

Reduce Infections Together in Everyone: A Concept and a Hospital Program

Pranavi V. Sreeramoju, MD MPH

UT Southwestern Internal Medicine Grand Rounds

September 7, 2018

This is to acknowledge that Pranavi V. Sreeramoju has disclosed that she does not have any financial interest or other relationships with commercial concerns related directly or indirectly to this program. Dr. Sreeramoju will not be discussing off-label uses in her presentation.

Pranavi V. Sreeramoju, MD, MPH, FIDSA, FSHEA
Associate Professor, Internal Medicine-Infectious Diseases and Geographic Medicine
UT Southwestern Medical Center, Dallas, TX

Dr. Sreeramoju is recognized as a subject matter expert in healthcare-associated infections and the intersection between the fields of quality improvement, patient safety and healthcare epidemiology. She has been a healthcare epidemiologist in the UT System for thirteen years and currently serves as Chief of Infection Prevention for the Parkland Health and Hospital System. This year, she is pursuing her interest in the business of medicine by enrolling in an MBA program at UT Dallas and took on an additional role as Medical Director Clinical Liaison with Finance in the UTSW Health System. She was awarded Junior Faculty Researcher of the Year in Internal Medicine in 2007 at UT Health San Antonio, and Teacher of the Year in Infectious Diseases in 2011 at UTSW. She has been named as one of the ‘Top 50 leaders in Patient Safety in 2015’ by Becker’s Hospital Review and she is the recipient of Judene Bartley Award for Public Policy and Advocacy in 2015 jointly awarded by the Society of Healthcare Epidemiology of America and the Association for Professionals in Infection Control and Epidemiology. Her research has been published in several infectious diseases journals. She is an active blogger (www.pranavimd.com). She obtained her MD from Jawaharlal Institute in Puducherry, India and MPH in Epidemiology from Tulane University in New Orleans, USA. She completed her Internal Medicine residency training in Cook County Health and Hospitals System and Kaiser Permanente Oakland Medical Center, and Infectious Diseases fellowship training in University of Illinois and University of Chicago.

Purpose and Overview

The purpose of this session is to understand the role of socioadaptive approaches in preventing healthcare-associated infections and learn the different types of approaches that have been tried thus far. The results of a study on positive deviance and a hospital-wide program to reduce healthcare-associated infections and sepsis mortality are presented within the context of local secular trends.

Educational Objectives:

At the conclusion of this lecture, the listener should be able:

1. To understand the importance of adding socioadaptive interventions to technical interventions in order to reduce healthcare-associated infections ‘together’
2. To learn the principles of choosing the right socioadaptive intervention for a given context and situation
3. To learn about positive deviance as a socioadaptive approach
4. To briefly describe the Parkland program, Reduce Infections Together in Everyone

Healthcare-associated infections (HAI) continue to be a public health burden, in spite of acceleration of efforts to reduce the burden since publication of ‘Crossing the Quality Chasm’ by the Institute of Medicine.¹ Four percent of hospitalized patients were estimated to have developed an HAI during their hospital stay in 2011 in the United States, with estimated annual occurrence of over 721,000 HAI.² These infections cost the U.S. economy over ten billion dollars in excess healthcare costs.^{3,4} Significant progress has been made over the years, with the proportion of hospitalized patients who develop HAI dropping to 3.2% in 2015.⁵ Per the Centers for Diseases Control and Prevention that oversees surveillance of these infections through the National Health Safety Network,⁶ central line associated bloodstream infections (CLABSI) have reduced by 40%, catheter-associated urinary tract infections (CAUTI) by 46%, surgical site infections (SSI) after ten procedures by 18%, hospital-onset methicillin-resistant *Staphylococcus aureus* (MRSA) by 9% and hospital-onset *Clostridium difficile* infection (CDI) by 15%, over a span of ten years from 2006 to 2016.⁷

Although several evidence-based best practices to reduce HAI exist, reducing HAI often requires the use of practices beyond known best practices.⁸ Both technical solutions like making alcohol hand sanitizer and hand washing sinks available, making central line insertion kits available, and adaptive solutions like programs to engage clinicians and address social and cultural norms of clinical practice, are necessary. A national collaborative of regional HAI programs⁹ identified several social and adaptive challenges encountered by clinicians engaged in improvement initiatives, including initial resistance from several layers of the organization and the need to understand it in order to foster change, and challenges related to frontline staff engagement and empowerment. Because of studies like this, there is increasing recognition for HAI as a sociotechnical problem, in the current decade. This review is for modern day physicians and physicians-in-training who are expected to participate in interventions to reduce HAI, and for those who serve as physician champions or even lead these initiatives, so that they gain a better understanding of socioadaptive approaches that help reduce these infections. Several principles and practices described in this review are also helpful for application in healthcare improvement initiatives not related to infection prevention.

