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Control of Health-Care--Associated Infections, 1961--2011

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Richard E Dixon, MD

Health Net of California, Rancho Cordova, California

Corresponding author: Richard E. Dixon, MD, Regional Medical Director; Health Net of California, Inc., 11971 Foundation Place; Rancho Cordova, CA 95670; Telephone: 916-935-1941; Fax 800-258-3506; E-mail: rdixon@RLAtech.com.

Introduction

For centuries, hospitals have been known as dangerous places. In 1847, Ignaz Semmelweis presented evidence that childbed fever was spread from person to person on the unclean hands of health-care workers (*1*). Semmelweis's findings did not immediately improve sanitary conditions in hospitals, but surgeons gradually adopted aseptic and antiseptic techniques and became leading innovators of techniques to reduce patients' susceptibility to postoperative infections. Concerns about the spread of infection by air, water, and contaminated surfaces gradually changed practices in hospitals, making them safer. During the 1950s, epidemic penicillin-resistant *Staphylococcus aureus* infections, especially in hospital nurseries, captured the public's attention and highlighted the importance of techniques to prevent hospital-acquired infections, now also referred to as health-care--associated infections (HAIs; i.e., nosocomial infections) (*2*). By the mid-20th century, some surgeons, microbiologists, and infectious disease physicians had focused their studies on the epidemiology and control of HAIs (*3,4*). From the efforts of these pioneers grew the notion that hospitals had the ability---and the obligation---to prevent HAIs.

By the 1960s, hospital-based infection control efforts had been established in scattered hospitals throughout the United States. The number of hospitals with HAI control programs increased substantially during the 1970s, and HAI control programs were established in virtually every U.S. hospital by the early 1990s. The remarkable spread and adoption of programs designed to prevent and control HAIs hold valuable lessons about the ways that other public health initiatives can be designed, developed, and implemented. This report traces the strategic and tactical steps used to bring about a major public health success: the ubiquity of formal established infection control

programs in virtually all U.S. hospitals and expanding into other health-care settings.

Developing the Public Health Model for Hospital Infection Control

By the late 1950s and early 1960s, a small proportion of hospitals had begun to implement programs designed to understand and control HAIs. The pioneering leaders of those efforts were located mostly in large, academic medical centers, not in public health agencies. Although state, local, and federal public health agencies were sporadically called on to provide epidemiologic or laboratory support to investigate particular problems, they did not consider hospitals as communities needing ongoing public health resources. Nor did hospitals routinely see themselves as communities needing such assistance. During the 1950s and even afterwards, many hospitals saw themselves as "the doctor's workshop" and their roles as providers of space and personnel to support practicing physicians. In most communities, a hospital was perceived as good because doctors who practiced there were perceived as good, not because the hospital's outcomes were better than its competitors'. Focused on patients and doctors as individuals, most hospitals neither tracked nor had systems in place designed to improve their overall outcomes; public health--based and population-based principles often were not important management priorities. The nosocomial staphylococcal epidemics of the 1950s began to change those attitudes.

History did not record who first understood---or when it was first recognized---that hospitals are discrete communities in which public health principles could be used to prevent and control HAIs. But by the 1960s, hospital-based clinicians and CDC epidemiologists clearly were beginning to apply a public health model to HAIs. That model was built around systematic surveillance to identify HAIs; ongoing analysis of surveillance data to recognize potential problems; application of epidemic investigation techniques to epidemic and endemic HAIs; and implementation of hospitalwide interventions to protect patients, staff, and visitors who seemed to be at particular risk.

One might assume that the public health system would have managed the public health approach to HAIs. It did not. Instead, a different approach evolved. Hospitals built and managed their own infection control programs. The historical record is murky as to why infection control programs became the responsibility of hospitals, rather than local, state, or national public health agencies. Although many exceptions certainly existed, hospitals generally did not work closely with their local health departments, and when they did interact, the health departments were sometimes seen to be regulators, not colleagues. A perception at the time was that most health departments had little interest in the hospitals' clinical activities.

Given the absence of a tradition of collaboration between community hospitals and local health departments, two of CDC's first public health research and development activities were embedded in hospitals themselves. One was a national network of hospitals that volunteered to conduct HAI surveillance by using CDC methods and to report those data to CDC each month. That voluntary surveillance system, the National Nosocomial Infection Surveillance program, has changed over the years but remains active as the National Healthcare Safety Network (NHSN; http://www.cdc.gov/nhsn/) and continues to provide information about the changing patterns of HAIs.

