



**World Health
Organization**

Patient Safety

A World Alliance for Safer Health Care

Introduction to Patient Safety Research

Presentation 13: Identifying Solutions: Prospective Intervention Study



2: Introduction: Study Details

■ Full Reference

- Pronovost P, et. al. An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU. The New England Journal of Medicine, 2006, 355:2725-32

■ [Link to Abstract \(HTML\)](#)

ABSTRACT

BACKGROUND
Catheter-related bloodstream infections occurring in the intensive care unit (ICU) are common, costly, and potentially lethal.

METHODS
We conducted a collaborative cohort study predominantly in ICUs in Michigan. An evidence-based intervention was used to reduce the incidence of catheter-related bloodstream infections. Multilevel Poisson regression modeling was used to compare infection rates before, during, and up to 18 months after implementation of the study intervention. Rates of infection per 1000 catheter-days were measured at 3-month intervals, according to the guidelines of the National Nosocomial Infection Surveillance System.

RESULTS
A total of 108 ICUs agreed to participate in the study, and 103 reported data. The analysis included 1961 ICU-months of data and 375,757 catheter-days. The median rate of catheter-related bloodstream infection per 1000 catheter-days decreased from 2.7 infections at baseline to 0 at 3 months after implementation of the study intervention ($P \leq 0.002$), and the mean rate per 1000 catheter-days decreased from 7.7 at baseline to 1.4 at 16 to 18 months of follow-up ($P < 0.002$). The regression model showed a significant decrease in infection rates from baseline, with incidence-rate ratios continuously decreasing from 0.62 (95% confidence interval [CI], 0.47 to 0.81) at 0 to 3 months after implementation of the intervention to 0.34 (95% CI, 0.23 to 0.50) at 16 to 18 months.

CONCLUSIONS
An evidence-based intervention resulted in a large and sustained reduction (up to 66%) in rates of catheter-related bloodstream infection that was maintained throughout the 18-month study period.

[Link to Full Text \(PDF\)](#)

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An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU

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3: Introduction: Patient Safety Research Team

- **Lead researcher - Peter Pronovost, MD, PhD**
 - Director, Quality and Safety Research Group
 - Department of Anaesthesiology and Critical Care Medicine, Health Policy and Management
 - Johns Hopkins University Schools of Medicine and Public Health in Baltimore, MD, USA
 - Field of expertise: quality of care, patient safety, critical care
- **Other team members**
 - Dale Needham, MD, PhD
 - Sean Berenholtz, MD
 - David Sinopoli, MPH, MBA
 - Haitao Chu, MD, PhD
 - Sara Cosgrove, MD
 - Bryan Sexton, PhD
 - Robert Hyzy, MD
 - Robert Welsh, MD
 - Gary Roth, MD
 - Joseph Bander, MD
 - John Kepros, MD
 - Christine Goeschel, RN, MPA

4: Background: Opening Points

- Catheter-related bloodstream infections (CRBSI) in the intensive care unit (ICU) are common, costly, and potentially lethal
- Median rate of catheter-related bloodstream infection in ICUs of all types in the US ranges from 1.8 to 5.2 per 1000 catheter days
 - Source: National Nosocomial Infections Surveillance (NNIS) system of the Centers for Disease Control and Prevention (CDC)

5: Background: Study Rationale

- Each year in the US, central venous catheters cause estimated 80 000 CRBSI and up to 28 000 deaths among patients in ICUs
 - Average cost of care for a patient with this infection is \$45 000
 - Total cost is up to \$2.3 billion annually
- Interventions to decrease infection rate needed to reduce the serious public health consequences of this hospital-acquired infection
 - Research team had developed and implemented a program that nearly eliminated CRBSI at Johns Hopkins
 - Team sought to see if they could scale the program and achieve the same results throughout the state of Michigan, USA