The need for adaptation of an intervention to local social and cultural context is not new in the history of infection prevention. The most important lessons come from the experiences of Ignaz Semmelweis in 1847,¹⁰ and Florence Nightingale in 1855,¹¹ and the contrasting experiences they have had. Both Semmelweis and Nightingale made astute observations that the patient outcomes might potentially altered by changing certain care practices. While Semmelweis introduced and advocated for the practice of hand washing to reduce mortality in postpartum women, Nightingale introduced the idea of better wound care and nursing to reduce mortality among wounded soldiers in the Crimean War. They both collected and analyzed data diligently, and gave feedback with relevant data and interpretation to peers and superiors. Both of them met with initial resistance, but the subsequent course of the two ‘improvement initiatives’ diverged, with Semmelweis losing to the scientific establishment of his time, whereas Nightingale went on to convince the British Army leadership to accept her ideas and had many decades of successful work that subsequently laid the foundation of modern nursing. Their contrasting experiences illustrate the importance of scientific context (germ theory was not known at that time) for change and a deeper social context for change (the physicians during Semmelweis’s time were offended that a recommendation to wash hands implied that their hands were ‘dirty’), although on the surface, the differences in their personalities and leadership styles may have played a role.

Improvements in healthcare like reduction of HAI require multimodal interventions. While some situations (e.g., need to establish data infrastructures) may not need widespread support and the addition of socioadaptive interventions, situations that require widespread participation (e.g., hand hygiene, healthcare personnel vaccination, isolation precautions for patients) do require the use of socioadaptive interventions. These interventions help empower teams, address implementation challenges, offer solutions to overcome barriers, promote safety culture, team building, and leadership, promote engagement, promote understanding of the technical components to the end-users, allow translation of technical components into practice, and permit modifications to fit local culture, population, and work flow.^{12,13} They are different from structured educational interventions in that they are much more interactive and promote active learning. They do not substitute the need for science-based technical approaches or the need for proper workplace design and infrastructures that enable infection prevention to occur in healthcare facilities.

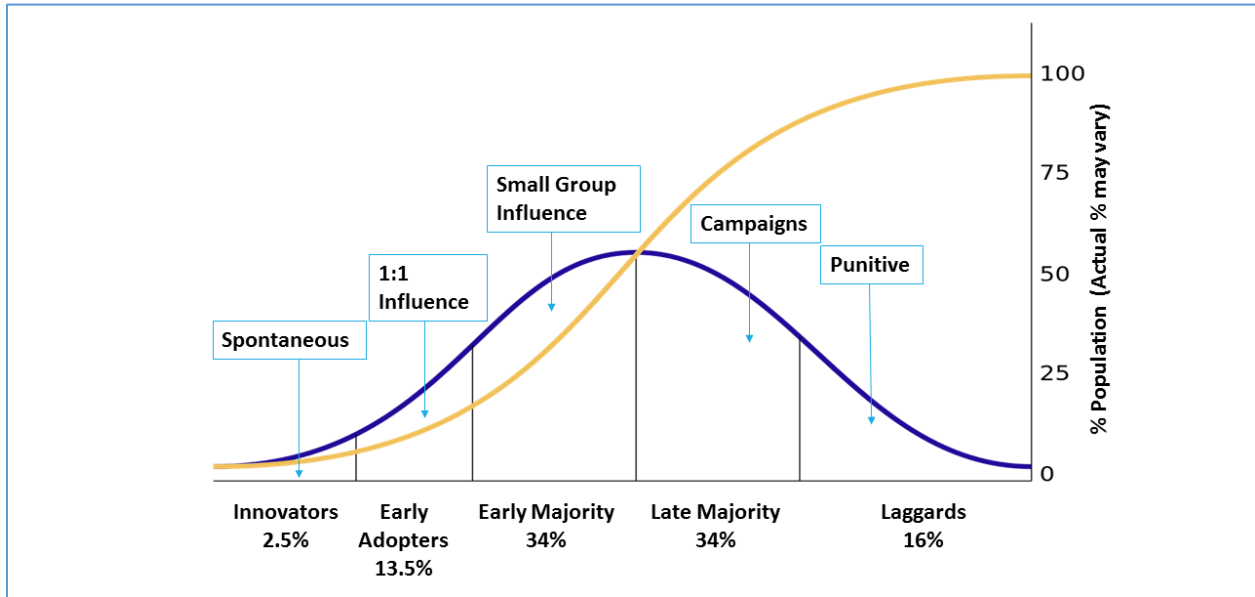
Factors Affecting Clinician Behavior

While no clinician is expected to intentionally use poor infection prevention practices, he or she may encounter barriers at different levels, at the level of patient, at the level of peer clinicians, multidisciplinary healthcare team, healthcare system or the broader environment, during routine clinical practice. Several predictors of human behavior have been studied in literature,¹⁴ such as knowledge, motivation, intention, outcome expectancy, perceived threat, and prevailing norms with regards to the use of infection prevention practices. Several theories have been studied as well.¹⁵ Cognitive theories suggest lack of knowledge of consequences for poor infection prevention practices. Adult learning theories suggest that the clinicians need to have first-hand experiences of complications. Behavioral theories suggest influences of feedback, incentives and role modeling. Social influence theories suggest that peer pressure has an impact. Marketing theories suggest that there is insufficient messaging in the clinical practice environment. Lastly, organizational theories suggest that poor practices are because of poor organization of processes in the healthcare system. Implementing behavior change interventions may need to take into account several of these theories, although one is not expected to learn about each one of these theories.