The second of CDC's research projects also was located in community hospitals, and it profoundly affected the evolution of infection control programs. The Comprehensive Hospital Infections Project

(CHIP) was begun in 1965 (*5*). Eight community hospitals, which were located in different cities across the country, participated in the project. Those hospitals served as the laboratories where surveillance and control techniques were developed. CDC funded those activities, and Atlanta-based CDC staff actively collaborated in the research. Physician and nurse epidemiologists, along with CDC microbiologists, visited CHIP hospitals regularly and conducted studies to learn the epidemiology of HAIs. CHIP studies helped to define how HAIs could be identified and distinguished from community-acquired infections. Hospital staff and CDC epidemiologists explored what data were needed to improve practices and how those data should be analyzed and reported. That direct field epidemiology experience gave CDC important insights into the ways that community hospitals worked. The close interactions with the hospitals undoubtedly helped CDC develop unique recommendations that were credible to hospitals and practical for them to use.

CDC's decision to use community hospitals for some of its early research was a strategic one. Most hospital inpatients were---and still are---treated in community hospitals. Although CDC staff interacted closely and shared ideas with leading infectious disease experts in the United States and Europe, CDC's involvement with community hospitals made the resulting infection control models and techniques more likely to be appropriate for use in the kinds of institutions where most patients get hospital care.

Promoting the Public Health Model to All U.S. Hospitals

As the infection control community developed confidence in the value of infection control programs, the next task was to assist other hospitals to adopt them voluntarily. Two barriers were obvious. First, hospitals were not required to have such programs, so the value of the activities had to be promoted to hospital administrators and clinical staffs. Because they recognized such programs as advantageous to the hospital and its patients, many hospitals voluntarily adopted and paid for such programs.

The second problem posed a larger challenge. Because local and state health departments did not have the resources to place their personnel in every hospital needing an infection control program, where would the trained infection control specialists come from? Existing hospital personnel had to be recruited and trained to use entirely new public health and epidemiologic skills.

The new jobs were often filled by existing staff nurses and laboratorians who built new careers as infection control practitioners (ICPs). The ICPs usually were supervised by hospital epidemiologists---typically physicians selected from the existing medical staff, such as pathologists or infectious disease--trained physicians. These doctoral-level program directors often were hired to provide this service part time, and many volunteered to serve without pay. Both positions---ICP and hospital epidemiologist---were newly created positions, and at the time, few ICPs or hospital epidemiologists had more than cursory formal training in epidemiology or any other public health discipline.

Training for these new careers often took place informally, on the job, by networking with colleagues in other hospitals, and by taking brief training courses. Many of the pioneer infection control programs were staffed by practitioners who had either attended a week-long training course conducted at CDC or had been trained by another practitioner who had been trained at CDC. As a result, the knowledge and attitudes of the earliest infection control staff had considerable uniformity. Those pioneers soon became the leaders of their new fields and naturally became the teachers and consultants for new practitioners. The public health model became an unofficial standard of practice;

it focused on active prospective surveillance, data analysis, and reporting, and it emphasized prevention programs that relied on the education of hospital staff about infection control techniques.

Although using existing hospital staff and retraining them for their new jobs provided many advantages, this practice also had unanticipated disadvantages. Few infection control pioneers brought investigative experience to their new positions. As a result, when problems were discovered by surveillance, instead of basing interventions on locally acquired epidemiological and laboratory evidence, often they were based merely on established guidelines and recommendations that seemed logically to make the most sense. The evidence base for many of those guidelines was not strong, however, because effectiveness studies of intervention programs had rarely been conducted.

Infection Control Becomes a Profession

The rapid growth and acceptance of infection control programs was undoubtedly stimulated by the new career possibilities offered by the emerging infection control field. Staff nurses, microbiologists, pathologists, and infectious disease clinicians were eager to become part of a field that provided new skills and offered new opportunities. The professionalization of infection control practice was strengthened when, in 1972, infection control practitioners formed a professional society, the Association of Practitioners in Infection Control (APIC, now the Association for Professionals in Infection Control and Epidemiology). APIC was formed to provide practitioners with continuing professional interaction, education, and growth. A certifying program based on practitioners' education, experience, and test scores followed in 1980, further establishing infection control as an attractive career.

The hospital epidemiologists followed soon afterwards in forming their own professional society, the Society of Hospital Epidemiologists of America (SHEA), now The Society for Healthcare Epidemiology of America. Its initial membership requirements allowed only physicians to join, and physician infectious disease subspecialists accounted for most of its early members. Only several years after its founding were nonphysician epidemiologists, sanitarians, microbiologists, and other doctoral-level practitioners able to join SHEA. The doctoral-level societies were also divided. Surgeons interested in hospital-acquired infections formed their own society: the Surgical Infection Society (SIS). SIS, like the other professional associations, has expanded membership to other categories of physicians, nurses, and others with an interest in surgical infections. SIS, SHEA, and APIC have not merged, although they have developed collegial working relationships and have important collaborations.

