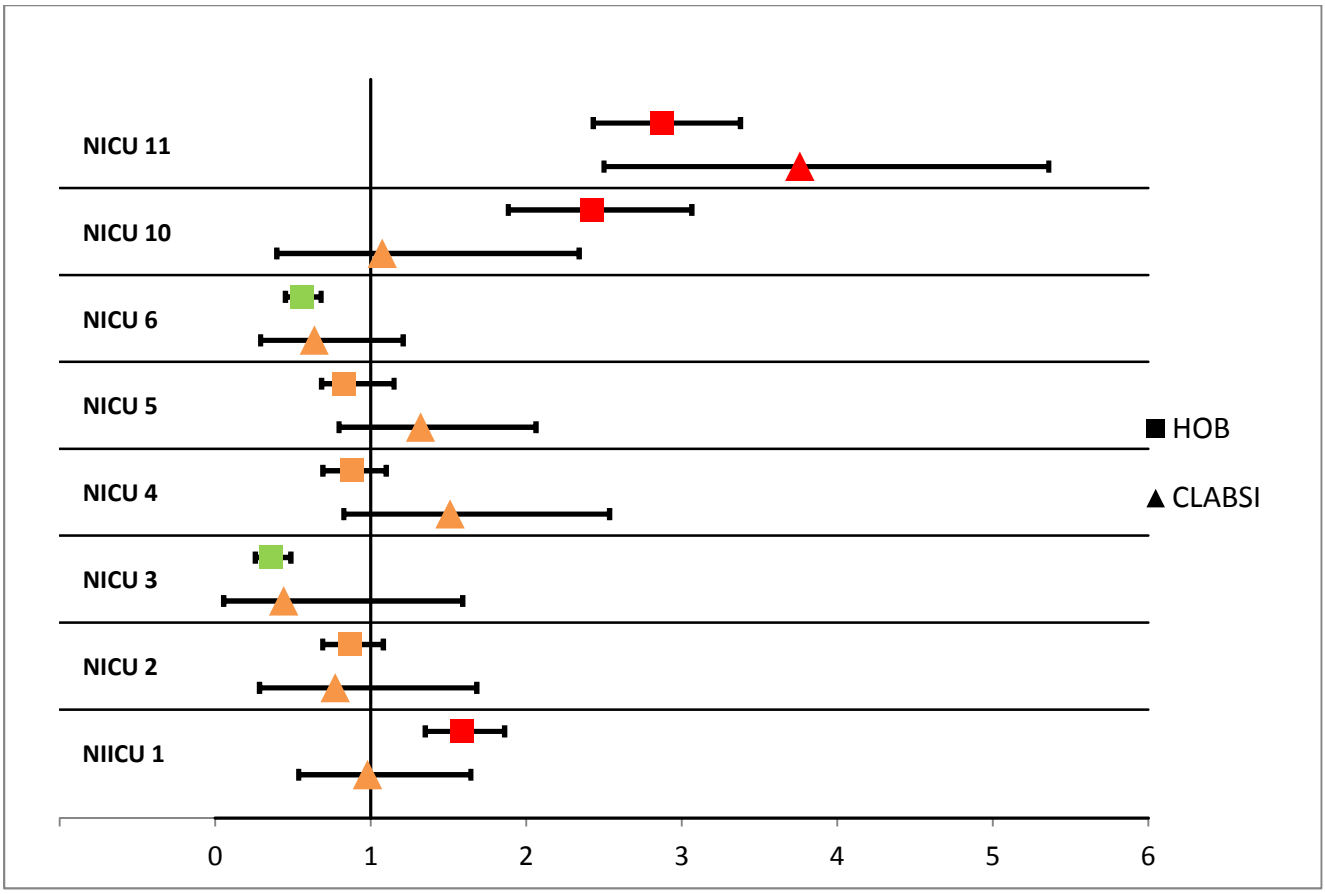

Figure 3 B: Standardized Infection Ratios (SIR) for CLABSI and HOB for each of the MICUs