Principles of Social Change Among Clinicians Based on Diffusion of Innovations Theory

The principles of diffusion of innovations theory^{16,17} are helpful to understand how a new practice or ‘change’ spreads within an organization or a community of practice. These principles in turn help a physician champion or leader responsible for an improvement initiative to choose appropriate methods to help recruit clinicians to participate in intended change. (See Figure 1) Innovators are the initial ~2.5% of people who are the origin of the new idea for change and they do not need any ‘recruitment.’ Early adopters who make up about 13.5% of the organization are the next to follow, and they are best recruited through word of mouth and 1:1 conversations. The early majority (~34%) are recruited through small group discussions, meetings, and special interest groups. The late majority (~34%) are recruited through campaigns, and the laggards (~16%) need disciplinary measures to participate in intended change.

Figure 1: Influencing Different Groups Based on Diffusion of Innovations Theory



Assessments to be Made Prior to Choosing a Socioadaptive Intervention

Before embarking on an improvement initiative, the first assessment that needs to be made is whether social adaptation of the intervention is necessary at all. Once it is determined that socioadaptive intervention is a necessary part of the improvement initiative, the next assessment must be to gain an approximate idea of how much buy-in there is already among the intended participants in change. For example, if an initiative has the early majority on board already, and needs the late majority to be recruited to ensure success of the initiative, implementing disciplinary measures may not be appropriate and may potentially have adverse consequences. Other assessments to be made include the overall organizational context, existing state of conversations and relationships among the intended participants.

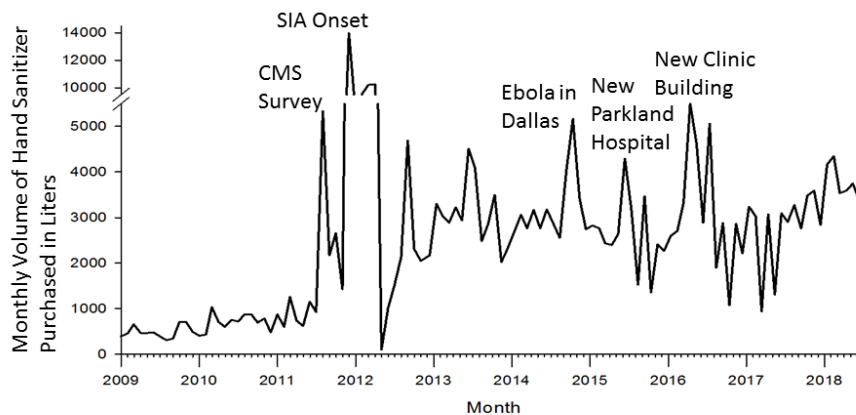
Role of Overall Organizational Context

It is important to gain some idea of the overall organizational context at the time of participating in or leading an improvement initiative. Context helps explain secular trends in outcomes. Don Berwick, a renowned expert in healthcare quality, is a proponent of the Context-Methods-Observation model for describing quality improvement initiatives.¹⁸

For example, at Parkland Health and Hospital System, the overarching context for initiatives to improve quality and patient safety in last seven years was the Systems Improvement Agreement (September 2011 to July 2013)¹⁹ and the Quality Review Organization/ Corporate Integrity Agreement (June 2013 to May 2018)²⁰ with the Centers for Medicare and Medicaid Services. Hand hygiene improvement initiatives were aggressively implemented during this time period. Because all clinicians need to practice hand hygiene during clinical care, and the early majority were already practising hand hygiene, the organizational need was to recruit the late majority and the laggards to practice hand hygiene. To accomplish this, both campaigns and accountability measures were utilized.

Figure 2. Volume of hand sanitizer purchased per month at Parkland Health and Hospital System

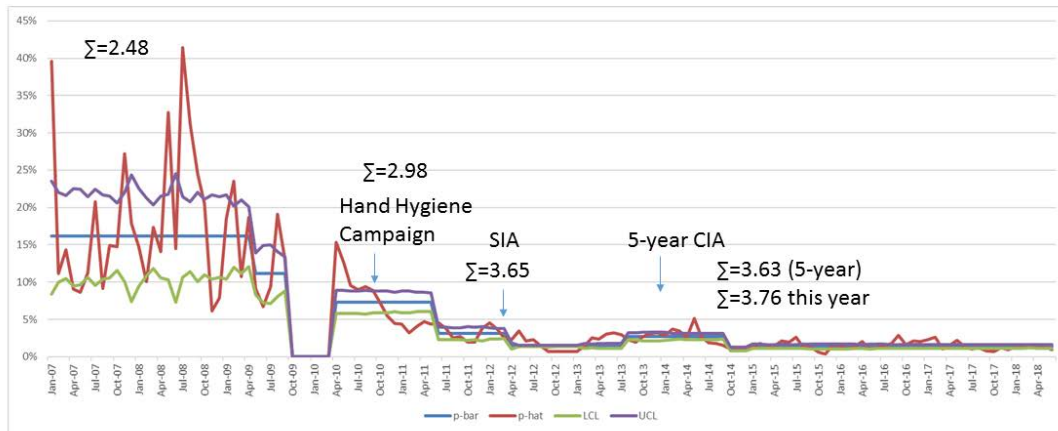
[Labels describe events during some of the spikes in purchased volume]



Data: Deborah Brooks; Graph Assistance: Robert Haley, MD

Figure 3. Percent Non-Compliance with Hand Hygiene at Parkland Health and Hospital System

[p-bar: Average % non-compliance during the period; p-hat: % non-compliance per month; LCL: lower confidence limit; UCL: upper confidence limit]



The amount of non-compliance with hand hygiene guidelines reduced as a result of these improvement initiatives. It is important to note the Sigma level, Σ , which is a measure of reliability (consistency) of practice. While this is in part, dependent on the number of hand hygiene measurements (observations) per month, it is important to note the pace of change. Achieving high reliability of practice takes persistent effort. The highest sigma level that can be achieved for any quality improvement is 6, which is the hallmark of a high reliability organization. Sigma levels close to six are seen in the airline industry, anaesthesiology and blood banking.