6: Background: Setting Up a Research Team

- Michigan Hospital Association contacted the Hopkins research team to form a partnership between the team
- **Funding**
 - Through grant from the Agency for Healthcare Research and Quality
 - One of the insurers in Michigan also provided support

7: Methods: Study Objectives

- **Primary study hypothesis:**
 - Rate of catheter-related bloodstream infection would be reduced during the first 3 months after implementation of the study intervention as compared with baseline
- **Secondary hypothesis:**
 - Observed decrease in the rate of infection between 0 and 3 months after implementation of the study intervention would be sustained during the subsequent observation period

8: Methods: Study Design

- **Design: prospective intervention study**
 - An evidence-based intervention used to reduce the incidence of catheter-related bloodstream infections
 - Multilevel Poisson regression modeling used to compare infection rates before, during, and up to 18 months after implementation of the study intervention

9: Methods: Study population and setting

- **Setting: all hospitals in Michigan, USA with adult ICUs**
 - 108 ICUs in 67 hospitals participated (52% were teaching facilities)
 - Of the 108 participating ICUs, 5 were excluded
 - Types of ICUs included medical, surgical, cardiac, medical or surgical, neurologic, and surgical trauma units and a pediatric unit
- **Population: ICUs represented 85% (1625 beds) of all ICU beds in Michigan**
 - 103 ICUs reported data for 1981 ICU-months
 - 375,757 catheter-days included in the final analysis

10: Methods: Intervention

- **Intervention targeted clinicians' use of five evidence-based procedures:**
 - Hand washing
 - Full-barrier precautions during insertion
 - Cleaning the skin with chlorhexidine
 - Avoiding the femoral site if possible
 - Removing unnecessary catheters
- **These procedures identified as having the greatest effect on rate of CRBSI and lowest barriers to implementation**

11: Methods: Procedures

- Between March 2004 and September 2005, each ICU implemented several patient-safety interventions and monitored their effects on specific safety measures
- In addition to the intervention to reduce the rate of catheter-related bloodstream infection, the ICUs implemented the use of:
 - A daily goals sheet to improve clinician-to-clinician communication within the ICU
 - An intervention to reduce the incidence of ventilator-associated pneumonia
 - A comprehensive unit-based safety program to improve the safety culture

12: Methods: Data Analysis and Interpretation

- **Medians and interquartile ranges used to summarize the data**
 - Medians compared with baseline values (two-sample Wilcoxon rank-sum test)
- **Measured the exposure-outcome relationship**
 - Quarterly number of catheter-related bloodstream infections (generalized linear latent and mixed model with Poisson distribution)
- **Two-level random effects to account for nested clustering within the data:**
 - Catheter-related bloodstream infections within hospitals
 - Hospitals within the geographic regions included in the study

13: Results: Key Findings

- Both the median and mean rate of catheter-related bloodstream infection per 1000 catheter-days decreased significantly
 - Median rate:** decreased from 2.7 infections at baseline to 0 at 3 months after implementation of the study intervention
 - Mean rate:** decreased from 7.7 at baseline to 1.4 at 16 to 18 months

Table 3. Rates of Catheter-Related Bloodstream Infection from Baseline (before Implementation of the Study Intervention) to 18 Months of Follow-up.*

