

Infection Control in Developing Countries

18

Patricia Lynch, Victor D. Rosenthal, Michael A. Borg, and Sergey R. Eremin

OVERVIEW

History

For centuries, historians and healers have commented about risks for complications associated with healthcare, especially infections. Florence Nightingale began the third edition of *Notes on Hospitals* with "It may be a strange principle to enunciate as the first requirement in a hospital is that it shall do the sick no harm" [1]. As the tools and procedures for care become more sophisticated, however, risk for complications, including healthcare-associated infections (HAI) increases.

Many factors affect infectious diseases: Poverty is a potent amplifier for transmission, morbidity, and mortality of all infections, including HAIs. Wars, homelessness due to poverty and persecution, emergence of new and old deadly and debilitating diseases, global travel and interdependence, economics, and politics all affect transmission and outcomes: Infectious diseases are the second most common cause of death in the world [2]. In the face of such uneven distribution of vital resources, the threat of global epidemics, terrorism with biological weapons and the sheer magnitude of the task, it is easy to feel discouraged about the potential for infection control (IC). There is much more to the story, though, and great cause for optimism.

There are now many well-coordinated global health initiatives, and the benefits of them are apparent in the lives of the recipients and the donors, who have gained skills and experiences of great value. Until recently, there had been no global initiatives to reduce the frequency of HAI, but that picture is slowly changing.

ESTABLISHING PREVENTION OF HAIS AS A GLOBAL PRIORITY

In all countries, resources for national priorities are allocated by governments; healthcare must compete for funding with other major goals, such as education, infrastructure, and the military. Results for building roads, schools, and military are highly visible and often healthcare, being less visible, is a lower priority. Even when it is a priority, the fraction of the health budget that is allocated to prevention of HAIs often is tiny and insufficient. In an ideal world, health issues that have the potential to affect many countries would be addressed globally, and resources would be allocated equitably, recognizing that improvements in global health are not isolated: All benefit indirectly and, in the case of epidemic diseases, many benefit directly.

HAIs are associated with significant patient morbidity and attributable mortality and with increased healthcare costs. Studies conducted in U.S. hospitals have shown that an integrated IC program, including targeted outcome surveillance of device-associated infections (DAIs), can reduce the incidence of HAIs by as much as 32% and lead to reduced healthcare costs [3].

There is a large body of literature which has shown that HAIs are one of the major causes of patient morbidity and mortality in industrialized countries [4,5]. DAIs, such as ventilator-associated pneumonia (VAP) [6–8], central venous catheter-associated bloodstream infection (CVC-BSI) [9–12] and catheter-associated urinary tract infection (CA-UTI) [13] have the greatest challenge to hospital safety and quality healthcare in intensive care unit (ICU) patients.

256 Section I: General Considerations of Hospital Infections

Prospective targeted epidemiological surveillance of HAIs has been standardized by the Centers for Disease Control and Prevention's (CDC) National Nosocomial Infections Surveillance (NNIS) system, providing definitions for DAIs [14–16]. Targeted surveillance and calculation of DAI rates of infection per 1,000 invasive device-days allows benchmarking with other different institutions in the same or even different countries and facilitates detection and improvement of institutional problems because the specific risk factor is included in the rate calculation.

Global Agenda for IC Research: Research Priorities Project

For many years, lack of any research agenda for the field of infection control was a limitation. In the last 20 years, the field of infection prevention and control has extended beyond the boundaries of HAIs to include all venues where health care is delivered and both patients and care providers. There are still many unanswered fundamental research questions in the areas of infection surveillance, prevention, control, and HAI epidemiology. The lack of an organized and thoughtful research agenda for the future limits the focus to small questions, promotes continued fragmentation, and often wastes valuable resources. An initial research agenda that addresses these newer segments and provides a framework for answering fundamental questions was funded and completed by The Research Foundation for Prevention of Complications Associated with Health Care (formerly APIC Research Foundation) in 2000. These priorities provide a framework for addressing HAI prevention.

The Research Priorities Project [17] used a four-round iterative (Delphi) process with 50 international experts who ultimately identified 21 high-ranked research priorities, which could be condensed into subject areas:

1. Measuring the financial impact of complications and the cost effectiveness of interventions.
2. Studies related to improved antibiotic usage and management of antibiotic resistance.
3. Improving compliance with practices known to be beneficial, especially hand hygiene, appropriate staffing in healthcare institutions, and other proven components of infection prevention and control programs.
4. Surveillance for infectious and noninfectious complications across the spectrum of inpatient and outpatient care delivery.
5. Assessment of prevention strategies at specific sites such as VAP.
6. Preventing occupational transmission of bloodborne pathogens.
7. Creation of regional networks to provide support and information, improve practices, and reduce the steep learning curve more efficiently and economically.

These issues will be addressed in the remainder of the chapter. Although timely in 2,000, currently the priorities would have to include response to biological threats through human intervention ("bioterrorism"), reduction of healthcare-associated transmission of epidemic respiratory diseases such as influenza, and supporting development of early IC programs where they are needed.

Characteristics of Healthcare Facilities

Hospitals and clinics around the world reflect the economic realities of their locations. Any country may have all three tiers represented.

- In the lowest tier, which is the most common facility at present, adequate supplies of clean water, sterile instruments and supplies for contact with normally sterile body sites, and clean equipment and supplies for contact with mucous membranes and non-intact skin are not available. Adequate hand hygiene is impossible. In these hospitals, patients often share beds and supplies, and families provide much food and care, especially for children. Standards for quality and accreditation do not exist. These facilities rarely have IC information, do not have IC programs, and frequently have HAI outbreaks. Patients and their families often are required to provide care materials, such as syringes, surgical gowns, and medications. Employee training is highly variable and often minimal. Transfusion and injection safety is uncommon and in some regions, transmission of human immunodeficiency virus (HIV) and hepatitis is more frequently related to health care than other means [18].
- The second tier is the most rapidly growing segment, reflecting economic improvement in much of the world. The hospitals have access to clean water and have sterilizers and cleaning processes, but often availability of sterile or high-level disinfected instruments and supplies is variable. Employees have more training, IC information is available, and occasionally a formal IC program exists with responsibilities assigned to a committee and individuals. Patients are housed in large wards and ICUs. Injection and transfusion safety is variable. Standards for quality are higher and increasing and, in some instances, are measured. Hand hygiene is possible with handwashing or alcohol rubs.
- The highest tier represents a tiny fraction of hospitals in the world. These facilities, both inpatient and clinics, have single-use sterile instruments and supplies, adequate reprocessing techniques, and abundant clean water. Accreditation processes exist, and most facilities have formal IC programs with committees. Certification of individual knowledge and practices exists and often is required. Complex surveillance systems demonstrate transmission of infectious agents among the patients, particularly in ICUs. Outbreaks of HAIs are

rare and quickly recognized. Interestingly, compliance with recommendations for hand hygiene, presurgical antibiotic prophylaxis, and insertion and maintenance of invasive devices, such as central vascular lines and ventilators, is poor, at least by industrial standards such as those for car manufacture or airline maintenance.

Persistent Global Infection Prevention Problems

Global IC efforts are weakened by several factors, the most important of which is inadequate attention and promotion by national and international agencies dedicated to health improvement. Other major issues include poverty and lack of commitment by hospitals, governments, and their ministries of health. Furthermore, the professional societies of physicians, nurses, and laboratorians are not effectively engaged in infection prevention, and many nations have either weak or non-existent IC societies.

Global IC is strengthened by factors that unify practitioners and optimize effort, adequate funding and infrastructure, and strong focus. Examples of improvement include the fact that the World Health Organization (WHO) finally has a global health initiative related to HAI prevention and that more than half of all manuscript submissions to the major English-language IC journals are from authors outside the United States, Canada, and the United Kingdom.

LACK OF GLOBAL PLANNING RELATED TO HAIS

The magnitude and scope of the problem of HAIs and the difficulty of gaining improvement have been consistently underestimated by public health agencies. Some examples of global planning have occurred: severe acute respiratory syndrome (SARS) in 2003 resulted in rapid mobilization of WHO resources coordinated with experts, laboratories, and pharmaceutical research from many national agencies around the world: Tracking and containment of spread was quite successful.

EPIDEMIC RESPIRATORY INFECTIONS

One of the major lessons of SARS received very little attention even in countries with highly developed healthcare facilities: Approximately 40% of SARS infections were acquired in healthcare facilities, presumably reflecting the "normal" transmission rate for similar respiratory pathogens, such as influenza. Transmission of SARS and other epidemic respiratory infections is amplified, not reduced, in healthcare facilities. Massive planning to reduce infection and mortality from H5N1 (Avian) influenza has not recognized the pivotal relationship of healthcare facilities to transmission.

UNSAFE INJECTION AND TRANSFUSION PRACTICES

As part of the Year 2,000 Global Burden of Disease study, investigators quantified the death and disability from injection-associated infections with hepatitis B virus (HBV), hepatitis C virus (HCV), and HIV [18]. They modeled the fraction attributable to healthcare injections in the year 2000 on the basis of the annual number of injections, the proportion of injections administered with reused equipment, the probability of transmission following percutaneous exposure, the prevalence of active infection, the prevalence of immunity, and the total incidence. In 2000, persons in the study regions (countries in the lower 80% of economic strata) received an average of 3.4 injections per year, 39.3% of which were given with reused equipment. In 2000, contaminated injections caused an estimated 21 million HBV infections, 2 million HCV infections, and 260,000 HIV infections, accounting for 32%, 40%, and 5%, respectively, of new infections in that year. This constitutes one of the greatest infection prevention challenges.

HOSPITAL-ACQUIRED NEONATAL INFECTIONS IN DEVELOPING COUNTRIES

Babies born in hospitals in developing countries are at increased risk of neonatal infections because of poor intrapartum and postnatal IC practices. In a major review, reported rates of neonatal infections were 3–20 times higher than those reported for hospital-born babies in industrialized countries [19]. Neonatal infections are estimated to cause 1.6 million annual deaths or 40% of all neonatal deaths, in developing countries [20]. Neonatal deaths account for more than one-third of the global burden of child mortality [21]. Neonatal mortality rates (deaths in the first 28 days of life) are as high as 40–50 per 1,000 live births in many of the poorest parts of the world. Infections are the major cause of neonatal deaths in developing countries.

