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Fifteen years after *To Err is Human*: a success story to learn from

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Preventable harm is a major cause of preventable death worldwide. In late 1999, the Institute of Medicine (IOM) released To *Err is Human*,[1] a report that riveted the world's attention to between 44 000 and 98 000 patient deaths annually in the USA from medical errors. Progress towards reducing these harms has proven difficult because healthcare lacks robust mechanisms to routinely measure the problem and estimates of the magnitude vary widely. It is hard to gauge safety when healthcare uses multiple different measures for the same harm and provides limited investment in measurement, implementation and applied sciences.

Central line-associated bloodstream infection (CLABSI) provides a notable exception and case study for learning. Over the past 15 years, through the combined and coordinated efforts of many, these infections have been reduced over 80% in intensive care units (ICU), decreasing patient mortality.[2] In this essay, we reflect on the journey in preventing these infections and explore how this success can inform and accelerate efforts to reduce other types of preventable harm.

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While this paper is a synthesis of past work, what is novel is providing the historical profile of CLABSI, comparing infection rates before and 15 years after the IOM report and offering new insights into what led to the substantial reductions in infections. The journey began in the 1970s when the Centers for Disease Control and Prevention (CDC) began collecting data on ICU CLABSIs. Over the next several decades, the CDC published data on national benchmarks for CLABSI, investigated bloodstream infection outbreaks and published the first Guideline for the Prevention of Intravascular Catheter-Related Infections in 1991. These early efforts brought little change in ICU CLABSI rates throughout the 1990s, with clinicians and policy makers believing infections were inevitable.

Over the last decade, ICU CLABSI rates have dropped throughout the USA (table 1) and today these infections are considered largely preventable. The attitude change, spurred by examples of preventable infections and experiences at the frontlines of care in substantially reducing CLABSIs, contributed to the drop in bloodstream infection rates. Although many groups and efforts contributed to this reduction and it is difficult to dissect the independent contribution of these and other factors, we believe five elements were essential to the national success in reducing CLABSI rates. We arrived at these five elements through discussion and reflection on our collective experience, theory and the published literature.[3–8]

RELIABLE AND VALID MEASUREMENT SYSTEM

First, the CDC created a valid and reliable measure for CLABSI and implemented a mechanism to broadly collect and report these data through the National Healthcare Safety Network (NHSN).[9] Surveillance definitions and methodologies represent best available evidence and were developed with extensive input from diverse stakeholders, revising the measures as new data emerged. In addition to collecting accurate events (numerator data), the NHSN also collects information to help risk-adjust CLABSI rates so hospitals can make valid comparisons of their progress to other facilities. This includes a focus on denominator data (central line days) to identify the population most at-risk for the event. The CDC developed a summary measure, called the standardised infection ratio, which allows facilities to summarise their CLABSI experience across different unit types.

This collaborative evidence-based approach to measurement created confidence in the definitions and methods, improving data use by clinicians, and prompting health system boards, employers, patient advocates and policy makers to hold clinicians accountable for CLABSI rates. A unit, hospital, health system, state or the nation can benchmark to other organisations. A potent feature of CLABSI surveillance is the use of a common measure, evolved over time, based on clinical evidence, by hospitals for quality improvement and by policy makers to monitor progress, to publicly report performance and to link payment to quality improvement. Global efforts to reduce CLABSI demonstrated that countries with existing mechanisms to measure CLABSI[10] seemed to have more robust measurement systems than countries that created de novo mechanisms.[11]

EVIDENCE-BASED CARE PRACTICES

Second, outbreak investigations and research funded by the National Institutes of Health (NIH) and the CDC identified important causes of CLABSIs that informed practice guidelines, outlining effective strategies to reduce these infections. These evidence-based recommendations formed the foundation for subsequent checklists that have proven essential in CLABSI reductions.[12]

INVESTMENT IN IMPLEMENTATION SCIENCES

Third, the federal government, through the CDC and the Agency for Healthcare Research and Quality (AHRQ), and private philanthropy created an enabling infrastructure and advanced implementation science to reduce CLABSI. To help prove the concept of CLABSI prevention, Pittsburgh hospitals participated in a CDC collaborative starting in 2001, reducing infections in ICUs by 68% over 4 years.[13] In 2003, researchers from the Johns Hopkins University implemented an AHRQ-funded collaborative throughout Michigan and decreased ICU CLABSIs 66% within 18 months.[12]

The Michigan collaborative was a turning point in the CLABSI reduction journey. The intervention in this initiative was multifaceted and novel because it included technical components, such as a checklist, and adaptive components to change culture in an organisation.[14] The adaptive intervention included the Comprehensive Unit-based Safety Program (CUSP), a unit-level intervention designed to train frontline staff to recognise hazards and make care safer and improve safety culture, teamwork and communication combined with a focused checklist of five prevention practices proven to reduce CLABSI.[15] CUSP was implemented in units before the CLABSI checklist intervention and safety culture improved in the first year of the collaborative,[15] with further and sustained improvements demonstrated.[16] In an ex post theory, components of the CUSP intervention were linked to the Michigan collaborative's success.[14] Moreover, an analysis of the Michigan data demonstrated that the CUSP intervention was as potent as the central line insertion checklist in reducing CLABSI. In addition, when Spain launched *Zero Bacteremia*, their initiative to reduce CLABSI, they bypassed CUSP and focused only on the checklist but improvement stalled; when they implemented CUSP CLABSIs declined.[10] To further build support, researchers associated reductions in CLABSI with fewer deaths,[17] and cost savings for hospitals, insurers[18] and the Centers for Medicare and Medicaid Services (CMS).[19]