Although the development of trained professional cadres of infection control experts in every hospital seems to be an obvious benefit, it must be asked whether infection control would have been more innovative and might have advanced faster if the practitioners of the new careers had welcomed other disciplines and other kinds of expertise into the field earlier. Would that have promoted innovation? Would it have led to faster development of an evidence base for infection control? Perhaps so. Public health officials need also to consider this question as they develop and deploy new approaches to public health practice.

Transforming Infection Control from Movement to Mandate

By the late 1970s, the infection control field was well established. It had strong presences in hospitals across the country, organized work forces, a coherent model that guided the field's activities, and a

rapidly expanding body of scientific publications. A decade earlier, during the late 1960s and early 1970s, however, that degree of success was not certain. During the early 1970s, the hospital infection control movement faced the same challenges as many other public health initiatives have before it: how to increase adoption by more communities and how to convert a good idea into a virtual mandate for action.

By the mid-1970s, HAIs were recognized as a major threat associated with medical care. Despite the increasing public and professional concern about HAIs, it became apparent during the mid-1970s that not all hospitals were adopting infection control programs. CDC had ready access to national professional societies, health-care trade associations, accrediting organizations, and regulatory agencies, but infection control programs, although encouraged, were not mandated. Some hospitals had no programs at all. Other hospitals had programs, but no requirement existed to ensure they were properly staffed, well structured, or effective. The absence of a requirement that hospitals have effective infection control programs to protect the public was due, in part, to the fact that the evidence for the effectiveness of the public health model for infection control programs was mostly only anecdotal. It had a compelling story; it seemed like a good thing to do; but it was not evidence based.

CDC determined that a rigorous scientific assessment of the effectiveness of infection control programs would be necessary to propel widespread adoption of hospital-based programs. That decision led to the Study on the Effectiveness of Nosocomial Infection Control (SENIC), a rigorous assessment of infection control effectiveness that compared outcomes in hospitals with and without CDC-style infection control programs (*6*). The study was designed to determine whether infection control programs using CDC-recommended practices actually reduced the risks from HAIs. To conduct the study, 338 U.S. hospitals were randomly selected and were stratified by geography, inpatient bed capacity, and teaching status. Approximately half of the study hospitals had established infection surveillance and control programs. When that study showed that hospitals with infection control programs had significantly lower rates of HAIs than did hospitals without such programs (*7*), expectations for hospital programs changed. With strong scientific evidence supporting the value of such programs, accrediting organizations such as the Joint Commission on Accreditation of Hospitals (now The Joint Commission) mandated that accredited hospitals have infection control programs similar to those recommended by CDC and the professional organizations of hospital epidemiologists and infection control practitioners. The Joint Commission made this an accreditation requirement in 1976 (*8*).

The SENIC study converted a movement into a mandate. Although it is widely agreed that new treatment interventions for individual patients should be tested in rigorous clinical trials, such trials are much less common for large population-based interventions. The design and conduct of assessments for population-based interventions can be difficult scientifically, legally, and ethically. They also can be expensive, and often no commercial company is interested enough to sponsor such studies. As a result, SENIC-style studies are rarely conducted by public health agencies.

Beyond its revolutionary effect on infection control practices in hospitals, the SENIC study served as an example that rigorously conducted public health research can change the credibility and acceptability of public health interventions and can speed adoption of important programs. It established how, when a public health problem is important enough, a scientifically rigorous population-based assessment can be used to propel the implementation of effective programs. In the

future, public health programs are likely to face ever-greater demands for proof of worth and more competition for support, and more SENIC-style studies may be needed.

Hospital Epidemiology in the New Century

CDC continues to play an important role in HAI prevention research. CDC's Division of Healthcare Quality Promotion (DHQP) has substantial expertise in HAI control, stemming in part from decades of experience in HAI epidemiologic investigations. That, along with its central role in the public health infrastructure, gives CDC a unique opportunity and responsibility to guide and support research that directly addresses the knowledge gaps most relevant to the public health.

In addition to the important research contributions that arise directly from the core activities of outbreak investigation, laboratory support, and HAI surveillance, CDC dedicates funds for innovative extramural HAI prevention research through its Prevention Epicenter Program. DHQP began the Prevention Epicenters Program in 1997 as a way to work directly with academic partners to address important scientific questions about the prevention of health-care--associated infections, antibiotic resistance, and other adverse events associated with health care. Through a collaborative funding mechanism, DHQP staff work closely with a network of academic centers to foster research on the epidemiology and prevention of HAI, with an emphasis on multicenter collaborative research projects. The program has provided a unique forum in which leaders in health-care epidemiology can collaborate with each other and with CDC to pursue innovative research endeavors that bring into alignment both academic and public health research goals and objectives and create important synergies that might not be possible for a single academic center or without the benefit of cross-fertilization of ideas between academic and public health experts.