Role of Conversations

Suchman²¹ proposes conceptualizing an organization as a set of conversations. This model, he argues, allows the change leader to think of organizational change as something that requires mindful participation instead of having an unrealistic expectation of control. There are patterns to what healthcare personnel are saying and thinking and how people are interacting. Through several iterations and reciprocal interactions, very small changes can amplify and spread. Diversity of thought, he argues, needs to be accompanied by responsiveness to change or else,

people may hold rigidly to certain thought patterns and practices and the change initiative may fail. By influencing the nature of conversations, change is allowed to occur in organizations. Jordan and colleagues²² propose that conversations that are informal and unplanned as healthcare personnel go about their daily work, have an important role in shaping healthcare interventions, and have the ability to facilitate or block the success of an intervention.

Effective leadership and teamwork processes need to promote healthy productive conversations among frontline personnel and also make it safe for personnel to speak up. In one study, implementation of leadership rounds led to frontline staff engagement, fostered open problem-solving and reduced barriers to implementation and subsequently²³ led to measurable reduction in healthcare-associated infections. Psychological safety is built through framing the work as a learning situation, acknowledging that mistakes can happen, and modeling curiosity. Psychological safety and learning climate have been shown to be positively associated with patient safety.

Role of Relationships

Relationships among healthcare personnel are important for ongoing learning, sensemaking and improvisation. If one takes this approach, one could view adopters of change in healthcare organizations as active transformers of ideas and plans as opposed to passive receivers of interventions. For relationships to be effective in clinical practice, they need to be characterized by trust, mindfulness, sensitivity to the task on hand, and respect.²⁴ Because preexisting relationships can be a barrier or a facilitator of intervention attempts, those leading change must determine whether the relationships are conducive to productive conversation.

Relational coordination is a concept that is well studied in airline industry and it is an emerging concept in healthcare. Jodi Gittel and her colleagues²⁵ found in their research that there are seven aspects of relationships between team members that predicted positive outcomes. They showed that a relational coordination score which is an aggregate of measurements on 1) timeliness, (2) accuracy, (3) frequency, and (4) problem-solving nature of communication; and (5) respect, (6) goals, and (7) knowledge shared with team members strongly predicted fewer

passenger complaints, fewer late arrivals and fewer baggage handling errors. They repeated their work in different settings like knee replacement surgery and found that the results are reproducible. In one study related to HAI,²⁶ however, RC scores were not different between hospital units with high or low rates of device-associated infections. This lack of effect may be due to study limitations or due to lack of sufficient interdependence between the healthcare personnel to accomplish the task of catheter care (as in, each clinician does the right practice independently of another clinician).

Types of Socioadaptive Approaches Used to Reduce Healthcare-Associated Infections

This decade has seen increased development and application of socioadaptive approaches to reduce healthcare-associated infections. There is a need for further research in this area. Some approaches that have been tried thus far are described below.

Comprehensive Unit-based Safety Program

Comprehensive unit-based safety program (CUSP) is the leading socioadaptive approach currently and has had increasing adoption in healthcare facilities during this decade. The components of CUSP are educating healthcare personnel on science of safety, identifying defects, engaging executives, having multidisciplinary conversations on learning from defects and implementing teamwork tools. The questions that guide learning from defects are: What happened? Why did it happen? What will we do to reduce the risk of recurrence? How will we know the risk is reduced?

Several studies have demonstrated the effectiveness of CUSP as an addition to the technical bundle of strategies to reduce device-associated infections. Berenholtz and colleagues²⁷ reported improvements in CLABSI rates in 1,071 ICUs from 44 states in the US, which participated in the national collaborative cohort study, “On the CUSP: Stop BSI” sponsored by the Agency for Healthcare Research and Quality (AHRQ). Through implementation of central line bundle that includes hand hygiene, use of chlorhexidine skin preparation, full barrier drape over the patient, sterile attire by the person placing the central line and daily review of necessity, along with the

socioadaptive bundle, CUSP, the CLABSI rate in these ICUs decreased significantly from 1.96 to 1.15 per 1000 catheter-days at 16-18 months after implementation. Sanjay Saint and colleagues²⁸ implemented CUSP along with urinary catheter bundle to reduce CAUTI in 926 hospital units (60% wards, 40% ICUs) nationally through a similar program sponsored by the AHRQ, “On the CUSP: Stop CAUTI” and demonstrated significant reduction in CAUTI from 2.40 to 2.05 infections per 1000 catheter-days at 12 months after implementation. Lona Mody and colleagues¹³ repeated this intervention in 404 nursing homes and demonstrated improvement in CAUTI rate among residents from 6.42 to 3.33 per catheter-days over a 30-month period. CUSP has been shown to improve other aspects of healthcare like primary care practice²⁹ and quality of surgical care.³⁰

Implementation of CUSP, however, does require presence of strong leadership structure as well as presence of psychological safety and conditions that allow open and transparent discussions during multidisciplinary team meetings.