WHO: CLEAN CARE IS SAFER CARE: GLOBAL PATIENT SAFETY CHALLENGE

A hopeful sign related to hand hygiene is "Clean Care Is Safer Care," the first global challenge of the WHO World Alliance for Patient Safety [22]. In October 2004, the World Alliance for Patient Safety was formed, focusing first on prevention of HAIs through a combination of initiatives that include mobilizing patients and patient safety organizations, generating teaching tools, directing and conducting research, developing a taxonomy of definitions and data management methods, and coordinating

258 Section I: General Considerations of Hospital Infections

international efforts on future solutions. The intent is to engage all countries in infection prevention.

Countries will be invited to adopt this challenge for their own healthcare systems with the following main principles [23]:

- Formally assessing the scale and nature of HAIs within their healthcare system.
- Adopting an internationally recognized approach to surveillance of the problems so that current baseline incidence of HAI can be established and change can be monitored.
- Conducting an analysis of the root causes of the problem with particular emphasis on “systems thinking.”
- Developing solutions to improve safety and reduce risk by focusing on five action areas in particular: (1) hand hygiene, particularly use of alcohol hand rubs, (2) blood safety, (3) injection practices and immunization, (4) water, basic sanitation, and waste management, and (5) clinical procedures.
- Relying on evidence-based best practice in all aspects of addressing the challenge.
- Fully engaging patients and service users as well as healthcare professionals in improvement and action plans.
- Ensuring the sustainability of all action beyond the initial two-year challenge period.

Pittet and Donaldson [22] state the vision of the World Alliance for Patient Safety: “to catalyse commitment by all players—policy makers, frontline staff, patients and managers—to make ‘Clean care is safer care’ an everyday reality in all countries and everywhere healthcare is provided.”

ANTIBIOTIC RESISTANCE AND APPROPRIATE ANTIBIOTIC USE

Antimicrobial resistance poses a particular challenge to developing countries where 45% of deaths are due to infectious diseases [WHO]. Albeit sparse, available information indicates that the problem is more pronounced in low-resource nations. The SENTRY Antimicrobial Surveillance Program identified the highest prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in its collaborating centers within the Far East and Latin America [24] whereas data from the Antibiotic Resistance Surveillance & Control in the Mediterranean Region (ARMed) project (www.slh.gov.mt/armed) has shown significantly greater multiresistance in *S. aureus* and *E. coli* within the south and east of the Mediterranean when compared with the more affluent European countries that form the northern border of this region. Studies have proposed a link, at least partial, between antimicrobial use and resistance [25], and it is generally accepted that a pragmatic approach aimed at encouraging good antibiotic prescribing practices should be adopted within healthcare institutions [26].

The axiom describing improper antibiotic prescribing in hospitals as “too many patients receiving unnecessary broadspectrum antibiotics by the wrong route, in the wrong dose and for too long” appears to be particularly relevant in developing countries. Such practices may stem from lack of knowledge of local antibiotic resistance epidemiology as result of inadequate laboratory support, which subsequently influences prescribers to use broadspectrum combinations that offer a stronger psychological reassurance. The situation is compounded by poor quality control of drug production with no guarantee that the indicated amount and type of active ingredient is actually present in the formulation being dispensed or for that matter whether the product being supplied is indeed genuine. Developing nations have reported major problems from counterfeit antibiotics, which either contain little or no active ingredient or in which excipients are adulterated [27]. These drugs proliferate despite the efforts of the regulatory local agencies that often do not possess the necessary analytic capabilities to detect these fakes.

There is good evidence that antibiotic stewardship programs have been successful in modifying antimicrobial prescribing practices, resulting in most instances in reduction of use [28]. Unfortunately, such programs often are lacking in developing countries. Data from ARMed have shown that in even centers with relatively established IC programs and infrastructure, antibiotic policy development, and prescriber feedback of resistance epidemiology often is lacking. Even when these initiatives are in place, sociocultural elements may pose considerable obstacles to progress. Misconceptions may be present among prescribers who feel that personal experience is more relevant than evidence-based recommendations. In the community, patients may choose to self-prescribe and buy over the counter to avoid a doctor’s fee or because access to medical advice is too difficult to obtain. Interventions that have been long accepted in Western countries, including prescriber audit and antibiotic restriction, are difficult to implement, especially among senior physicians who possess a high level of influence at both healthcare institution and national levels. Educational opportunities may be limited and the influence of pharmaceutical companies on prescribing decision making is significant. Donations of considerable quantities of antibiotics to healthcare institutions are common practices that often introduce a prescribing bias because the choice of drug would be influenced not on what is microbiologically indicated but on what is easily available (or least expensive).

In the light of these challenges, an integrated approach aimed at improving antibiotic stewardship both within hospitals and in the community is paramount in efforts to reduce HAIs. The WHO has identified, through its Global Strategy for Containment of Antimicrobial Resistance, several areas of intervention to reduce the burden of antimicrobial resistance. The starting point of any strategy needs to focus on training key individuals

and allocating resources for effective surveillance, IC, and therapeutic support. Even in the background of limited resources, educational interventions centered on teaching healthcare professionals, especially physicians, and developing and disseminating guidelines will yield good results and improve antibiotic use in healthcare institutions.

Antimicrobial Resistance in Europe

The European continent provides an interesting multifaceted picture of the epidemiology of multidrug-resistance and its consequences. Data on MRSA produced by the European Antimicrobial Resistance Surveillance System (EARSS) database immediately identifies a consistent north-south shift in prevalence. The north of the continent, especially the Scandinavian countries and Holland, are characterized by very low prevalence of MRSA, in some instances practically nonexistent. Central European countries, including Germany, Poland, and Austria, have intermediate prevalence rates with around 10% of *S. aureus* bacteremias being methicillin resistant. Most, if not all, of the Mediterranean countries exhibit extremely high MRSA infection rates with up to 50% of *S. aureus* isolates being resistant. The United Kingdom and some Eastern European countries (such as Romania) also follow this pattern. The high MRSA prevalence in the Mediterranean is not restricted only to the European countries of this region. Recent data from the ARMed project has confirmed that MRSA is a major challenge for all of the countries bordering this sea. MRSA proportions >50% have been reported from Turkey, Egypt, and Jordan [29]. (www.slh.gov.mt/armed).

It also is apparent that the problem continues to get worse. The most recent EARSS report documents a continued increase in antimicrobial resistance in Spain, Croatia, the United Kingdom, and Italy^(EARSS) [3]. Even in the lower prevalence countries, such as Germany, MRSA bacteremia rates have increased almost 20% from its 8.5% level at the beginning of the EARSS study. The Netherlands still maintains a low MRSA rate of 1.1%; however, even this is four times higher than its 1999 rate. There have been some success stories, most notably in Slovenia and France, but they are few and far between, and it is apparent that the struggle against MRSA in most of Europe is one of containment and damage limitation.

The recent emergence of community-acquired MRSA infection in a number of European countries, particularly France, in young, previously healthy adults admitted with severe necrotizing cellulites or pneumonia increases the importance of controlling MRSA transmission. The community-acquired strains of MRSA are distinct from those causing HAIs and often are found to carry the Panton Valentine leucocidin (PVL) gene [30]. Gould et al. have estimated that MRSA costs the National Health Service of the United Kingdom in excess of £500 million every year while Dancer et al. have calculated extra costs as a result of

MRSA infection in a British hospital to range from \$3,000 to \$30,000 per case [31] (Table 18-1).

IC Systems in the Former Soviet Union (FSU)

Most developing countries are facing similar problems, but there is a huge geopolitical space in which the situation with IC has several distinctive features. This is the former soviet union (FSU: Russia, Ukraine, Belarus, Central Asia, Caucasus, the Baltic states) and, to less extent, its former satellites in Eastern and Southern Europe. These countries have substantial economic, political, and cultural differences, but they share one critical aspect of hospital IC, which is its regulatory framework. In the FSU, HAIs were (and in some countries still are) included in the regulatory purview of an external body (the so-called Sanitary Epidemiologic Service [SES]). This bureau of classically trained epidemiologists and hygienists was responsible for gathering data on infectious diseases and taking corrective, historically authoritarian action. The requirements of SES concerning hospitals were regulated by outdated documents that paid most attention to hospital hygiene, virtually ignoring importance of patient-care practices as major risk factors. Until recently, punitive fines and outdated practices were the norm in IC, and some tension between SES and clinicians remains in many facilities. Although SES continues to wield its power, however, it is currently engaged in a reassessment of hospital epidemiology and IC, realizing that the focal point of IC efforts should be within healthcare facilities themselves.

In addition to a punitive regulatory environment, a historical reluctance to impart potentially embarrassing information coupled with problems in classification and diagnosis has and still prevents obtaining meaningful HAI surveillance data or national rate estimates. Recently conducted prospective prevalence studies based on the modern internationally recognized technologies (the most reliable data come from the Baltic states, Russia, Kyrgyzstan, and Georgia) have shown that the significance of various infections in most FSU countries obviously (as in many other countries with limited resources) differs from that in the developed countries. Proportion of UTIs, BSIs, and lower respiratory infections rates usually are lower, given relatively low use of invasive devices. At the same time, where reliable data exist, HAI rates often are higher than in the West. Data obtained in most parts of the FSU show that surgical site infections (SSIs) are 2-5 times more frequent compared to NNIS and European surveillance data, which may be partially explained by inadequate antimicrobial prophylaxis and technical and IC deficiencies. For example, Latvia and Lithuania reported overall HAI prevalence rates of 5.6% [32] and 9.2% [33]. Georgia and Russia reported overall SSI incidence rates of 14.7% [34] and 9.5% [35], and Kyrgyzstan reported an overall SSI prevalence rate of 20.2% [36].

TABLE 18-1
KEY RECOMMENDATIONS OF THE WHO GLOBAL STRATEGY FOR CONTAINMENT OF ANTIMICROBIAL RESISTANCE

1. Educate all groups of prescribers and dispensers (including drug sellers) in the importance of appropriate antimicrobial use and containment of antimicrobial resistance.
2. Promote targeted undergraduate and postgraduate educational programs for all health care workers, veterinarians, prescribers and dispensers on accurate diagnosis and management of common infections.
3. Encourage prescribers and dispensers to educate patients on antimicrobial use and the importance of adherence to prescribed treatments.
4. Improve antimicrobial use by supervision and support of clinical practices, especially diagnostic and treatment strategies.
5. Monitor prescribing and dispensing practices and utilize peer group or external standard comparisons to provide feedback and endorsement of appropriate antimicrobial prescribing.
6. Encourage development and use of guidelines and treatment algorithms to foster appropriate use of antimicrobials.
7. Empower formulary managers to limit antimicrobial use to the prescription of an appropriate range of selected antimicrobials.
8. Link professional registration requirements for prescribers and dispensers to requirements for training and continuing education.
9. Establish effective hospital therapeutics committees with responsibility for oversight of antimicrobial use in hospitals.
10. Develop and regularly update guidelines for antimicrobial treatment, prophylaxis, and hospital antimicrobial formularies.
11. Monitor antimicrobial usage, including quantity and patterns of use, and feed back results to prescribers.
12. Ensure on-site availability of microbiology laboratory services which are appropriately matched to the level of the hospital (e.g., secondary, tertiary).
13. Ensure performance and quality assurance of appropriate diagnostic tests, bacterial identification, antimicrobial susceptibility tests of key pathogens, and timely and relevant reporting of results.
14. Ensure that laboratory data are recorded (preferably on a database) and are used to produce clinically and epidemiologically useful surveillance reports of resistance patterns among common pathogens and infections in a timely manner and feed back to prescribers and the infection control programme.
15. Make the containment of antimicrobial resistance a national priority through the creation of a national intersectoral task force to raise awareness about antimicrobial resistance, organize data collection, and allocate resources to promote the implementation of interventions to contain resistance including appropriate utilization of antimicrobial drugs, control and prevention of infection, and research activities.