Because these prior studies were observational, lacked a concurrent control group and could not establish causality, the Johns Hopkins team conducted a cluster randomised trial in the Adventist health system, reducing CLABSI by 70% in the intervention group and only by 21% in the control group.[20] These projects demonstrated the importance of conducting studies with concurrent controls and with a randomised design to account for secular trends.[21,22] These studies also demonstrated that CLABSI prevention was possible on a large scale, changing norms about preventability and building support for a national infrastructure to promote prevention. Informed by the Michigan initiative, other groups, such as professional societies, state health departments and hospital associations, the Institute for Healthcare

Improvement and The Joint Commission, embarked on efforts to reduce CLABSI. Moreover, the Michigan effort prompted support from AHRQ to spread the CUSP for CLABSI programme state by state across the country, partnering with state hospital associations, further reducing CLABSI rates by 43%.[23] In addition, the CUSP-CLABSI programme was associated with a significant reduction in CLABSI rates in Spain[10] and the United Arab Emirates.[24]

In 2009, the American Recovery and Reinvestment Act began funding all state health departments to initiate and bolster state-based efforts to prevent healthcare-acquired infections (HAIs). States used part of these funds to congregate relevant stakeholders to work on preventing HAIs, starting with CLABSIs.

LOCAL OWNERSHIP AND PEER LEARNING COMMUNITIES

Fourth, clinicians led the work to reduce CLABSI and created clinical communities in which peer hospitals learned from each other.[6] These communities were powerful vehicles in changing peer norms from infections are inevitable to infections are preventable and 'I' can do something about it. The power of peer communities comes from peer learning and tapping into intrinsic motivation among professionals.[725]

ALIGN AND SYNERGIZE EFFORTS AROUND A COMMON GOAL AND MEASURES

Finally, policy makers, clinicians and researchers coordinated and aligned CLABSI reduction efforts. The Department of Health and Human Services worked with patient and professional organisations on realistic yet ambitious goals to reduce HAIs and issued the National Action Plan to Prevent Healthcare-Associated Infections in 2009. Patient advocacy groups promoted prevention and transparency of CLABSI rates, stimulating hospital leaders to engage in prevention efforts, spurring state and federal policy initiatives to report and reduce CLABSIs. A national 5-year CLABSI prevention goal was set at 50% for 2009–2013. Congress incorporated the national HAI Action Plan into Value-Based Purchasing as part of the Affordable Care Act, creating a powerful incentive for prevention. In 2011, CMS started reporting ICU CLABSI data submitted to their Inpatient Quality Reporting Program on their Hospital Compare website. While these CLABSI rates are used in pay for reporting rather than pay for quality, CMS has financial penalties for CLABSI measured using billing data in its Hospital-acquired Condition Program. Nonetheless, intrinsic rewards rather than extrinsic penalties, such as pay for performance, appear to be a more potent motivator to power improvement.[26–28]

The journey to reduce CLABSIs aligned multiple stakeholders around a common goal, and each played a role in achieving this goal. We distilled this journey into a five-phase framework that could be applied to other types of harm (box 1). This framework offers a mechanism for evaluating individual types of harm at a time rather than multiple harms.

Of course, the challenge is that patients are at risk of suffering more than one harm, in some cases over a dozen harms. Conceptually, our framework would work for multiple harms except the implementation phase would require a different approach. For example, if a checklist of prevention practices were used for each harm, the list could become unruly given the number of tasks required and the need to perform many of these tasks multiple times per day. It would be unfeasible to expect clinicians to follow this long checklist without some visual display showing whether patients received these tasks. Electronic health records do not provide this display. Nonetheless, our research team at Johns Hopkins is using a systems engineering approach to build a complex information technology system to reduce multiple harms.[29] This engineering approach is based on a concept of operations, seeking to predict who is at risk for each harm, recommend evidenced-based therapies for these harms, display whether patients received those therapies, and monitor and learn how patients did.

Aside from HAIs, healthcare lacks valid, scalable and transparent measures (widely adopted at the hospital level) for most types of harms. Fifteen years after *To Err is Human*, the reduction in CLABSI is a success story that could inform other harm reduction efforts. We took a novel approach and chronicled this story, reported new data comparing national infection rates from the 1990s with rates in 2013 and provided our insights of what components led to this success. It is our hope that the next 15 years will see dramatic reductions in many of the preventable harms that we continue to battle.

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Box 1

Phases of framework to reduce preventable harm

One: Create valid and transparent measures and scalable mechanisms to collect and report performance for any level, from an individual unit up to an entire country.

Two: Mature the basic and clinical science to understand the harm pathogenesis.

Identify clinical therapies to prevent the harm.

Three: Advance implementation science by combining the clinical therapies with a culture and practice change intervention to eliminate the harm.

Build an infrastructure to apply and manage those interventions.

Four: Engage clinicians and connect them in clinical communities to support peer learning and tap into intrinsic motivation of clinicians through professional norms.

Five: Align and synergize policy efforts around common goals and measures.

Accelerate change through intrinsic motivation and exercise caution when using extrinsic motivation through public reporting and pay for quality.

Table 1

Central line-associated bloodstream infection rates in intensive care units*

Unit type	NNIS system 1992–1999	NHSN system 2013
Medical	6.1†	1.1 (not major teaching) 1.2 (major teaching)
Medical/surgical (major teaching)	6.0	1.1
Medical/surgical (not major teaching)	4.1	0.8
Paediatric	7.9†	0.8 (medical) 1.2 (medical/surgical)
Surgical	5.6†	0.9 (not major teaching) 1.1 (major teaching)

*Data are from intensive care units reporting to the Centers for Disease Control and Prevention databases: NNIS for 1991–1999 and NHSN for 2013; rate reported is number of infections per 1000 central line days.

†Stratified data are not available for this time period.

NHSN, National Healthcare Safety Network; NNIS, National Nosocomial Infection Surveillance.