Positive Deviance

Positive deviance (PD)³¹⁻³⁴ is a strategy that has gained attention in recent years. It was previously used to successfully solve seemingly intractable and complex social and public health problems. Through intentional inquiry, the PD approach explores social aspects of infection prevention practices among healthcare personnel. In addition to identifying barriers and potential solutions, the approach focuses on identifying and deploying peer role models to generate positive peer pressure and mobilize change.

Unlike CUSP, implementation of positive deviance does not need strong unit-based leadership structures or structured and scheduled meetings. The inquiry is conducted initially by an external team, with the goal of arousing curiosity among the healthcare personnel so that they continue the dialogues long after the external team ceases involvement. The following open-ended questions are asked of the personnel so that they reflect and evaluate their practices and come forth with solutions. How do you know or recognize when healthcare-associated infection is present? How do you protect yourself, patients and others from transmission of any

microorganisms? What prevents you from taking these actions all the time? Is there any group or anyone you know who is able to overcome the barriers frequently and effortlessly? How? Do you have any ideas? What initial steps need to be pursued to make it happen? Any volunteers? Who else needs to be involved?

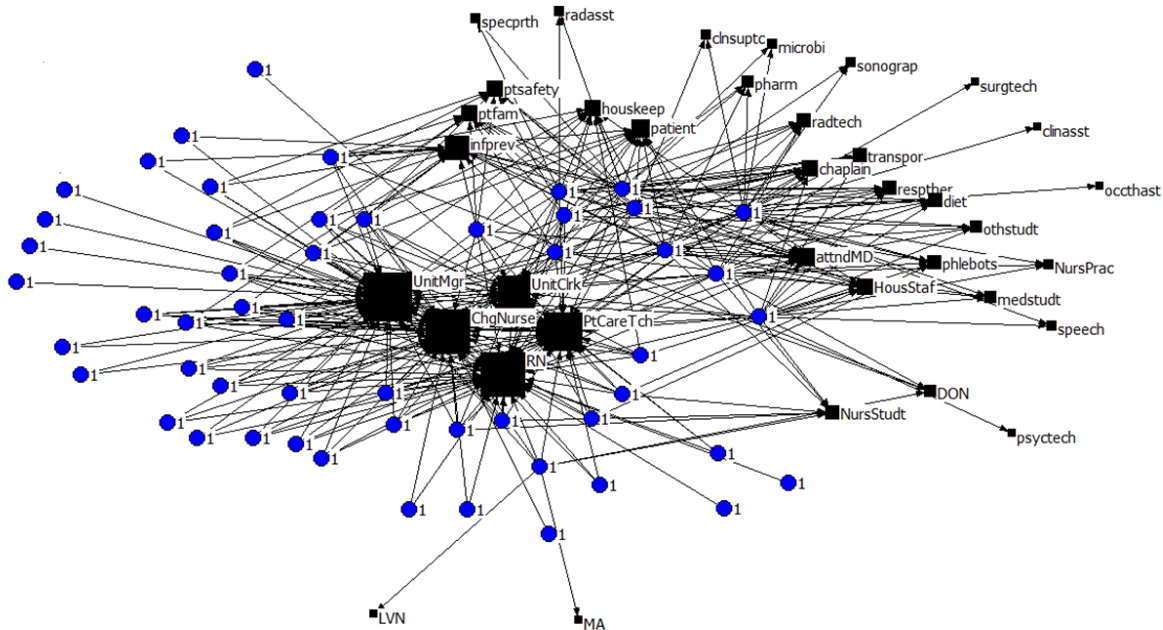
In the national veterans affairs initiative to reduce MRSA infections,³⁵ positive deviance was used successfully in addition to active surveillance and contact isolation precautions, to reduce healthcare-associated MRSA infections from 1.64 per 1000 patient-days to 0.62 per 1000 patient-days. In a study conducted at Parkland Memorial Hospital by Sreeramoju and colleagues,³⁶ which, coincided with the onset of Systems Improvement Agreement, implementation of positive deviance approach for nine months in three medicine wards was associated with positive impact on culture of safety. Secular trends in HAI reduction outweighed the study's ability to detect difference in HAI reduction due to positive deviance. The composite rate of HAI (CLABSI, CAUTI, Clostridium difficile infection and hospital-associated pneumonia) decreased in three control wards from 4.8 to 2.8 infections per 1000 patient-days, while the HAI rate in wards where the healthcare personnel received positive deviance intervention reduced from 5.0 to 2.1 infections per 1000 patient days. More research is necessary to evaluate positive deviance as a viable socioadaptive approach for wider use.