Research conducted through the Epicenters program has produced valuable contributions to the field and to the mission of DHQP. The program has resulted in approximately 150 peer-reviewed publications that cover a broad array of topics relevant to HAI prevention, including the epidemiology of infections caused by multidrug-resistant organisms and *Clostridium difficile*; development and testing of novel prevention strategies, such as the use of chlorhexidine bathing to prevent bloodstream infections and pathogen transmission among intensive-care unit patients; and development of novel HAI surveillance strategies that are helping to shape the future of HAI surveillance through the National Healthcare Safety Network. CDC should seek to maintain an active participatory role in HAI research.

As CDC plans its research agenda, another lesson taught by the development of infection control as a public health discipline should be remembered: sometimes public health agencies need to actually *conduct* research, not just fund it. CDC's credibility obtained through its own research was an essential factor in its ability to promote infection control programs. Working in hospitals, collecting data, and conducting field studies alongside hospital workers gave CDC a unique understanding of the challenges that hospital-based infection control personnel face. As a result, CDC recommendations were more likely to be useful and appropriate than they would have been had CDC simply funded others to do its research. Learning the subtleties of what did *not* work or what was impractical to implement was perhaps more important than learning what did work, and this was learned best by the agency conducting the research itself.

The landscape of infection control and health-care epidemiology began another dramatic shift with

the publication of the Institute of Medicine (IOM) report, *To Err is Human*, in 1999 (*9*). This report revealed that thousands of patients in U.S. hospitals were injured or died each year because of medical errors---many of which might have been preventable. HAIs were recognized as a leading cause of these preventable harms. This report was followed by an influential series of investigative articles on health-care--associated infections published by the *Chicago Tribune*. These reports underscored the findings of the IOM report on the major public health effects of HAIs and criticized hospitals for failing to prevent these infections and keeping secret the scope of the problem. The IOM report and *Chicago Tribune* articles touched off an active debate about HAI prevention and spurred action by consumers and legislatures. In 2002, four states (Illinois, Florida, Missouri, and Pennsylvania) passed laws to mandate that health-care facilities report HAIs to the public. Proponents of the legislation argued that health-care facilities would finally begin to take real steps toward preventing HAIs if they had to disclose them more openly.

Public interest in HAIs reached an important tipping point in 2005--2006 with the publication of two studies about the prevention of central line--associated bloodstream infections (CLABSIs). One study was a collaboration between CDC and the Pittsburgh Regional Healthcare Initiative and the other a collaboration between researchers at Johns Hopkins University Hospital and the Michigan Hospital Association (*10*,*11*). Both studies brought together staff from a large number of intensive-care units who collaborated to reduce CLABSIs by implementing a relatively simple set of interventions. The results of the studies were striking and consistent. In each, CLABSIs were reduced by roughly 65%.

Increasing awareness of the scope of the HAI problem, coupled with the recognition that a substantial portion of these infections could be prevented, galvanized even more consumers and policy makers to take action. Many other state legislatures began to debate and pass laws to mandate the public reporting of HAIs. In recognition of the growing interest in so-called public reporting, CDC worked with the Healthcare Infection Control Practices Advisory Committee to develop recommendations to help guide future legislation (*12*). These laws have now become widespread. Twenty-eight states have passed legislation that requires the public reporting of one or more HAIs, and legislation is pending in others. Federal lawmakers also have taken up the HAI issue. In 2008, as part of the larger deficit-reduction act, Congress mandated that the Center for Medicare and Medicaid Services (CMS) stop giving hospitals increased payments for the care of patients with HAIs. CMS worked closely with CDC to identify HAIs that were "reasonably preventable" to support implementation of this requirement. In 2010, Congress incorporated HAI prevention into the Value Based Purchasing program of the Affordable Care Act. CMS has elected to implement the requirement by requiring national public reporting of HAIs, beginning with CLABSIs in 2011.