The antimicrobial resistance rates, especially MRSA, extended-spectrum beta lactamase (ESBL) producing gram-negatives, or vancomycin-resistant enterococci (VRE), are lower than in most developed countries, but they are increasing, and, taking into account the lack of restrictive antibiotic policies, it is predictable that such rates will increase in the near future.

SURVEILLANCE

Outcome Surveillance

Outcome surveillance is the measurement of the rates and consequences of HAIs, including but not limited to, the following few variables: HAI rates, mortality, extra length of stay, attributable cost, and resistance rates. Development of IC programs in industrialized countries has been supported by outcome surveillance data. Baseline epidemiology should include the previously mentioned activities to plan specific targeted interventions, the most relevant one being the HAI rate.

Outcome surveillance allows evaluation of the cost-effectiveness of specific IC interventions. Such methods also are used to analyze case-control studies to identify risk

factors and determine extra cost and mortality. In summary, outcome surveillance is the infrastructure for HAI management. Outcome surveillance of DAI [37,38] has become an integral feature of IC and quality assurance in the industrialized countries since risk adjustment by device use and duration of stay provides a more precise estimate of risk.

Standards for institutional surveillance have been adopted in the United States [37], UK [39], Australia [40], Canada [41], and Germany [42] among other countries. These industrialized countries report HAI rates as DAI per 1,000 device days, allowing them to further analyze the impact of specific risk factors and guide their targeted interventions.

Developing countries more frequently report percentage (cases over discharges or admissions) of HAIs [43–68] (Table 18-2).

Risk of infection is higher among seriously ill patients who often have several indwelling devices, thus the higher infection rates in ICUs. Because the denominator of number of device-days is unknown, it is impossible to compare rates among the hospitals, and the rates are less useful for secular trend comparisons within the same hospital.

Sometimes the HAI rate is reported as number of infections per 1,000 patient-days [43–46,49–53,56–59,66,

TABLE 18-2
OVERALL HEALTHCARE-ASSOCIATED INFECTION RATES IN FACILITIES FROM COUNTRIES
DEFINED AS LOW INCOME BY THE WORLD BANK REPORTED AS CRUDE RATES: PROPORTION
INFECTED OVER PATIENTS DISCHARGED OR ADMITTED TO THE UNITS AND REPORTED
AS PROPORTION INFECTED PER 1,000 PATIENT-DAYS IN THE UNIT OR HOSPITAL

Country	Type of Study/Unit	Type of HAI	HAI Rate (%)	Year	Reference
Argentina	Multicenter adult ICU	Overall	27.0	2003	[43]
Brazil	Multicenter new born ICU	Overall	28.1	2004	[44]
Brazil	Multicenter adult ICU	Overall	29.6	2006	[45]
Brazil	Newborn ICU	Overall	50.7	2002	[46]
Chile	Hospitalwide	Overall	14.0	2001	[47]
China	Hospitalwide	Overall	3.04	2005	[48]
Colombia	Newborn ICU	Overall	5.3	2005	[49]
Colombia	Multicenter adult ICU	Overall	12.2	2006	[50]
Croatia	Adult ICU	Overall	7.0	2006	[51]
Egypt	Pediatric ICU	Overall	23.0	2005	[52]
India	Multicenter adult ICU	Overall	12.3	2005	[53]
Mexico	Hospitalwide	Overall	21.0	2002	[54]
Mexico	Multicenter adult ICU	Overall	23.2	2000	[55]
Mexico	Multicenter adult ICU	Overall	24.4	2006	[56]
Morocco	Adult medical ICU	Overall	19.3	2005	[57]
Peru	Multicenter adult ICU	Overall	11.2	2005	[58]
Philippines	Adult ICU	Overall	19.1	2006	[59]
Saudi Arabia	Multicenter hospitalwide	Overall	2.8	2004	[60]
Saudi Arabia	Hospitalwide maternity hospital	Overall	4.0	2002	[61]
Saudi Arabia	Hospitalwide	Overall	8.5	2002	[62]
Saudi Arabia	Adult ICU	Overall	19.8	2002	[62]
Saudi Arabia	Newborn ICU	Overall	35.8	2002	[62]
Tanzania	Multicenter hospitalwide	Overall	14.8	2003	[63]
Tanzania	Adult medical ICU	Overall	40.0	2003	[63]
Turkey	Adult ICU	Overall	12.5	2000	[64]
Turkey	Adult ICU	Overall	33.0	2003	[65]
Turkey	Multicenter adult ICU	Overall	43.1	2005	[66]
Turkey	Multicenter adult ICU	Overall	48.7	2004	[67]
Turkey	Neurology ICU	Overall	88.9	2005	[68]
INICC	Multicenter adult ICU	Overall	15.1	2005	[154]
Argentina	Multicenter adult ICU	Overall	90.0 per 1,000 patient-days	2003	[43]
Brazil	Multicenter adult ICU	Overall	30.6 per 1,000 patient-days	2006	[45]
Brazil	Multicenter newborn ICU	Overall	24.9 per 1,000 patient-days	2004	[44]
Brazil	Newborn ICU	Overall	62.0 per 1,000 patient-days	2002	[46]
Colombia	Newborn ICU	Overall	6.2 per 1,000 patient-days	2005	[49]
Colombia	Multicenter adult ICU	Overall	18.2 per 1,000 patient-days	2006	[50]
Croatia	Adult ICU	Overall	25.6 per 1,000 patient-days	2006	[51]
Egypt	Pediatric ICU	Overall	40.0 per 1,000 patient-days	2005	[52]
India	Multicenter adult ICU	Overall	21.4 per 1,000 patient-days	2005	[53]
India	Hospitalwide	Overall	36.2 per 1,000 patient-days	2004	[69]
Mexico	Multicenter adult ICU	Overall	39.0 per 1,000 patient-days	2006	[56]
Morocco	Adult medical ICU	Overall	20.4 per 1,000 patients-days	2005	[57]
Peru	Multicenter adult ICU	Overall	25.3 per 1,000 patient-days	2005	[58]
Philippines	Adult ICU	Overall	27.5 per 1,000 patient-days	2006	[59]
Turkey	Multicenter adult ICU	Overall	48.4 per 1,000 patient-days	2005	[70]
Turkey	Neurology ICU	Overall	84.2 per 1,000 patient-days	2005	[66]
INICC ^a	Multicenter adult ICU	Overall	22.9 per 1,000 patient-days	2005	[154]

^aInternational Nosocomial Infection Control Consortium.

262 Section I: General Considerations of Hospital Infections

69,70], but again, the rates may not be compared because of the lack of appropriate denominators.

Device-days were reported in the following recent studies, and infection rates were calculated by number of infections per 1,000 device-days [44,45,50–53,56–59, 66,71–76] (Table 18-3).

Rates of DAI in developing countries were far higher than reported by the NNIS system: The overall rate of CVC-BSI in the International Nosocomial Infection Control Consortium (INICC) medical–surgical ICUs, 12.5 per 1,000 CVC days, is nearly fourfold higher than the 3.4 per 1,000 CVC-days reported for comparable U.S. ICUs; the