Social Network Analysis

Tracing social networks is an important aspect of contact tracing and outbreak investigation in infectious diseases and public health. The idea of analyzing social networks in healthcare settings to influence results of intervention and monitor success is relatively new.³⁶⁻³⁸ Networks of relationships are important both for a baseline assessment and for evaluating the impact of intervention. It is important to know who works with who (current or collaboration network), who actually has active projects with who (project network) who would like to work with who (potential or future network), who seeks ideas from who (innovation or ideas network). Two studies on HAI prevention utilized social networks to gather qualitative information. In the positive deviance study by Sreeramoju and colleagues, it was found that the bedside nurse, charge nurse, hospital unit manager, patient care technician and the hospital unit clerk were the

most connected in a hospital unit, suggesting that any intervention needing dissemination of information is likely to be more successful when these personnel are empowered and harnessed for implementation success. (see Figure 4)

Figure 4. Social Network Map Representing Who Works With Who in a Hospital Ward



[Round nodes labeled 1 represent healthcare personnel who were surveyed, while square, black nodes represent the job roles of other personnel in the ward they worked with (Abbreviations in the image: RN=registered nurse, UnitMgr=unit manager, ChgNurse=charge nurse, UnitClrk=unit clerk, PtCareTch=patient care tech, infprev= infection prevention, houskeep= housekeeper, ptfam= patient's family, chaplain, patient, atndMD=attending physician, HousStaf= resident physician, ptsafety= patient safety, pharm=pharmacist, radtech=radiology technician, phlebots=phlebotomist, medstud=medical student, NursStudt=nursing student, DON=director of nursing, psyctech=psychiatry technician, speech=speech therapist, NursPrac=nurse practitioner, othstudt=other student, respther=respiratory therapist, diet=dietician, transport=transporter, specprth=special procedures technician, radasst= radiology assistant, chsuptc=clinical support tech, microbi=microbiologist, sonograp=sonographer, surgtech=surgery technician, chasst= clinic staff assistant, occhasst=occupational therapy assistant; VP=vice president, SVP=senior vice president, othhosp=someone in another hospital). Size of nodes is directly proportional to how frequently they worked with someone in that job role. Roles that were not chosen by anyone are not connected to any HCP and shown on upper left corner.]

Link Nurses and Local Liaisons

Several hospital infection programs utilize local liaisons in the form of unlicensed assistive personnel, physician champions, and link nurses.^{39,40} They act as a link between their own clinical unit and the infection prevention team. Because of their visibility in their own clinical unit or service, they have a greater chance of being accepted by healthcare personnel in the clinical area they are representing and they may have a greater ability to influence local change in infection prevention practices. Sopirala and colleagues⁴¹ successfully implemented a link nurse program in several hospitals in Ohio and demonstrated reduction in healthcare-associated MRSA bloodstream infections by 41%.

Stop the Line Policies

When healthcare personnel are willing to speak up about errors or opportunities for improvement without fear of retaliation, the safety culture in hospitals tends to be stronger. In a qualitative study in six hospitals,⁴² a positive, nonpunitive culture for speaking up was associated with lower CLABSI rates. Management and organizational factors that contributed to creating a nonpunitive environment for speaking up were active seeking of feedback by leaders from the frontline healthcare personnel, training of employees to speak up, and availability of multiple reporting and communication tools.

The following table is a suggestion based on best available expert opinion for matching choice of socioadaptive intervention to the local situation in order to optimize success of improvement initiative.

Table 1: Matching Socioadaptive Intervention to Local Situation

Situation	Suggested Intervention
If strong and transparent unit structure with trained managers comfortable analyzing defects	Comprehensive Unit-based Safety Program
If change needed from grassroots	Positive Deviance
If teams strong, but issues between teams or issues between individuals	Relational Coordination
If processes relatively stable, but local monitoring and support needed	Link Nurses
If need to learn patterns of social networking in order to influence those who are most connected	Social Network Analysis
If bedside reminders needed and safety culture is strong	Stop the Line Policies

Impact of Socioadaptive Interventions on Culture of Safety

Culture of safety in health care settings is largely measured using the Hospital Survey of Patient Safety Climate tool⁴³ and less commonly using the Safety Attitudes Questionnaire.⁴⁴ They measure different aspects of safety culture such as teamwork, management support and frequency of events reported. A detailed review of culture of safety is beyond the scope this review. Although socioadaptive interventions have been developed in response to social and cultural challenges encountered by implementation teams, their impact on culture of safety is not clear. Meddings and colleagues⁴⁵ analyzed results of two national collaboratives and found that use of CUSP reduced CAUTI and CLABSI without having a measurable impact on culture of safety. A single institution study using positive deviance showed a positive impact on culture of safety in three wards compared to control wards.³⁶ HAI reduction can be achieved without a corresponding improvement in culture of safety, although improvement in culture of safety may be necessary for sustainment.

Sustaining Change

Sustainment of improvements in HAI rates is necessary in order to ensure continued patient safety. The Parkland program to Reduce Infections Together in Everyone (RITE) that was initiated in 2013 to reduce CLABSI and CAUTI throughout the hospital, SSI after eighteen different procedures, and sepsis mortality in patients presenting to the emergency department with signs and symptoms of sepsis, is an example of a system-wide program that needs to be sustained in the years to come. The program results thus far are shown in Table 2. The program employed several technical strategies such as implementation of central line and urinary catheter bundles, central line dressing change kits, chlorhexidine cloths in patients on the night before and the morning of surgery, improvements in peri-operative antimicrobial prophylaxis, best practice alerts to screen patients for suspected sepsis with the help of novel prediction models, smart order sets for sepsis care, standardizing education content and delivering content to over 9000 clinicians throughout the system, and training over 500 leaders in key concepts in quality and safety improvement. The program also employed socioadaptive interventions such as intentional inquiry to identify barriers to implementation and standardization of care, 1:1 interviews of key leaders and stakeholders, and an awareness campaign.