Study Period	No. of ICUs	No. of Bloodstream Infections per 1000 Catheter-Days				
		Overall	Teaching Hospital	Nonteaching Hospital	<200 Beds	≥200 Beds
			<i>median (interquartile range)</i>			
Baseline	55	2.7 (0.6–4.8)	2.7 (1.3–4.7)	2.6 (0–4.9)	2.1 (0–3.0)	2.7 (1.3–4.8)
During implementation	96	1.6 (0–4.4)†	1.7 (0–4.5)	0 (0–3.5)	0 (0–5.8)	1.7 (0–4.3)†
After implementation						
0–3 mo	96	0 (0–3.0)‡	1.3 (0–3.1)†	0 (0–1.6)†	0 (0–2.7)	1.1 (0–3.1)‡
4–6 mo	96	0 (0–2.7)‡	1.1 (0–3.6)†	0 (0–0)‡	0 (0–0)†	0 (0–3.2)‡
7–9 mo	95	0 (0–2.1)‡	0.8 (0–2.4)‡	0 (0–0)‡	0 (0–0)†	0 (0–2.2)‡
10–12 mo	90	0 (0–1.9)‡	0 (0–2.3)‡	0 (0–1.5)‡	0 (0–0)†	0.2 (0–2.3)‡
13–15 mo	85	0 (0–1.6)‡	0 (0–2.2)‡	0 (0–0)‡	0 (0–0)†	0 (0–2.0)‡
16–18 mo	70	0 (0–2.4)‡	0 (0–2.7)‡	0 (0–1.2)†	0 (0–0)†	0 (0–2.6)‡

14: Results: Incidence Ratios

Table 4. Incidence-Rate Ratios for Catheter-Related Bloodstream Infections.*

Variable	Incidence-Rate Ratio (95% CI)	P Value
Study period		
Baseline	1.00	
During implementation	0.76 (0.57–1.01)	0.063
After implementation		
0–3 mo	0.62 (0.47–0.81)	0.001
4–6 mo	0.56 (0.38–0.84)	0.005
7–9 mo	0.47 (0.34–0.65)	<0.001
10–12 mo	0.42 (0.28–0.63)	<0.001
13–15 mo	0.37 (0.20–0.68)	0.001
16–18 mo	0.34 (0.23–0.50)	<0.001
Teaching hospital	1.34 (0.73–2.46)	0.35
Bed size (per 100 beds)	1.03 (0.97–1.09)	0.33

* Incidence-rate ratios were calculated with the use of a generalized linear latent and mixed model (Rabe-Hesketh and Skrondal¹⁸), with robust variance estimation and random effects to account for clustering of catheter-related bloodstream infections within hospitals and clustering of hospitals within geographic regions. Rates of catheter-related bloodstream infection during and after implementation of the study intervention were compared with baseline (preimplementation) values, adjusted for the hospital's teaching status and number of beds.

- Regression model showed a significant decrease in infection rates from baseline
- Incidence-rate ratios continuously decreased:
 - From 0.62 at 0 to 3 months after implementation of intervention
 - To 0.34 at 16 to 18 months

15: Conclusion: Main Points

- **A large-scale project focused on reducing the incidence of catheter related bloodstream infection is feasible and can have important public health consequences**
 - **Evidence-based intervention resulted in a large and sustained reduction (up to 66%) in catheter-related bloodstream infections**
 - **Reduction maintained throughout the 18-month study period**

16: Conclusion: Discussion

- **Translating evidence into practice is a three step process:**
 - 1. Develop the intervention and evaluation, which includes:**
 - Understanding evidence and converting the evidence into checklists,
 - Understanding barriers to implementing the evidence (including local context),
 - Developing measures to evaluate whether safety actually improved
 - 2. Pilot test the interventions and evaluation tools in a sample of hospitals to better understand local context**
 - 3. Package the program and broadly implement it in a country**

17: Conclusion: Study Impact

- **Academic impact**

- *"The implications for academia were profound.*
- *In general, academia has not viewed the delivery of care as science. As such patient safety research did not have credibility as a legitimate science and was not a robust path for promotion.*
- *This study changed that. It demonstrated that you can do scholarly quality improvement work that has profound impact on patients.*
- *This type of research is very applied and as such must find the balance between feasibility and scientific validity. That is, where the art of patient safety research lies."*

18: Conclusion: Study Impact (2)

■ Policy impact

- *"The policy impact was also profound. It lead to national efforts and global efforts to reduce these infections.*
- *Because of the rigor with which the study was conducted, physicians believed the results and sought to replicate it. Policy makers (given the great return on investment) sough to replicate.*
- *We are currently implementing the program throughout the U.S and in several countries."*