TABLE 18-3
DEVICE-ASSOCIATED INFECTIONS REPORTED BY HOSPITALS FROM COUNTRIES DEFINED AS LOW INCOME BY THE WORLD BANK

Country	Type of Study/Unit	Type of HAI	HAI Rate	Year	Reference
Argentina	Multicenter adult ICU	IVD-BSI ^a	30.3 per 1,000 central line days	2004	[71]
Brazil	Multicenter adult ICU	IVD-BSI	9.2 per 1,000 central line days	2006	[45]
Brazil	Multicenter new born ICU	IVD-BSI	17.3 to 34.9 per 1,000 central line days	2004	[44]
Colombia	Multicenter adult ICU	IVD-BSI	11.3 per 1,000 central line days	2006	[50]
Croatia	Adult ICU	IVD-BSI	8.3 per 1,000 central line days	2006	[51]
Egypt	Pediatric ICU	IVD-BSI	18.7 per 1,000 central line days	2005	[52]
India	Multicenter adult ICU	IVD-BSI	11.1 per 1,000 central line days	2005	[53]
Mexico	Multicenter adult ICU	IVD-BSI	23.1 per 1,000 central line days	2006	[56]
Mexico	Pediatric ward	IVD-BSI	26.0 per 1,000 central line days	2001	[72]
Morocco	Adult medical ICU	IVD-BSI	5.8 per 1,000 central line days	2005	[57]
Peru	Multicenter adult ICU	IVD-BSI	7.8 per 1,000 central line days	2005	[58]
Philippines	Adult ICU	IVD-BSI	8.6 per 1,000 central line days	2006	[59]
Turkey	Hospitalwide	IVD-BSI	9.2 per 1,000 central line days	2004	[73]
Turkey	Multicenter adult ICU	IVD-BSI	24.5 per 1,000 central line days	2005	[66]
Saudi Arabia	Pediatric ICU	IVD-BSI	20.0 per 1,000 central line days	2006	[74]
INICC	Multicenter adult ICU	IVD-BSI	13.0 per 1,000 central line days	2005	[154]
Argentina	Multicenter adult ICU	VAP ^b	46.3 per 1,000 ventilator-days	2004	[71]
Brazil	Multicenter adult ICU	VAP	21.2 per 1,000 ventilator-days	2006	[45]
Brazil	Multicenter newborn ICU	VAP	7.0 to 9.2 per 1,000 ventilator-days	2004	[44]
China	Adult ICU	VAP	32.4 per 1,000 ventilator-days	2004	[75]
Colombia	Multicenter adult ICU	VAP	10.0 per 1,000 ventilator-days	2006	[50]
Croatia	Adult ICU	VAP	47.8 per 1,000 ventilator-days	2006	[51]
Egypt	Pediatric ICU	VAP	10.9 per 1,000 ventilator-days	2005	[52]
India	Multicenter adult ICU	VAP	38.1 per 1,000 ventilator-days	2005	[53]
Mexico	Multicenter adult ICU	VAP	21.8 per 1,000 ventilator-days	2006	[56]
Mexico	Pediatric ward	VAP	28.0 per 1,000 ventilator-days	2001	[72]
Morocco	Adult ICU	VAP	48.1 per 1,000 ventilator-days	2005	[57]
Peru	Multicenter adult ICU	VAP	33.3 per 1,000 ventilator-days	2005	[58]
Philippines	Adult ICU	VAP	22.7 per 1,000 ventilator-days	2006	[59]
Saudi Arabia	Pediatric ICU	VAP	8.9 per 1,000 ventilator-days	2004	[76]
Turkey	Multicenter adult ICU	VAP	36.5 per 1,000 ventilator-days	2005	[66]
INICC ^c	Multicenter adult ICU	VAP	24.6 per 1,000 ventilator-days	2005	[154]
Argentina	Multicenter adult ICU	CAUTI ^d	18.5 per 1,000 device-days	2004	[71]
Brazil	Multicenter adult ICU	CAUTI	9.8 per 1,000 device-days	2006	[45]
Colombia	Multicenter adult ICU	CAUTI	4.3 per 1,000 device-days	2006	[50]
Croatia	Adult ICU	CAUTI	6.0 per 1,000 device-days	2006	[51]
Egypt	Pediatric ICU	CAUTI	25.5 per 1,000 device-days	2005	[52]
India	Multicenter adult ICU	CAUTI	5.7 per 1,000 device-days	2005	[53]
Mexico	Multicenter adult ICU	CAUTI	13.4 per 1,000 device-days	2006	[56]
Morocco	Adult medical ICU	CAUTI	12.5 per 1,000 device-days	2005	[57]
Peru	Multicenter adult ICU	CAUTI	6.2 per 1,000 device-days	2005	[58]
Philippines	Adult ICU	CAUTI	22.0 per 1,000 device-days	2006	[59]
Turkey	Multicenter adult ICU	CAUTI	11.1 per 1,000 device-days	2005	[66]
INICC	Multicenter adult ICU	CAUTI	9.8 per 1,000 device-days	2005	[154]

^aIVD-BSI;

^bVAP;

^cInternational Nosocomial Infection Control Consortium.

^dCAUTI.

Chapter 18: Infection Control in Developing Countries 263

overall rate of VAP also was higher than the pooled NNIS rates, 24.1 vs. 5.1 per 1,000 ventilator-days, respectively, and the rate of CAUTI was 8.9 compared with 3.3 per 1,000 catheter-days [45,50,51,53,56–59,66,71].

There are a number of explanations for the higher rates of DAIs in developing country ICU patients [72,77,78]. Most developing countries do not have mandatory laws for HAI control programs and hospital accreditation is not mandatory. Hand hygiene is highly variable [79–81]. There are very limited funds and resources for IC [82–85], and nurse-to-patient staffing ratios are lower than in most industrialized countries. Use of outdated technology also is a factor (e.g., use of open rather than closed intravenous infusion and urinary collection systems [86]).

In developing countries, the perception is generally that HAI rates are low and that compliance with hand hygiene recommendations are high. However, frequently no formal outcome and process surveillance is conducted to validate the perception. Outcome surveillance of DAIs defines the magnitude of the problem, identifies the most high risk devices, and provides the framework for planning to reduce infection risk [3]. The second step is to implement targeted specific IC practices that have been shown to prevent HAI [87–91].

The authors have evaluated hospitals in which outcome and process surveillance has been the driving force to reduce HAI risk and related mortality. Targeted incidence of CVC-associated BSIs, CA-UTIs, and nosocomial pneumonia in many developing countries hospitals have been substantially reduced by the institution of outcome surveillance, process surveillance, and targeted performance feedback programs for hand hygiene, central venous catheter, ventilator, and urinary catheter care [92–106].

Process Surveillance

Process surveillance is the standardized collection of data regarding the IC practices actually used in the facility. This includes compliance with hand hygiene recommendations, vascular catheter care, urinary catheter care, measures to prevent VAP (such as position of the head and type of secretion suctioning), and measures to prevent SSI (e.g., presurgical shower, hair removal, antibiotic prophylaxis, etc.). Process surveillance usually is done by observation of actual practices, analysis of the data, and performance feedback to the healthcare personnel.

Hand hygiene is a fundamental aspect of IC; several studies reported a decline in HAI rates when compliance with hand hygiene is enhanced [107–112]. Despite universal acknowledgment of the pivotal role that hand hygiene and device care play in reducing HAI risk, hand hygiene compliance among healthcare workers in developing countries remains poor, with rates ranging from 9% to 75% [92,113–132] (Table 18-4).

A survey of 163 physicians reported that their compliance with hand hygiene recommendations was associated

with awareness of being observed, and this is one of the key aspects of process surveillance [133]. Several interventions have been attempted to improve hand hygiene practices; among the most effective are those that emphasize targeted education, process surveillance, and frequent performance feedback [134–138]. Dubbert et al. found that while education alone improved compliance rates in a transient way, process surveillance and performance feedback resulted in sustained improvement in compliance [134].

In developing countries, implementation of education, process surveillance, and performance feedback considerably enhanced hand hygiene [92,114,116,126,139–142] [Table 18-5].

Numerous strategies have been attempted to enhance compliance with hand hygiene; some of them have resulted in improved short-term compliance [134,143,144], (but achievement of sustained improvement remains elusive [109]. In Argentina between April 1999 and October 2003, 15,531 patient contacts were observed in one hospital. The baseline rate of hand hygiene before contact with patients was 17%. With education, process surveillance, and performance feedback, hand hygiene before contact with the patients increased to 58% [114]. This program consisted of frequent focused education of healthcare workers, process surveillance, and performance feedback. Simultaneously, HAI rates were measured at baseline [71] and during the intervention to determine whether improved compliance would be associated with a reduction in HAIs. A 42% relative reduction in HAI rates was reported [92]. Lower adherence was found among physicians, similar to results reported in industrialized countries [133].

Process surveillance for vascular and urinary catheter care also has been effective in reducing associated HAIs in several previous studies conducted in developing countries, such as Argentina [92–94,139], Brazil [95,96], Colombia [97], India [98–100], Mexico [101,103], and Turkey [104–106] among others.

The International Nosocomial Infection Control Consortium (INICC) Program

INICC (www.INICC.org) is a nonprofit, open, multicenter, international, collaborative program modeled on the U.S. NNIS system. Formed in 1998, it is the first international research network and is responsible for much national and global progress. Founded in Argentina, it is a prospective, targeted, and outcome and process surveillance system designed to identify and reduce HAI rates and their consequences in the participating facilities. INICC employs a multiple-approach strategy combining the following interventions: outcome surveillance, process surveillance, performance feedback, targeted interventions guided by risk factor analysis, cost-effective interventions guided by cost analysis, tutorial for surveillance, training in IC guidelines application, secretarial and administrative support in entering data and developing charts, scientific

TABLE 18-4
BASELINE HAND HYGIENE COMPLIANCE BEFORE CONTACT WITH PATIENTS REPORTED BY HOSPITALS FROM COUNTRIES DEFINED AS LOW INCOME BY THE WORLD BANK

Country	Type of Study/Unit	Number of Observations	Hand Hygiene Compliance (%)	Year	Reference
Algeria	Multicenter hospitalwide		18.6	2006	[113]
Argentina	Multicenter adult ICU	15,531	17.0	2003	[114]
Argentina	Adult ICU	1,160	23.1	2005	[92]
Brazil	Multicenter adult ICU	3407	71.5	2004	[115]
China	Newborn ICU		40.0	2004	[116]
Eritrea (Africa)	Hospitalwide		30.0	2005	[117]
South Africa	Hospitalwide		65.2	2003	[118]
Colombia	Multicenter adult ICU	1,692	48.9	2004	[119]
Egypt	Multicenter hospitalwide		52.8	2006	[113]
India	Multicenter adult ICU	588	74.8	2005	[120]
Mexico	Multicenter adult ICU	6,861	35.8	2004	[121]
Mexico	Pediatric ICU	321	64.5	2004	[122]
Mexico	Newborn ICU	1,070	46.3	2005	[123]
Morocco	Adult ICU	139	64.0	2005	[124]
Morocco	Multicenter hospitalwide		16.9	2006	[113]
Peru	Multicenter adult ICU	1,329	63.1	2004	[125]
Russia	Newborn ICU	1,027	44.2	2003	[126]
Thailand	Hospitalwide		24.1	2003	[127]
Tunisia	Multicenter hospitalwide		32.3	2006	[113]
Turkey	Adult ICU		12.9	2002	[128]
Turkey	Multicenter adult ICU	4,657	28.8	2004	[129]
Turkey	Hospitalwide	1,400	31.9	2005	[130]
Turkey	Hematology unit	638	9.0	2005	[131]
INICC ^a	Multicenter adult ICU	62,626	50.9	2006	[132]

^aInternational Nosocomial Infection Control Consortium.

data analysis and data interpretation to guide actions, sharing data at scientific meetings and in peer-reviewed journals, and cooperating with hospitals and organizations worldwide. Hospitals review the protocol with their research committees and agree to full participation by signing a commitment sheet and sending it to the INICC central office in Buenos Aires, which then provides analysis and reports monthly, answers questions, and augments the tutorial with personal instruction when needed.

Forms and software designed to record data and direct IC activity are used for both control patients without HAI and cases with HAI. These forms include name, medical record, age, gender, underlying diseases, and severity of illness score at the time of entrance to the ICU. On a daily basis, information regarding temperature, blood pressure, device-days, cultures taken, presence of clinical pneumonia, antibiotic use, and characteristics of any infection is collected both for cases and controls. Thus, it is

TABLE 18-5
RESULTS REPORTED BY PROGRAMS TO IMPROVE HAND HYGIENE COMPLIANCE IN HOSPITALS FROM COUNTRIES DEFINED AS LOW INCOME BY THE WORLD BANK

Country	Type of Study/Unit	Hand Hygiene Compliance Improvement (%)	Year	Reference
Argentina	Multicenter adult ICU	17.0 to 44.0	2003	[114]
Argentina	Adult ICU	23.1 to 64.5	2005	[92]
China	Newborn ICU	40.0 to 53.0	2004	[116]
Mexico	Multicenter adult ICU	35.8 to 75.8	2004	[140]
Mexico	Newborn ICU	46.3 to 67.7	2005	[141]
Russia	Newborn ICU	44.2 to 48.0	2003	[126]
Turkey	Multicenter adult ICU	11.9 to 43.9	2005	[142]

also possible to analyze cases and controls in a prospective cohort nested study [45,50,51,53,56–59,66,71].