Table 2. Results of Parkland RITE Program

	FY2013	FY2017	% Reduction	#Prevented
CAUTI Rate per 1000 catheter-days	4.7	1.26	73%	318
CLABSI Rate per 1000 catheter-days	1.6	0.77	52%	119
SSI Rate per 100 procedures	3.4	1.3	62%	580
Sepsis Mortality per 100 patients in ED with Sepsis Present on Admission	9.4	2.9	69%	526

The AHRQ model for sustaining and spreading safety interventions⁴⁶ includes the following components. Leadership commits to bold improvement goals. The hospital develops and sustains a strong culture of safety. The safety program has champions who motivate individuals to continue to improve. Interdisciplinary teams create and sustain effective safety practices. Staff

learn both technical and adaptive interventions. Frontline staff are empowered to raise safety concerns. Key outcomes are continuously monitored and communicated. Success is communicated and rewarded. Change is incorporated into daily work flow, and the facility is a learning organization.

Conclusions and Future Direction:

In summary, socioadaptive interventions are necessary additions to technical interventions in an overall multi-component strategy to reduce healthcare-associated infections. Assessment of local social and cultural context and needs is key to choosing the right socioadaptive approach for any improvement initiative. Future research on socioadaptive interventions needs to be multidisciplinary and focus on identifying tools and strategies for diagnosing local context and study how these interventions might influence culture of safety in a measurable manner. Additional research is needed to develop strategies to sustain momentum of improvement efforts.

References

1. Washington, D.C.: National Academy Press. Institute of Medicine (U.S.). Committee on Quality of Health Care in America. *Crossing the Quality Chasm: A New Health System for the 21st Century*.
2. Magill SS, Edwards JR, Bamberg W, et al. Multistate point-prevalence survey of health care-associated infections. *N Engl J Med* 2014;370:1198-208.
3. Zimlichman E, Henderson D, Tamir O, et al. Health care-associated infections: a meta-analysis of costs and financial impact on the US health care system. *JAMA Intern Med* 2013;173:2039-46.
4. Scott R. The direct medical costs of healthcare-associated infections in US hospitals and the benefits of prevention. 2009. http://www.cdc.gov/hai/pdfs/hai/scott_costpaper.pdf (accessed 4 September 2018).
5. Reduction in the prevalence of healthcare-associated infections in U.S. acute care hospitals, 2015 versus 2011. <https://idsa.confex.com/idsa/2017/webprogram/Paper63280.html>. (accessed 3 August 2018)
6. Centers for Disease Control and Prevention National Health Safety Network. <https://www.cdc.gov/nhsn/index.html> (accessed 4 September 2018).

7. Healthcare-associated Infections in the United States, 2006-2016: A Story of Progress. Centers for Disease Control and Prevention National Health and Safety Network. <https://www.cdc.gov/hai/surveillance/data-reports/data-summary-assessing-progress.html>. (accessed 3 August 2018)
8. Sreeramoju P. Preventing healthcare-associated infections: beyond best practice. *Am J Med Sci* 2013;345:239-44.
9. Welsh CA, Flanagan ME, Hoke SC, et al. Reducing health care-associated infections (HAIs): lessons learned from a national collaborative of regional HAI programs. *Am J Infect Control* 2012;40:29-34.
10. Manor J, Blum N, Lurie Y. "No Good Deed Goes Unpunished": Ignaz Semmelweis and the Story of Puerperal Fever. *Infect Control Hosp Epidemiol* 2016;37:881-7.
11. McDonald L. Florence Nightingale a Hundred Years on: who she was and what she was not. *Womens Hist Rev* 2010;19:721-40.
12. Septimus E, Yokoe DS, Weinstein RA, Perl TM, Maragakis LL, Berenholtz SM. Maintaining the momentum of change: the role of the 2014 updates to the compendium in preventing healthcare-associated infections. *Infect Control Hosp Epidemiol* 2014;35 Suppl 2:S6-9.
13. Mody L, Greene MT, Meddings J, et al. A National Implementation Project to Prevent Catheter-Associated Urinary Tract Infection in Nursing Home Residents. *JAMA Intern Med* 2017;177:1154-62.
14. Whitby M, Pessoa-Silva CL, McLaws ML, et al. Behavioural considerations for hand hygiene practices: the basic building blocks. *J Hosp Infect* 2007;65:1-8.
15. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet* 2003;362:1225-30.
16. Rogers EM. Diffusion of preventive innovations. *Addict Behav* 2002;27:989-93.
17. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q* 2004;82:581-629.
18. Berwick DM. The science of improvement. *JAMA* 2008;299:1182-4.
19. Sreeramoju P, Weber SG. Regulatory issues concerning healthcare epidemiology and infection prevention. In: Malani P, Lautenbach E, Woeltje K, eds. *Practical Healthcare Epidemiology*. 4th ed. 2018. Textbook for Healthcare Epidemiology published by The Society for Healthcare Epidemiology of America. Alexandria, VA