Figure 3 (A) and (B) show the Standardized Infection Ratios (SIR) for the CLABSI and HOB for each of the MICUs and NICUs respectively. The vertical line at 1 represents the reference or null value: where the expected rate (study benchmark) of CLABSI or HOB for each MICU (3A) or NICU (3B) lies (SIR=1). The filled in circle represents the HOB rate and the filled in star represents the CLABSI rate. The horizontal line though each symbol represents the 95% confidence interval around the parameter. Those that lie to the right of the SIR 1 reference line have greater than the expected number of CLABSI or HOB (colored in red; worse than the study benchmark), conversely those that lie to the left have less than expected number of CLABSI or HOB (colored in green; better than the

study benchmark). Those that include the expected number of CLABSI or HOB include the SIR reference line and are colored in orange.

In response to the survey, it was estimated that an average of 15.8 hours per week is spent by Infection Preventionists on CLABSI surveillance per hospital. All facilities used the CDC NHSN definition to define CLABSIs.

IV. DISCUSSION

We collected CLABSI rates and calculated HOB rates for 79 ICUs in 16 hospitals within the US and Canada. This study found that HOB was a far more frequent occurrence than CLABSI. The majority (1376/1896, 73%) of the individual ICU-months reported zero CLABSI and much fewer, 221 (11.8%), reporting zero HOB. HOB therefore has more potential to reflect changes in infection prevention and quality. We found that HOB is a strong predictor of CLABSI; for every unit increase in HOB rate there was a relative 2.2% increase in CLABSI rate. HOB, therefore could potentially replace CLABSI as a single global outcome measure but still reflect changes in CLABSI rates. We found that HOB provided greater discrimination when used as an outcome measure for hospital ranking as compared to CLABSI.

In this study we found that 73 % of individual ICU months had zero CLABSIs. Conversely HOB only had 11.8 % of months with zero HOBS. CLABSI rates obtained through surveillance programs have decreased in recent years.[12] Reasons for this are multifactorial and include bundle interventions for practice change, new technology and pressure from benchmarking and public reporting.[13] This pressure may partially result from a broad acceptance by stakeholders that zero CLABSI rates are always achievable.[14] It is difficult to make valid inferences regarding infection prevention practices in the ICU during the months with zero CLABSIs. CLABSI rates, with so many zero months, lack the responsiveness needed to detect change over time, making CLABSI a poor outcome measure when trying to examine outcomes of infection prevention and quality improvement strategies in the ICUs. This is reflected in the choice of outcome measures in large infection prevention randomized controlled trials, whereby, HOB is often used as

an outcome measure.[15,16,17] A recent large multicenter cluster randomized controlled trial looking at universal and targeted MRSA decolonization included ICU-attributable bloodstream infection caused by any pathogen as an outcome measure.[17] The use of CLABSI rates as an outcome in such a study would not be satisfactory as it is so infrequent it would lack the ability to reflect any improvement over time due to the intervention. The infrequency of CLABSI, therefore, makes it a poor choice for outcome measure for any quality intervention and difficult to use it in comparing performances between different ICUs. HOB is a much more frequent event and therefore a more robust measure and easier to follow trends and changes in response to quality interventions.

We found that HOB was a strong predictor of CLABSI over time; each increase of 1in the HOB rate was associated with a relative increase of 2.2% in the CLABSI rate. This suggests that the HOB measure might be responsive to many of the same infection prevention interventions as CLABSI, but at the same time provide a more global outcome measure that includes multiple sources of hospital-acquired infection. A ventilator associated pneumonia infection prevention intervention bundle in the long term care facility showed a concurrent decrease in the incidence rate of bacteremia from any cause, from 1.36 cases/1,000 patient-days to 0.20 cases/1,000 patient-days.[18] In a previous single-center study, we showed that HOB had a relative decrease of 2.7% post CLABSI prevention intervention, with CLABSI rates with a relative decrease of 5.1%.[19] A previous study has shown a correlation between CLABSI rates and other quality of care indicators such as patient satisfaction with nursing care.[20] It may be that HOB is reflective of an even more global quality measures than just that of infection prevention.