At the same time, process surveillance and performance feedback are done for hand hygiene compliance, vascular and urinary catheter care, and mechanical ventilator care. Additional data collected include (1) placement of gauze on intravascular (IV) access insertion sites, marking the date on the IV administration set, condition of the gauze dressing (the presence or absence of moisture, blood, gross soilage, and the appearance of the insertion site), (2) position of the urinary catheter regarding the leg and position of urine bag regarding the bed, position of the bed head, cleanliness of tubes, aspiration technique, and (3) hand hygiene with alcohol hand rub or hand washing with water and antiseptic soap before patient contact. Data are entered into a standard form by local researchers who observed healthcare worker practices in the study units five days a week.

INICC has reported HAI and mortality results from several participating hospitals that applied both outcome and process surveillance (Table 18-6) [86,92–106,139].

Recently, INICC has joined with the International Federation of Infection Control (IFIC) to develop and test clinical definitions to facilitate surveillance in hospitals

that lack laboratory capabilities and thus prevent the hospitals from using the laboratory-based NNIS definitions.

ECONOMIC VALUATION: COSTS OF INFECTIONS, COSTS, AND BENEFITS OF IC

HAIs cost lives, reduce quality of life, and cause loss of productivity; occasionally, patients and/or their families are never whole again. Attributable costs include hospital stay (room and board), drugs and treatment, diagnostic tests, outbreak investigations, and surgical interventions; usually uncounted costs include time off work for patient and family, outpatient care, and societal loss of productivity. All of these costs cannot be adequately quantified, but some costs can be attached mostly derived from sophisticated hospitals:

- In the United Kingdom, Plowman reported an overall HAI rate of 7.8% based on 4,000 patients in a local hospital. These patients experienced a stay 11 days longer due to their HAI and costs 2.8 times higher than

TABLE 18-6
BEFORE AND AFTER STUDIES SHOWING HAI AND MORTALITY RATES REDUCTION BY APPLYING INICC STRATEGY

Country	Study Type	ICU	Reduction	RR ^a	CI ^b (95%)	p-Value	Ref
Argentina	Overall D-AI	A	41.0%; 47.56 to 27.9/1,000 bed-days	0.59	0.46–0.74	<0.0001	[92]
	IVD-BSI	A	75.0%; 45.9 to 11.1/1,000 catheter-days	0.25	0.17–0.36	<0.001	[93]
	IVD-BSI	A	64.0%; 6.5 to 2.4/1,000 catheter-days	0.36	0.14–0.94	0.02	[86]
	VAP ^e	A	31.0%; 51.3 to 35.5/1,000 ventilator-days	0.69	0.49–0.98	0.003	[139]
	CAUTI	A	42.0%; 21.3 to 12.4/1,000 catheter-days	0.58	0.39–0.86	0.006	[94]
Brazil	IVD-BSI	A	50.0%; 14.0 to 7.1/1,000 CVC-days	0.50	0.32–0.8	0.002	[95]
	IVD-BSI	A	54.0%; 7.1 to 3.2/1,000 CVC-days	0.46	0.23–0.91	0.02	[96]
Colombia	IVD-BSI	N	89.0%; 54.8 to 6.0/1,000 CVC-days	0.11	0.01–0.98	0.01	[97]
India	Overall D-AI	A	99.3%; 3.9 to 0.3/1,000 bed-days	0.07	0.02–0.34	0.000	[98]
	Overall D-AI	A	62.0%; 18.1 to 6.9/1,000 bed-days	0.38	0.19–0.78	0.006	[99]
	Mortality	A	78.0%; 1.9 to 0.4/1,000 bed-days	0.22	0.06–0.74	0.007	[100]
	IVD-BSI	A	54.0%; 22.6 to 10.3/1,000 bed-days	0.46	0.21–0.98	0.03	[99]
	VAP	A	50.6%; 29.1 to 14.4/1,000 ventilator-days	0.49	0.26–0.93	0.02	[100]
	CAUTI	A	88.8%; 4.5 to 0.5/1,000 catheter-days	0.11	0.01–0.86	0.01	[100]
Mexico	Overall D-AI	N	62.0%; 13.0% to 5.0%	0.38	0.15–0.99	0.0	[103]
	Mortality	A	78.0%; 48.5% to 32.8%	0.68	0.50–0.81	0.01	[101]
	Mortality	A	33.0%; 27.0% to 16.6%	0.67	0.52–0.87	0.002	[102]
	IVD-BSI	A	58.0%; 46.3 to 19.5/1,000 CVC-days	0.42	0.27–0.66	0.0001	[101]
	IVD-BSI	A	82.0%; 17.0 to 3.0/1,000 CVC-days	0.18	0.10–0.32	0.000	[102]
	IVD-BSI	N	75.0%; 40.7 to 10.3/1,000 CVC-days	0.25	0.08–0.84	0.01	[103]
Turkey	Overall D-AI	A	39.0%; 30.0 to 18.3/1,000 bed-days	0.61	0.38–0.98	0.03	[104]
	IVD-BSI	A	82.0%; 10.0 to 1.8/1,000 CVC-days	0.18	0.05–0.6	0.001	[105]
	IVD-BSI	A	82.0%; 29.1 to 13.0/1,000 CVC-days	0.45	0.24–0.82	0.007	[106]

ICU: A = adult; N = neonatal; D-AI = device-associated infection; VAP = ventilator-associated pneumonia; CAUTI = catheter-associated urinary tract infection; IVD-BSI = intravenous device-associated bloodstream infection; CVC = central venous catheter.

266 Section I: General Considerations of Hospital Infections

uninfected, matched patients; 13% of infected patients died compared with 2% of uninfected patients [145].

- Stone reported results of a systematic audit linking costs of infections and IC interventions. Fifty-five IC studies published between 1990 and 2000 from North America, Europe, Australia, Asia, and South America were reviewed. The investigators found that length of stay decreased from 7.9 to 5.3 during the period but that HAI rates increased from 7.2 to 0.9 per 1,000 patient-days. The average cost for HAIs was \$13,973US [145].
- Rosenthal reported HAI rates from ICUs in 10 developing countries to be 3 to 5 times higher than those reported by the NNIS system [45,50,51,53,56–59,66,71]
- Rosenthal also reported that in developing countries, VAP increased length of stay by 9 extra days and increased cost by \$2,255 [146] and that CVC-BSIs increased length of stay by 12 extra days and increased cost by \$4,888 in Argentina [147], and in Mexico, CVC-BSIs increased length of stay by 6 extra days and increased costs by \$11,591 [148].

Who Pays for Infections?

Payer sources for hospitalization can be classified as follows:

- *Single payer systems, such as a government agency, in which all costs and savings accrue to a single budget.* The economic argument for establishing and funding an effective IC program is obvious.
- *Mixed payers such as a combination of government and insurance funding.* These still have a strong economic incentive for effective infection prevention even if there is a fee-for-service component.
- *Fee-for-service health care.* These facilities have little incentive to fund infection prevention, and cost-saving arguments are contrary to their interests. They may be persuaded to improve infection prevention by appealing to national pride, providing statistics from comparable countries, using adverse publicity, and threatening litigation.

Benefits of IC

Many studies have shown that effective infection prevention saves lives and money, but the data usually are from developed countries with single or mixed payer funding. In the United States, the CDC estimated in 2000 that the national cost for HAIs was \$6 billion [149]. Haley reported that effective prevention programs in U.S. hospitals reduced HAI rates by 32%; HAIs rank in the top 10 causes of death in the United States. Effective programs conducted outcome surveillance, reported SSI rate data to surgeons, and had a trained physician directing the program and one infection control practitioner for every 250 beds [150]. HAIs are major contributors to complications of health care; one U.S. study reported that between 44,000 and 99,000 deaths

annually are attributable to HAIs. The study also reported that the NNIS system had a positive effect in reducing HAI rates among the participating hospitals [151].

The Keystone Project

Results from the Michigan Health and Hospital Association/Johns Hopkins Hospital Quality & Safety Research Group were announced in October 2005 for 120 hospital ICUs in the state of Michigan [152]. Participating hospitals enforced “best practices” derived from evidence-based studies. Using a predictive model and data collected from project participants, the study reported the total savings after 15 months of study and practice changes was follows:

- Patient lives saved: 1578
- Hospital-days saved: 81,020
- Healthcare dollars saved: \$165,534,736

Hospitals participating in Keystone have reduced CVC-BSI infections by 50%. Sixty-eight of the participating ICUs reported no CVC-BSIs or VAPs for six months or more

IC SOCIETIES: FORCE FOR CHANGE

During the 1950s, a pandemic of HAIs caused by a particularly virulent Staphylococcal 80/81 strain caught the attention of government agencies in the United States and England. Several national conferences were held in each country and, in the United States, led to recommendations from the CDC. The first formal IC program was in England, followed closely by two in the United States.

As the pandemic subsided in the early 1960s, major institutions in several countries began forming committees and appointing physicians, nurses, and laboratorians as IC coordinators. Because education and training in IC was not available as part of the undergraduate work in any of these fields, short workshops were developed, and the multidisciplinary participants began meeting together to share literature and information and to improve skills. By the late 1960s, many more hospitals were benefiting from IC programs and the need for training increased, resulting in 10–14-day workshops in several countries and languages, some of which continue now.

The first national, multidisciplinary IC societies were formed in the early 1970s and are responsible for much national and global progress: professionals are more likely to be effectively focused on the problem, education, research, and solutions than government agencies and are less likely to be distracted by political concerns. Just as the new IC professionals needed support, education, and a network of more experienced individuals, the new IC societies soon found that they also needed some of the same things. IC nurses from United States, United Kingdom, Sweden, Canada, and Denmark requested WHO support for an international IC meeting WHO sponsored the meeting attended by 75 professionals from 25 countries in

1978, and the development of the International Federation of Infection Control (www.theIFIC.org) began soon after. IFIC members are the national IC societies of more than 55 countries [153] the following are pertinent for the IFIC:

Vision: Every nation has a functioning IC organization.

Mission: The IFIC provides the essential tools, education materials, and communication that unite the existing IC societies and foster development of IC organizations where they are needed.