20. Parkland Health and Hospital System Corporate Integrity Agreement. https://oig.hhs.gov/fraud/cia/agreements/Parkland_Health_Hospital_System_05302013.pdf (accessed 4 September 2018)
21. Suchman AL. Organizations as machines, organizations as conversations: two core metaphors and their consequences. *Med Care* 2011;49 Suppl:S43-8.
22. Jordan ME, Lanham HJ, Crabtree BF, et al. The role of conversation in health care interventions: enabling sensemaking and learning. *Implement Sci* 2009;4:15.
23. Knobloch MJ, Chewning B, Musuuza J, et al. Leadership rounds to reduce health care-associated infections. *Am J Infect Control* 2018;46:303-10.
24. Lanham HJ, McDaniel RR, Jr., Crabtree BF, et al. How improving practice relationships among clinicians and nonclinicians can improve quality in primary care. *Jt Comm J Qual Patient Saf* 2009;35:457-66.
25. Gittell JH. *High Performance Healthcare: Using the Power of Relationships to Achieve Quality, Efficiency and Resilience*. 1st ed. New York: McGraw Hill; 2009.
26. Sreeramoju PV, Connally RC. Healthcare Personnel Relationships Related to Coordination of Catheter Care. *Infect Control Hosp Epidemiol* 2018;39:248-50.
27. Berenholtz SM, Lubomski LH, Weeks K, et al. Eliminating central line-associated bloodstream infections: a national patient safety imperative. *Infect Control Hosp Epidemiol* 2014;35:56-62.
28. Saint S, Greene MT, Krein SL, et al. A Program to Prevent Catheter-Associated Urinary Tract Infection in Acute Care. *N Engl J Med* 2016;374:2111-9.
29. Pitts SI, Maruthur NM, Luu NP, et al. Implementing the Comprehensive Unit-Based Safety Program (CUSP) to Improve Patient Safety in an Academic Primary Care Practice. *Jt Comm J Qual Patient Saf* 2017;43:591-7.
30. Cooper M, Makary MA. A comprehensive unit-based safety program (CUSP) in surgery: improving quality through transparency. *Surg Clin North Am* 2012;92:51-63.
31. Pascale RS, Sternin J, Sternin M. *The Power of Positive Deviance: How Unlikely Innovators Solve the World's Toughest Problems*. Boston, MA: Harvard Business Press; 2010.
32. Marra AR, Pavao Dos Santos OF, Cendoroglo Neto M, Edmond MB. Positive Deviance: A New Tool for Infection Prevention and Patient Safety. *Curr Infect Dis Rep*. 2013.
33. Lawton R, Taylor N, Clay-Williams R, Braithwaite J. Positive deviance: a different approach to achieving patient safety. *BMJ Qual Saf*. 2014;23(11):880-883.

34. Singhal AB, Buscell P, Lindberg, C. *Inviting Everyone: Healing Healthcare through Positive Deviance*. Bordentown, NJ: PlexusPress; 2010.
35. Jain R, Kralovic SM, Evans ME, et al. Veterans Affairs initiative to prevent methicillin-resistant *Staphylococcus aureus* infections. *N Engl J Med* 2011;364:1419-30.
36. Sreeramoju PV, Dura L, Fernandez ME, Minhajuddin, A, Simacek K, Fomby T, Doebbeling, B. Using Positive Deviance Approach to Influence Culture of Patient Safety Related to Infection Prevention. *Open Forum for Infectious Diseases*. In Press.
37. Lindberg C, Clancy TR. Positive deviance: an elegant solution to a complex problem. *J Nurs Adm* 2010;40:150-3.
38. Holley J. *Charting Pathways to Change: Mapping the Positive Deviance MRSA Prevention Networks at the VA Pittsburgh Healthcare System's Acute Care and Long-Term Care Facilities Shows Promise*. Washington, D.C. Plexus Institute; 2007.
39. Dawson SJ. The role of the infection control link nurse. *J Hosp Infect* 2003;54:251-7; quiz 320.
40. Zavalkoff S, Korah N, Quach C. Presence of a Physician Safety Champion Is Associated with a Reduction in Urinary Catheter Utilization in the Pediatric Intensive Care Unit. *PLoS One* 2015;10:e0144222.
41. Sopirala MM, Yahle-Dunbar L, Smyer J, et al. Infection control link nurse program: an interdisciplinary approach in targeting health care-acquired infection. *Am J Infect Control* 2014;42:353-9.
42. Robbins J, McAlearney AS. Encouraging employees to speak up to prevent infections: Opportunities to leverage quality improvement and care management processes. *Am J Infect Control* 2016;44:1224-30.
43. Sorra J, Nieva V, Famolaro T, Dyer N. *Hospital Survey on Patient Safety Culture*. 2004; <http://www.ahrq.gov/qual/patientsafetyculture/hospcult.pdf>. (accessed 4 September 2018)
44. Etchegaray JM, Thomas EJ. Comparing two safety culture surveys: safety attitudes questionnaire and hospital survey on patient safety. *BMJ Qual Saf* 2012;21:490-8.
45. Meddings J, Reichert H, Greene MT, et al. Evaluation of the association between Hospital Survey on Patient Safety Culture (HSOPS) measures and catheter-associated infections: results of two national collaboratives. *BMJ Qual Saf* 2017;26:226-35.
46. Agency for Healthcare Research and Quality. *A Model for Sustaining and Spreading Safety Interventions*. <https://www.ahrq.gov/professionals/quality-patient-safety/hais/cauti-tools/guides/sustainability-guide.html>. (accessed 4 September 2018)