HOB as an outcome measure provided better discrimination between hospitals than CLABSI. To demonstrate this point we calculated Standardized Infection Ratios (SIR), in a similar way to CMS on the Hospital Compare website [2] we calculated an expected rate of infection (for CLABSI and HOB separately) for each ICU, and divided by the observed number of infections, giving a SIR for each of the individual ICUs. (See figure 3 (a) and (b)). We found 95% confidence intervals around the SIR for each of the MICU and NICU CLABSI rates that were very wide and overlapping with each other. In fact for CLABSI rates the majority of ICU SIRs included the SIR threshold of 1, many more than that of HOB (14/18 vs 6/18 P=0.0176). This, in essence means that 14/18 (77.7%) hospitals would get the same yellow traffic light ranking for CLABSI, whereas only 6/18 (33.3%) hospitals would get the same yellow traffic light ranking for HOB. The lack of discrimination of the CLABSI as an outcome measure is important when looking at benchmarking and ranking between hospitals. The fact that so many hospitals receive the same "traffic light" signal for CLABSI make it difficult for the patient consumer to use this quality measure to truly discern poor and good quality hospitals and may not be helpful in informing choices about where to seek medical care.

When considering an outcome measure such as CLABSI, or HOB, the processes that are being measured need to be considered. When the outcome measure is CLABSI the process measures are infection prevention practices (development of infection prevention guidelines, education and compliance of clinical staff with these practices) in the ICU as they apply to patients with central lines. The bacteremias which occur in the patients without a central line, or that occur due to another HAI such as hospital-acquired pneumonia are not captured when looking at the CLABSI outcome measure. Conversely

HOB, which is inclusive of CLABSIs, but also includes all other hospital acquired bacteremias regardless of cause, is a more global measurement of all infection practices in the ICU for all patients. We found that CLABSIs represented only a small proportion of all HOB, meaning that there are several hospital-onset bacteremias from other etiologies that are not accounted for if one looks solely at the CLABSI rate.

An additional important benefit of HOB over CLABSI is that it is less resource intensive than CLABSI; in particular less time is required to be spent on manual chart review by infection preventionists. In our study infection preventionists spent an average of 15.8 hours per week on CLABSI surveillance. A study found that in US hospitals Infection preventionists spend a mean of 44.5% of their time engaged in infection surveillance practices. [21] In contrast HOB surveillance is much less resource intensive to perform. There is no manual chart review required as all bloodstream infections are included, regardless of etiology. It is likely that this automated method is feasible for hospitals to use in reporting surveillance measures. In 2012 nearly six in ten US hospitals use Electronic Health Records (EHR), and this is increasing due to Medicare and Medicaid EHR Incentive programs. [16] Another benefit due to automated nature of is that it is completely objective and not subject to inter-rater variability; whereas CLABSI is vulnerable to potential over and under reporting.

Limitations of this study include the retrospective nature. However, the fact that the individual hospitals were reporting blood stream infections previously classified as CLABSIs was in an effort to make the study as "real world" as possible. We included multiple positive blood cultures from the same infection episode more than once and included "contaminants" in our HOB rate in an effort to make this measure as

objective and simple as possible for reporting hospitals. It is possible that the objectivity and simplicity may be maintained with only including one bacteremia per episode and exclusion of contaminants.

Further studies may look at correlation between HOB rates and other hospital-acquired infection rates such as catheter-associated urinary tract infection and surgical site infection. This would validate HOB as an overall predictor of other hospital-acquired infection rates. In this multi-center study, we found HOB rates to be strongly predictive of CLABSI rates over time and provided greater discrimination between hospitals. These results, together with the objective and un-biased nature of the HOB measure, may make it more attractive than CLABSI for benchmarking hospital quality of care.