- IFIC fosters global development of IC societies and improvement in infection prevention practices by providing a communication network to promote education, training, and exchange of information among the member societies with particular emphasis on assisting those with limited resources.

Regional and international networks are an integral part of IFIC:

- Asia Pacific Society of Infection Control (APUSIC).
- Eastern Mediterranean Regional Network for IC (EMR-NIC).
- Baltic Network for Infection Control and Containment of Antimicrobial Resistance (BALTICCARE).
- Southeastern Europe Infection Control (SEEIC).
- International Nosocomial Infection Control Consortium (INICC).

CONCLUSION

It is clear that HAIs are a huge and largely unrecognized threat to patient safety in the developing world, a far greater than in the developed countries. Successful research in developing countries combined with intensive ongoing efforts to more consistently implement simple and inexpensive measures for prevention will lead to wider acceptance of IC practices in all hospitals of the developing countries.

REFERENCES

1. Nightingale F. *Notes on hospitals*. London: John W Parker,
2. Fauci AS. Infectious diseases: considerations for the 21st century. *Clin Infect Dis* 2001;32(5):675–685.
3. Hughes JM. Study on the efficacy of nosocomial infection control (SENIC Project): results and implications for the future. *Chemotherapy* 1988;34(6):553–561.
4. Jarvis WR. Selected aspects of the socioeconomic impact of nosocomial infections: morbidity, mortality, cost, and prevention. *Infect Control Hosp Epidemiol* 1996;17(8):552–527.
5. Diaz Molina C, Martinez de la Concha D, Salcedo Leal I, et al. Influence of nosocomial infection on mortality in an intensive care unit. *Gac Sanit* 1998;12(1):23–28.
6. Fagon JY, Chastre J, Vuagnat A, et al. Nosocomial pneumonia and mortality among patients in intensive care units. *JAMA* 1996;275(11):866–869.
7. Papazian L, Bregeon F, Thirion X, et al. Effect of ventilator-associated pneumonia on mortality and morbidity. *Am J Respir Crit Care Med* 1996;154(1):91–97.
8. Heyland DK, Cook DJ, Griffith L, et al. The attributable morbidity and mortality of ventilator-associated pneumonia in the critically ill patient: the Canadian Critical Trials Group. *Am J Respir Crit Care Med* 1999;159(4 Pt 1):1249–1256.
9. Digiovine B, Chenoweth C, Watts C, Higgins M. The attributable mortality and costs of primary nosocomial bloodstream infections in the intensive care unit. *Am J Respir Crit Care Med* 1999;160(3):976–981.
10. Laupland KB, Zygun DA, Doig CI, et al. One-year mortality of bloodstream infection-associated sepsis and septic shock among patients presenting to a regional critical care system. *Intensive Care Med* 2005;31(2):213–219.
11. Blot S, De Bacquer D, Hoste E, et al. Influence of matching for exposure time on estimates of attributable mortality caused by nosocomial bacteremia in critically ill patients. *Infect Control Hosp Epidemiol* 2005;26(4):352–356.
12. Osmon S, Ward S, Fraser VJ, Kollef MH. Hospital mortality for patients with bacteremia due to *Staphylococcus aureus* or *Pseudomonas aeruginosa*. *Chest* 2004;125(2):607–616.
13. Tambyah PA, Knasinski V, Maki DG. The direct costs of nosocomial catheter-associated urinary tract infection in the era of managed care. *Infect Control Hosp Epidemiol* 2002;23(1):27–31.
14. Emori TG, Culver DH, Horan TC. National nosocomial infections surveillance system (NNIS): description of surveillance methods. *Am J Infect Control* 1991;19(1):19–35.
15. Horan TC, Emori TG. Definitions of key terms used in the NNIS System. *Am J Infect Control* 1997;25(2):112–116.
16. Garner JS, Jarvis WR, Emori TG, et al. CDC definitions for nosocomial infections, 1988. *Am J Infect Control* 1988;16(3):128–140.
17. Lynch P, Jackson M, Saint S. Research Priorities Project, year 2000: establishing a direction for infection control and hospital epidemiology. *Am J Infect Control* 2001;29(2):73–78.
18. Hauri AM, Armstrong GL, Hutin YJ. The global burden of disease attributable to contaminated injections given in health care settings. *Int J STD AIDS* 2004;15(1):7–16.
19. Zaidi AK, Huskins WC, Thaver D, et al. Hospital-acquired neonatal infections in developing countries. *Lancet* 2005;365(9465):1175–1188.
20. Organisation WH. Removing obstacles to healthy development. 2006; (www.who.int/infectious-disease-report/index-rpt99.html) accessed February 28, 2006.
21. Lawn JE, Cousens S, Bhutta ZA, et al. Why are 4 million newborn babies dying each year? *Lancet* 2004;364(9432):399–401.
22. Pittet D, Donaldson L. Clean care is safer care: the first global challenge of the WHO World Alliance for Patient Safety. *Am J Infect Control* 2005;33(8):476–479.
23. www.who.int/en/, accessed April 29, 2006.
24. Diekema DJ, Pfaller MA, Schmitz FJ, et al. Survey of infections due to *Staphylococcus* species: frequency of occurrence and antimicrobial susceptibility of isolates collected in the United States, Canada, Latin America, Europe, and the Western Pacific region for the SENTRY Antimicrobial Surveillance Program, 1997–1999. *Clin Infect Dis* 2001;32 (suppl 2):S114–S132.
25. Gaynes R. The impact of antimicrobial use on the emergence of antimicrobial-resistant bacteria in hospitals. *Infect Dis Clin North Am* 1997;11(4):757–765.
26. Maccougall C, Polk RE. Antimicrobial stewardship programs in health care systems. *Clin Microbiol Rev* 2005;18(4):638–656.
27. Okeke IN, Lamikanra A, Edelman R. Socioeconomic and behavioral factors leading to acquired bacterial resistance to antibiotics in developing countries. *Emerg Infect Dis* 1999;5(1):18–27.
28. Gould IM. A review of the role of antibiotic policies in the control of antibiotic resistance. *J Antimicrob Chemother* 1999;43(4):459–465.
29. Borg MA, Scicluna E, de Kraker M, et al. Antibiotic Resistance in the South-Eastern Mediterranean—preliminary results from the ARMed Project, 2006 (www.slh.gov.mt/armed).
30. Vandenesch F, Naimi T, Enright MC, et al. Community-acquired methicillin-resistant *Staphylococcus aureus* carrying Panton-Valentine leukocidin genes: worldwide emergence. *Emerg Infect Dis* 2003;9(8):978–984.
31. Gould IM. The clinical significance of methicillin-resistant *Staphylococcus aureus*. *J Hosp Infect* 2005;61(4):277–282.
32. Dumpis U, Balode A, Vigante D, et al. Prevalence of nosocomial infections in two Latvian hospitals. *Euro Surveill* 2003;8(3):73–78.