■ Patient impact

- *Estimated that the intervention saved about 1800 lives and \$200,000 in Michigan annually.*
- *"Although these estimates likely contain some error, they demonstrate the substantial potential for well designed quality improvement programs to reduce preventable death and costs."*

19: Conclusion: Study Impact (3)

■ Practice impact

- *"We often hear that doctors resist quality improvement and patient safety efforts... While this may be true to some extent, much of the resistance is likely because the science of many quality improvement projects was sloppy.*
- *We found that when you use evidence-based intervention and provide robust evaluation that physician believe are valid they embrace quality improvement program.*
- *Indeed, we have created a hunger for quality and safety among MI physicians. They are asking what is the next program.*
- *The research community (and funders) need to ensure that we have a robust pipeline of quality program. It is neither efficient nor effective to develop these programs individually."*

20: Conclusion: Practical Considerations

- **Study duration**
 - Approximately two years
- **Cost**
 - Received about \$400,000 per year for two years, half of which went to Michigan to coordinate the program
- **Research team included:**
 - Clinical and methodological experts, project managers, database designers, research assistants and statisticians
 - Since intervention also sought to improve culture, team also included experts in psychology
- **Required expertise:**
 - Clinical medicine (ICU and infectious diseases), study design and measurement, data quality control, quality improvement, leadership, leading changes, project management and data analysis and measurement

21: Author Reflections: Lessons and Advice

- **If you could do one thing differently in this study, what would it be?**
 - *"Begin the data quality control program earlier. This would include training data collectors in the measures, auditing their performance, creating a data base automated data checks, and correct missing or biased data in real time.*
 - *We found that the research team should develop the technical program (evidence and measures) while local leaders do the adaptive (culture change) work and determine how to implement the evidence given the local context and resources."*

22: Author Reflections: Selecting Design

- **Alternative designs considered:**
 - *"We originally planned on doing a cluster randomized step wedge design. However, none of the participating hospital teams wanted to be randomized to the control group, so we adopted a time series design."*
- **Most of the debate about quality improvement research has focused on study design**
 - Yet design only influences selection bias, it does nothing for measurement or analytic bias
- **Regardless of design, important to reduce measurement error**
 - *"Our general philosophy is to reduce quantity but not quality of the data."*
- **Minimal trade-offs between randomized design vs. time series**
 - Because study included all ICU in the state and all patients in these ICUs, less concerned about selection bias

23: Author Reflections: Overcoming Barriers

- **What barriers or problematic issues did you encounter when setting up your research and how did you overcome these?**
 - *"The biggest problem was data quality control. We did not have resources to support data collection at each participating hospital. All the data collection was voluntary staff."*
 - *When we first started the program, we had about 70% missing data. We quickly implemented a robust data quality control program and reduce missing data to 10%.*
 - *...Measurement bias is a substantial problem in quality improvement studies. Robust data quality control program are essential to making accurate inferences regarding whether quality actually improved."*

24: Author Reflections: Developing Countries

- **Would this research be feasible and applicable in developing countries?**
 - *"WHO could provide technical support (evidence and measures) and developing countries could say how do they implement given their resources and culture.*
 - *It is critical to pilot test these programs in developing countries prior to broad implementation. For example we work with health ministers to agree to pilot test the program in a small number of hospitals lead by local leaders. If successful, the minister then implements throughout the country."*

25: Author Reflections: Developing Countries (2)

- **What message do you have for future researchers from developing countries?**
 - *"Make the technical program ruthlessly simple and obtain first hand data of local context."*
- **What would be an important research project you recommend that they do?**
 - *"Developing countries need to prioritize where to focus there resources. CRBSI may not be the program."*
 - *"One challenge is that in most developing countries, the hospitals vary from very modern to incredibly poor. This makes it difficult to meet all stakeholders needs."*

26: Additional References

- www.safetyresearch.jhu.edu