V. APPENDIX

SURVEY OF INFECTION PREVENTION PRACTICES AND HOSPITAL DEMOGRAPHICS

SHEA Education & Research Foundation

*SHEA Epi Competition: **The Use of All Cause Hospital-Acquired Bloodstream Infection (BSI) Rates as an Objective Surrogate Marker for Central Line-Associated Bloodstream Infection (CLABSI)***

All information will be kept confidential; reporting of data will be in aggregate. All identifiers will be removed and your facility will NOT be identified in any way. Email address is required for de-duplication purposes only and will be removed before the data are provided to investigators.

Thank you for your participation in this study!

Email address:
*

Total number of beds in your institution:

Number of infection preventionists (IPs) in facility:

Total number of hours spent by all IPs per week performing CLABSI surveillance:

Are you required by the state to report CLABSI rates?

☐ Yes ☐ No

During the study period (January 2011-December 2012) did the ICUs at your institution:

	Yes	No
Use the NHSN CDC definition to define CLABSI?	☐	☐
Enter data into the NHSN CLABSI module?	☐	☐

Number of ICUs in your facility:

Will you be responding on behalf of all ICUs in your facility?

☐ Yes ☐ No

If no, please provide the number of ICUs for which you will be responding. We will ask for further details on the next page.

For each ICU, please complete the following information:

ICU Type (1):

Other:

How many beds in this ICU? (numeric only)

ICU Type (2):

Other:

How many beds in this ICU? (numeric only)

Do you have a dedicated ICU, critical care unit, or other unit for the care of critically ill oncology patients?

☐ Yes ☐ No

If yes, what is the name of that unit?

Other:

If no, in which ICUs are critically ill oncology patients usually cared for? (check all that apply)

- ☐ Adult: Burn Critical Care
- ☐ Adult: Medical Cardiac Critical Care
- ☐ Adult: Medical Critical Care
- ☐ Adult: Medical/Surgical Critical Care
- ☐ Adult: Neurologic Critical Care
- ☐ Adult: Neurosurgical Critical Care
- ☐ Adult: ONC Medical Critical Care
- ☐ Adult: ONC Surgical Critical Care
- ☐ Adult: ONC Medical/Surgical Critical Care
- ☐ Adult: Prenatal Critical Care
- ☐ Adult: Respiratory Critical Care
- ☐ Adult: Surgical Cardiothoracic Critical Care
- ☐ Adult: Surgical Critical Care
- ☐ Adult: Trauma Critical Care
- ☐ Adult: Mixed Acuity Unit
- ☐ Adult: ONC Mixed Acuity Unit
- ☐ Pediatric: Burn Critical Care
- ☐ Pediatric: Cardiothoracic Critical Care
- ☐ Pediatric: Medical Critical Care
- ☐ Pediatric: Medical/Surgical Critical Care
- ☐ Pediatric: Neurosurgical Critical Care
- ☐ Pediatric: Respiratory Critical Care
- ☐ Pediatric: Surgical Critical Care
- ☐ Pediatric: Trauma Critical Care
- ☐ Pediatric: Mixed Acuity Unit
- ☐ Pediatric: ONC Mixed Acuity Unit
- ☐ Neonatal: Critical Care (Level II/III)
- ☐ Neonatal: Critical Care (Level III)

☐ Mixed Age Mixed Acuity Unit

☐ Mixed Age ONC Mixed Acuity Unit

☐ Other Critical Care _____

Thank you for responding to this SHEA Research Network questionnaire. We appreciate your commitment to advancing the science of healthcare epidemiology and infection prevention, and supporting the mission of the SHEA Research Network. Please reach out with questions and comments by emailing srn@shea-online.org.

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