268 Section I: General Considerations of Hospital Infections

33. Valinteliene R, Jurkuvenas V, Jepsen OB. Prevalence of hospital-acquired infection in a Lithuanian hospital. *J Hosp Infect* 1996;34(4):321-329.
34. Brown S. Incidence of surgical site infection in Tbilisi, Georgia. 12th Annual Meeting of the Society for Healthcare Epidemiology of America, April 6-9, 2006, Salt Lake City, Utah.
35. Brown S, Kyrgyzstan. The incidence of surgical site infections in St. Petersburg, Russia. 11th Annual Meeting of the Society for Healthcare Epidemiology of America, April 1-3, 2001, Toronto, Canada.
36. Djumalieva GA, Kravtsov AA. Epidemiological estimation of prevalence of the surgical site infections and preventive action. *Central Asian Medical Journal* 2004;10(8):152-155.
37. National Nosocomial Infections Surveillance (NNIS) System Report. Data summary from January 1992 through June 2004. issued October 2004. *Am J Infect Control* 2004;32(8):470-485.
38. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in coronary care units in the United States. National Nosocomial Infections Surveillance System. *American Journal of Cardiology* 1998;82(6):789-793.
39. Barrett SP. Infection control in Britain. *J Hosp Infect* 2002;50(2):106-109.
40. Reed CS, Gorrie G, Spelman D. Hospital infection control in Australia. *J Hosp Infect* 2003;54(4):267-271.
41. Cook DJ, Walter SD, Cook RJ, et al. Incidence of and risk factors for ventilator-associated pneumonia in critically ill patients. *Ann Intern Med* 1998;129(6):433-440.
42. Gastmeier P, Hentschel J, de Veer I, et al. Device-associated nosocomial infection surveillance in neonatal intensive care using specified criteria for neonates. *J Hosp Infect* 1998;38(1):51-60.
43. Rosenthal VD, Guzman S, Orellano PW, Safdar N. Nosocomial infections in medical-surgical intensive care units in Argentina: attributable mortality and length of stay. *Am J Infect Control* 2003;31(5):291-295.
44. Pessoa-Silva CL, Richtmann R, Calil R, et al. Healthcare-associated infections among neonates in Brazil. *Infect Control Hosp Epidemiol* 2004;25(9):772-777.
45. Salomao R, Nouer S, Grinberg G, et al. Extra length of stay of Nosocomial Infections at 5 hospitals of Brazil. International Nosocomial Infection Control Consortium (INICC), In: SHEA; 2006 March-18-21, Chicago, Illinois, 2006.
46. Nagata E, Brito AS, Matsuo T. Nosocomial infections in a neonatal intensive care unit: incidence and risk factors. *Am J Infect Control* 2002;30(1):26-31.
47. Febre N, de Medeiros ES, Wey SB, et al. Is the epidemiological surveillance system of nosocomial infections recommended by the American CDC applicable in a Chilean hospital? *Rev Med Chil* 2001;129(12):1379-1386.
48. Wang X, Zhou H, Wang X, et al. A study on nosocomial infection among inpatients in Beijing Hospital for elderly. *Zhonghua Liu Xing Bing Xue Za Zhi* 2001;22(3):212-214.
49. Efrid MM, Rojas MA, Lozano JM, et al. Epidemiology of nosocomial infections in selected neonatal intensive care units in Colombia, South America. *J Perinatol* 2005.
50. Moreno CA, Rosenthal VD, Olarte N, et al. Device-associated infection rate and mortality in intensive care units of 9 Colombian hospitals: findings of the international nosocomial infection control consortium. *Infect Control Hosp Epidemiol* 2006;27(4):349-356.
51. Kalenic S, Mihaljevic L, Rosenthal VD, et al. Device associated infection rate, stay and mortality in Croatian critical patients: findings of International Nosocomial Infection Control Consortium, July 3-5, 2006, Spier Estate, Stellenbosch, South Africa.
52. El-Nawawy AA, El-Fattah MM, Metwally HA, et al. One year study of bacterial and fungal nosocomial infections among patients in pediatric intensive care unit (PICU) in Alexandria. *J Trop Pediatr* 2005.
53. Mehta Y, Chakravarthy M, Nair R, et al. Device-associated nosocomial infection rates and extra length of stay in intensive care units of India. Proceedings and Abstracts of the 16th Annual Scientific Meeting of the Society for Healthcare Epidemiology of America, April 9-12, 2005, Los Angeles, California.
54. Soto-Hernandez JL, Ramirez-Crescencio MA, Reyes-Ramirez G, et al. Nosocomial infections at a neurologic hospital, analysis of 10 years. *Gac Med Mex* 2002;138(5):397-404.
55. Ponce de Leon-Rosales SP, Molinar-Ramos F, Dominguez-Cherit G, et al. Prevalence of infections in intensive care units in Mexico: a multicenter study. *Crit Care Med* 2000;28(5):1316-1321.
56. Ramirez Barba EJ, Rosenthal VD, Higuera F, et al. Device-associated nosocomial infection rates in intensive care units in four Mexican public hospitals. *American Journal of Infection Control* 2006 (in press).
57. Abouqal R, Madani N, Ali Zeggwagh A, Rosenthal VD. Extra length of stay and device-associated nosocomial infection rates in intensive care units in one hospital of Morocco. I.C.A.A.C., September 21-24, 2005, New Orleans, Louisiana.
58. Cuellar L, Fernández Maldonado E, Castañeda Sabogal A, et al. Extra length of stay and device-associated nosocomial infection Rates in intensive care units in three hospitals of Peru. I.C.A.A.C., September 21-24, 2005, New Orleans, Louisiana.
59. Ng J, Asetre-Luna I, Rosenthal VD, Yu C. Device-associated infection rate and length of stay in Philippine critical patients: findings of International Nosocomial Infection Control Consortium. IFIC, July 3-5, 2006, Spier Estate, Stellenbosch, South Africa.
60. Al-Asmary SM, Al-Helali NS, Abdel-Fattah MM, et al. Nosocomial urinary tract infection: risk factors, rates and trends. *Saudi Med J* 2004;25(7):895-900.
61. Bilal NE, Gedebo M, Al-Ghamdi S. Endemic nosocomial infections and misuse of antibiotics in a maternity hospital in Saudi Arabia. *Apmis* 2002;110(2):140-147.
62. Al-Ghamdi S, Gedebo M, Bilal NE. Nosocomial infections and misuse of antibiotics in a provincial community hospital, Saudi Arabia. *J Hosp Infect* 2002;50(2):115-121.
63. Gosling R, Mbatia R, Savage A, et al. Prevalence of hospital-acquired infections in a tertiary referral hospital in northern Tanzania. *Ann Trop Med Parasitol* 2003;97(1):69-73.
64. Durmaz B, Durmaz R, Otlu B, Sonmez E. Nosocomial infections in a new medical center, Turkey. *Infect Control Hosp Epidemiol* 2000;21(8):534-536.
65. Yoluglu S, Durmaz B, Bayindir Y. Nosocomial infections and risk factors in intensive care units. *New Microbiol* 2003;26(3):299-303.
66. Leblebicioglu H, Özgültekin A, Akan Arikan Ö, et al. Extra length of stay and device-associated nosocomial infection rates in intensive care units (ICU) in nine hospitals of Turkey. I.C.A.A.C., September 21-24, 2005, New Orleans, Louisiana.
67. Esen S, Leblebicioglu H. Prevalence of nosocomial infections at intensive care units in Turkey: a multicentre 1-day point prevalence study. *Scand J Infect Dis* 2004;36(2):144-148.
68. Cevik MA, Yilmaz GR, Erdinc FS, Ucler S, Tulek NE. Relationship between nosocomial infection and mortality in a neurology intensive care unit in Turkey. *J Hosp Infect* 2005;59(4):324-330.
69. Taneja N, Emmanuel R, Chari PS, Sharma M. A prospective study of hospital-acquired infections in burn patients at a tertiary care referral centre in North India. *Burns* 2004;30(7):665-669.
70. Leblebicioglu H, Özgültekin A, Akan Arikan Ö, et al. Extra length of stay and device-associated nosocomial infection rates in intensive care units (ICU) in nine hospitals of Turkey. I.C.A.A.C. December 16-19, 2005, Washington DC.
71. Rosenthal VD, Guzman S, Crnich C. Device-associated nosocomial infection rates in intensive care units of Argentina. *Infect Control Hosp Epidemiol* 2004;25(3):251-255.
72. Martinez-Aguilar G, Anaya-Arriaga MC, Avila-Figueroa C. Incidence of nosocomial bacteremia and pneumonia in pediatric unit. *Salud Publica Mex* 2001;43(6):515-523.
73. Hosoglu S, Akalin S, Kidir V, Suner A, et al. Prospective surveillance study for risk factors of central venous catheter-related bloodstream infections. *Am J Infect Control* 2004;32(3):131-134.
74. Almuneef MA, Memish ZA, Balkhy HH, et al. Rate, risk factors and outcomes of catheter-related bloodstream infection in a paediatric intensive care unit in Saudi Arabia. *J Hosp Infect* 2006;62(2):207-213.
75. Li HY, He LX, Hu BJ, et al. A prospective cohort study of risk factors for ventilator-associated pneumonia in intensive care unit. *Zhonghua Nei Ke Za Zhi* 2004;43(5):325-328.
76. Almuneef M, Memish ZA, Balkhy HH, et al. Ventilator-associated pneumonia in a pediatric intensive care unit in Saudi Arabia: a

Chapter 18: Infection Control in Developing Countries 269

- 30-month prospective surveillance. *Infect Control Hosp Epidemiol* 2004;25(9):753–758.
77. Rezende EM, Couto BR, Starling CE, Modena CM. Prevalence of nosocomial infections in general hospitals in Belo Horizonte. *Infect Control Hosp Epidemiol* 1998;19(11):872–876.
 78. Tinoco JC, Salvador-Moysen J, Perez-Prado MC, et al. Epidemiology of nosocomial infections in a second level hospital. *Salud Publica Mex* 1997;39(1):25–31.
 79. Karabey S, Ay P, Derbentli S, et al. Handwashing frequencies in an intensive care unit. *J Hosp Infect* 2002;50(1):36–41.
 80. Rosenthal VD, McCormick RD, Guzman S, et al. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. *Am J Infect Control* 2003;31(2):85–92.
 81. Higuera F, Rosenthal VD, Duarte P, et al. The effect of process control on the incidence of central venous catheter associated bloodstream infections and mortality in intensive care units in Mexico. *Critical Care Medicine* 2005;
 82. Merchant M, Karnad DR, Kanbur AA. Incidence of nosocomial pneumonia in a medical intensive care unit and general medical ward patients in a public hospital in Bombay, India. *J Hosp Infect* 1998;39(2):143–148.
 83. Orrett FA, Brooks PJ, Richardson EG. Nosocomial infections in a rural regional hospital in a developing country: infection rates by site, service, cost, and infection control practices. *Infect Control Hosp Epidemiol* 1998;19(2):136–140.
 84. Macías AE, Muñoz JM, Bruckner DA, et al. Parenteral infusions bacterial contamination in a multi-institutional survey in Mexico: considerations for nosocomial mortality. *Am J Infect Control* 1999;27(3):285–290.
 85. Chandra PN, Milind K. Lapses in measures recommended for preventing hospital-acquired infection. *J Hosp Infect* 2001;47(3):218–222.
 86. Rosenthal VD, Maki DG. Prospective study of the impact of open and closed infusion systems on rates of central venous catheter-associated bacteremia. *Am J Infect Control* 2004;32(3):135–141.
 87. Centers for Disease Control and Prevention. Guidelines for prevention of nosocomial pneumonia. *MMWR Recomm Rep* 1997;46(RR-1):1–79.
 88. O'Grady N P, Alexander M, Dellinger EP, et al. Guidelines for the prevention of intravascular catheter-related infections. *Am J Infect Control* 2002;30(8):476–489.
 89. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *MMWR Recomm Rep* 2002;51(RR-16):1–45.
 90. Mangram AJ, Horan TC, Pearson ML, et al. Guideline for prevention of surgical site infection, 1999. *Am J Infect Control* 1999;27(2):97–132.
 91. Garner JS. Guideline for isolation precautions in hospitals. *Infect Control Hosp Epidemiol* 1996;17(1):53–80.
 92. Rosenthal VD, Guzman S, Safdar N. Reduction in nosocomial infection with improved hand hygiene in intensive care units of a tertiary care hospital in Argentina. *Am J Infect Control* 2005;33(7):392–397.
 93. Rosenthal VD, Guzman S, Pezzotto SM, Crnich CJ. Effect of an infection control program using education and performance feedback on rates of intravascular device-associated bloodstream infections in intensive care units in Argentina. *Am J Infect Control* 2003;31(7):405–409.
 94. Rosenthal VD, Guzman S, Safdar N. Effect of education and performance feedback on rates of catheter-associated urinary tract infection in intensive care units in Argentina. *Infect Control Hosp Epidemiol* 2004;25(1):47–50.
 95. Salomao R, Blecher S, Maretti da Silva M, et al. Education and performance feedback effect on rates of central vascular catheter-associated bloodstream infections in adult intensive care units of one Brazilian hospital of Sao Paulo. June 19–23, 2005, Baltimore, Maryland.
 96. Salomao R, Maretti da Silva MA, Vilins M, et al. Prospective study of the impact of switching from an open IV infusion system to a closed system on rates of central venous catheter-associated bloodstream infection in a Brazilian hospital. September 21–24, 2005, New Orleans, Louisiana.
 97. Villamil Gómez W, Ruiz Vergara G, Marrugo Pertuz A, Rosenthal VD. Education and performance feedback effect on rates of central vascular catheter-associated bloodstream infections in new born intensive care units in a Private Hospital of Sucre, Colombia. June 19–23, 2005, Baltimore, Maryland.
 98. Chakravarthy M, Jawali V, Rosenthal VD, Venkatachalam N. Process and outcome surveillance plus education and feedback effect on device associated infections rates in Indian critical patients. July 3–5, 2006, Spier Estate, Stellenbosch, South Africa.
 99. Mehta A, Rosenthal VD, Rodrigues C, et al. Process and outcome surveillance plus education and performance feedback effect on rates of device associated infections in adult intensive care units of one Indian hospital. VI Pan-American Infection Control and Hospital Epidemiology Meeting; September 11–15, 2006, Porto Alegre, Brazil.
 100. Mehta Y, Rosenthal VD, Nair R, et al. Process and outcome surveillance plus education and performance feedback effect on rates of ventilator associated pneumonia, catheter associated urinary tract infections, and mortality rate in adult intensive care units of one Indian Hospital. VI Panamerican Infection Control and Hospital Epidemiology Meeting; September 11–15, 2006, Porto Alegre, Brazil.
 101. Higuera F, Rosenthal VD, Duarte P, et al. The effect of process control on the incidence of central venous catheter-associated bloodstream infections and mortality in intensive care units in Mexico. *Crit Care Med* 2005;33(9):2022–2027.
 102. Rangel-Frausto MS, Higuera F, Martínez Soto J, Rosenthal VD. Cost effectiveness of switching from an open IV infusion system to a closed system on rates of central venous catheter-associated bloodstream infection in three Mexican hospitals. June 19–23, 2005, Baltimore, Maryland.
 103. Sobreyra Oropeza M, Herrera Bravo M, Rosenthal V. Nosocomial infection global rates and central vascular catheter-associated bloodstream infections rates reduction in a new born intensive care unit of one Mexican public hospital. April 9–12, 2005, Los Angeles, California.
 104. Koksall I, Rosenthal VD, Aydin K, Caylan R. Process and outcome surveillance plus education and performance feedback effect on rates of device associated infections in adult intensive care units of one Turkish hospital. VI Pan-American Infection Control and Hospital Epidemiology Meeting, September 11–15, 2006, Porto Alegre, Brazil.
 105. Ozgultekin A, Rosenthal VD, Turan G, Akgun N. Education and performance feedback effect on rates of central vascular catheter-associated bloodstream infections in adult intensive care units of one Turkish hospital. June 11–15, 2006, Tampa, Florida.
 106. Ulger F, Esen S, Leblebicioglu H, Rosenthal VD. Process and outcome surveillance plus education and feedback effect on bloodstream infections in one Turkish intensive care unit. July 3–5, 2006, Spier Estate, Stellenbosch, South Africa.
 107. Larson E. Skin hygiene and infection prevention: more of the same or different approaches? *Clin Infect Dis* 1999;29(5):1287–1294.
 108. Doebbeling BN, Stanley GL, Sheetz CT, et al. Comparative efficacy of alternative hand-washing agents in reducing nosocomial infections in intensive care units. *N Engl J M* 1992;327(2):88–93.
 109. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. *Lancet* 2000;356(9238):1307–1312.
 110. Fendler EJ, Ali Y, Hammond BS, et al. The impact of alcohol hand sanitizer use on infection rates in an extended care facility. *Am J Infect Control* 2002;30(4):226–233.
 111. Zafar AB, Butler RC, Reese DJ, et al. Use of 0.3% triclosan (Bacti-Stat) to eradicate an outbreak of methicillin-resistant *Staphylococcus aureus* in a neonatal nursery. *Am J Infect Control* 1995;23(3):200–208.
 112. Casewell M, Phillips I. Hands as route of transmission for *Klebsiella* species. *Br Med J* 1977;2(6098):1315–1317.
 113. Amzian K, Abdelmoumene T, Sekkat S, et al. Multicentre study on hand hygiene facilities and practice in the Mediterranean area: results from the NosoMed Network. *J Hosp Infect* 2006;62(3):311–318.
 114. Rosenthal VD, McCormick RD, Guzman S, et al. Effect of education and performance feedback on handwashing: the