CDC is playing a central role in supporting legislative mandates on HAI reporting and prevention. Laws in 22 of the 28 states that require reporting of HAIs specifically stipulate that facilities use the CDC's NHSN as the platform for that reporting. Likewise, the new CMS mandate will require submission of data to NHSN. These requirements have led to a dramatic expansion in NHSN enrollment, from roughly 300 hospitals in 2006 to approximately 3,500 in 2010. Increasingly, state health departments, with support from CDC, are leading HAI prevention efforts. Their role in HAI prevention was recognized and greatly enhanced in 2009 with passage of the American Recovery and Reinvestment Act. That legislation included $50 million to support state-based HAI prevention efforts. American Recovery and Reinvestment Act funds were distributed through CDC's Epidemiology and Laboratory Capacity grant to support state efforts to build HAI infrastructure and

expand surveillance and prevention efforts. CDC staff and experts are now supporting HAI prevention efforts in 49 funded states, the District of Columbia, and Puerto Rico. Specifically, CDC subject-matter experts are helping guide the expansion and validation of HAI surveillance data and the initiation and expansion of HAI prevention.

Conclusions

Efforts to prevent and control HAIs have led to profound changes in the ways that those infections are perceived and managed in the United States and abroad. Programs focused on preventing and controlling HAIs were rare in U.S. hospitals in the early 1970s; now, they are present in virtually every hospital in the nation and in many hospitals abroad.

Among the main factors that led to this success was, most importantly, CDC's decision to use a rigorous scientific study, the SENIC study, to demonstrate that infection control programs were effective. This evidence obtained from SENIC converted infection control programs from being something worth doing into programs that must be implemented to reduce illness and death. Before SENIC, the evidence for the effectiveness of infection control programs was insufficient to make these programs mandatory. With evidence from SENIC, it was virtually impossible for hospitals to avoid implementing them.

CDC's ability to work with others to design and refine infection control programs was almost certainly aided by CDC's direct field experience investigating epidemics. Perhaps even more important was CDC's experience working directly with hospitals over a long period to design and test surveillance and control techniques. That first-hand field epidemiology helped CDC to learn how hospitals function and to design infection control programs that were practical and could be implemented.

CDC and other pioneers helped to define a new field (hospital epidemiology) and new professional disciplines (infection control and hospital epidemiology). When no training courses or job descriptions existed for those essential hospital workers, CDC provided the key early training and job-development resources used by a large proportion of infection control pioneers. Because of CDC's early dominance in defining the work of these new disciplines, CDC profoundly affected knowledge base, work activities, and extent of the practitioners' responsibilities.

Finally, hospital epidemiology was, for many years, a misleading title for a field that mainly focused on HAIs. As the patient safety movement has vividly shown, the opportunities for strong public health skills in hospitals extend far beyond mere infection control. CDC has the capacity to continue to support that effort and thereby help prevent the range of errors, omissions, and other preventable mishaps that still plague the organizations that should heal, not harm.

References

1. Semmelweis I. Etiology, concept and prophylaxis of childbed fever. Madison, WI: University of Wisconsin Press; 1983.
2. Wise RI, Ossman EA, Littlefield DR. Personal reflections on nosocomial staphylococcal infections and the development of hospital surveillance. Med J Aust 1978;12:543--6.
3. Finland M, McGowan JE Jr. Nosocomial infections in surgical patients. Observations on effects of prophylactic antibiotics. Arch Surg 1976;111:143--5.
4. McGowan JE Jr, Barnes MW, Finland M. Bacteremia at Boston City Hospital: occurrence and

mortality during 12 selected years (1935--1972), with special reference to hospital-acquired cases. J Infect Dis 1975;132:316--35.
5. CDC. Nosocomial infections in community hospitals, report no. 4, July 1968--1969. Atlanta, GA: US Department of Health, Education, and Welfare, CDC; 1969.
6. Haley RW, Quade D, Freeman HE, et al. The SENIC project: Study on the Efficacy of Nosocomial Infection Control (SENIC PROJECT): summary of study design. Am J Epidemiol 1980;111:472--85.
7. Haley RW, Culver DH, White JW, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985;121:182--205.
8. Weinstein RA. Nosocoomial infection update. Emerg Infect Dis 1998;4;416--20.
9. Institute of Medicine. To err is human: building a safer health system. Washington, DC: National Academies Press; 2000.
10. CDC. Reduction in central line--associated bloodstream infections among patients in intensive care units---Pennsylvania, April 2001--March 2005. MMWR 2005;54:1013--6.
11. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med 2006;355:2725--32.
12. McKibben L, Horan T, Tokars JI, Guidance on public reporting of healthcare-associated infections: recommendations of the Healthcare Infection Control Practices Advisory Committee. Am J Infect Control 2005;33:217--26.

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Centers for Disease Control and Prevention 1600 Clifton Road Atlanta, GA 30329-4027, USA
800-CDC-INFO (800-232-4636) TTY: (888) 232-6348 - Contact CDC–INFO