270 Section I: General Considerations of Hospital Infections

- benefit of administrative support in Argentinean hospitals. *Am J Infect Control* 2003;31(2):85-92.
115. Salomao R, Maretti Da Silva M, Vilins M, et al. Multi-center prospective study to evaluate hand washing compliance in hospitals from Brazil: behaviour comparison between different stratum. Fifth Pan-American Congress of Infection Control and Hospital Epidemiology, October 7-10, 2004, Lima, Peru.
 116. Lam BC, Lee J, Lau YL. Hand hygiene practices in a neonatal intensive care unit: a multimodal intervention and impact on nosocomial infection. *Pediatrics* 2004;114(5):e565-e571.
 117. Samuel R, Almedom AM, Hagos G, et al. Promotion of handwashing as a measure of quality of care and prevention of hospital-acquired infections in Eritrea: the Keren study. *Afr Health Sci* 2005;5(1):4-13.
 118. Jelly S, Tjale A. Hand decontamination practices in paediatric wards. *Curationis* 2003;26(4):72-76.
 119. Álvarez Moreno C, Linares C, Agray M, et al. Multi-center prospective study to evaluate hand washing compliance in hospitals from Colombia: behaviour comparison between different stratum. Fifth Pan-American Congress of Infection Control and Hospital Epidemiology, October 7-10, 2004, Lima, Peru.
 120. Mehta Y, Chakravarthy M, Nair R, et al. Prospective study to evaluate hand washing compliance at two Indian hospitals of New Delhi and Bangalore: behaviour comparison between different stratum. APIC; June 19-23, 2005, Baltimore, Maryland.
 121. Higuera F, Rangel-Frausto MS, Martinez Soto J, et al. National multi-center study to evaluate the effect of education and performance feedback on hand washing in the intensive care units (ICUs) of three Mexican hospitals: differences between gender, health care workers and type of procedure. APIC meeting, June 7-10, 2004, Phoenix, Arizona.
 122. Armas Ruiz A, Yberri I, Nuñez Espinoza E, et al. Prospective study to evaluate hand washing compliance in one pediatric intensive care unit of a Social Security hospital from Mexico: behaviour comparison between different stratum. Fifth Pan-American Congress of Infection Control and Hospital Epidemiology, October 7-10, 2004, Lima, Peru.
 123. Sobreira Oropeza M, Herrera Bravo M, Rosenthal VD. Effect of education and performance feedback on handwashing in a Mexican public hospital of Mexico City. APIC, meeting, 19-23, 2005, Baltimore, Maryland.
 124. Abouqal R, Ali Zeggwagh A, Madani N, Rosenthal VD. Hand washing compliance in a hospital of Morocco: difference between stratum. April 9-12, 2005, Los Angeles, California.
 125. Cuellar L, Rosales R, Castillo Bravo LI, et al. Multi-center national prospective study to evaluate hand washing compliance in hospitals from Peru: behaviour comparison between different stratum. Fifth Pan-American Congress of Infection Control and Hospital Epidemiology, October 7-10, 2004, Lima, Peru.
 126. Brown SM, Lubimova AV, Khrustalyeva NM, et al. Use of an alcohol-based hand rub and quality improvement interventions to improve hand hygiene in a Russian neonatal intensive care unit. *Infect Control Hosp Epidemiol* 2003;24(3):172-179.
 127. Paotong D, Trakarnchansiri J, Phongsanon K, et al. Compliance with handwashing in a university hospital in Thailand. *Am J Infect Control* 2003;31(2):128.
 128. Karabey S, Ay P, Derbentli S, et al. Handwashing frequencies in an intensive care unit. *J Hosp Infect* 2002;50(1):36-41.
 129. Cetinkaya Y, Yildirim G, Iskit A, et al. Multi-center national prospective study to evaluate hand washing compliance in hospitals from Turkey: behaviour comparison between different stratum. Fifth Pan-American Congress of Infection Control and Hospital Epidemiology, October 7-10, 2004, Lima, Peru.
 130. Kuzu N, Ozer F, Aydemir S, et al. Compliance with hand hygiene and glove use in a university-affiliated hospital. *Infect Control Hosp Epidemiol* 2005;26(3):312-315.
 131. Saba R, Inan D, Seyman D, et al. Hand hygiene compliance in a hematology unit. *Acta Haematol* 2005;113(3):190-193.
 132. Rosenthal V, Salomao R, Leblebicioglu H, et al. Hand hygiene compliance in Argentina, Brazil, Colombia, India, Mexico, Morocco, Peru and Turkey. June 11-15, 2006, Tampa, Florida.
 133. Pittet D, Mourouga P, Perneger TV. Compliance with handwashing in a teaching hospital: infection control program. *Ann Intern Med* 1999;130(2):126-130.
 134. Dubbert PM, Dolce J, Richter W, et al. Increasing ICU staff handwashing: effects of education and group feedback. *Infect Control Hosp Epidemiol* 1990;11(4):191-193.
 135. van de Mortel T, Bourke R, Fillipi L, et al. Maximising handwashing rates in the critical care unit through yearly performance feedback. *Aust Crit Care* 2000;13(3):91-95.
 136. Tibballs J. Teaching hospital medical staff to handwash. *Med J Aust* 1996;164(7):395-398.
 137. Aspöck C, Koller W. A simple hand hygiene exercise. *Am J Infect Control* 1999;27(4):370-372.
 138. Colombo C, Giger H, Grote J, et al. Impact of teaching interventions on nurse compliance with hand disinfection. *J Hosp Infect* 2002;51(1):69-72.
 139. Rosenthal VD, Guzman S, Crnich C. Impact of an infection control program on rates of ventilator-associated pneumonia in intensive care units in 2 Argentinean hospitals. *Am J Infect Control* 2006;34(2):58-63.
 140. Higuera F, Rangel-Frausto MS, Martinez Soto, et al. National multi-center study to evaluate the effect of education and performance feedback on hand washing in the intensive care units (ICUs) of three Mexican hospitals: differences between gender, health care workers and type of procedure. APIC meeting, June 7-10, 2004, Phoenix, Arizona.
 141. Sobreira Oropeza M, Herrera Bravo M, Rosenthal VD. Effect of education and performance feedback on handwashing in a Mexican public hospital of Mexico City. APIC meeting, June 19-23, 2005, Baltimore, Maryland.
 142. Akan A, Özgultekin A, Rosenthal V. Effect of education and performance feedback on handwashing in two Turkish hospitals of Istanbul and Ankara. APIC meeting, June 19-23, 2005, Baltimore, Maryland.
 143. Pittet D. Improving adherence to hand hygiene practice: a multidisciplinary approach. *Emerg Infect Dis* 2001;7(2):234-240.
 144. Larson EL, Bryan JL, Adler LM, Blane C. A multifaceted approach to changing handwashing behavior. *Am J Infect Control* 1997;25(1):3-10.
 145. Stone PW, Braccia D, Larson E. Systematic review of economic analyses of health care-associated infections. *Am J Infect Control* 2005;33(9):501-509.
 146. Rosenthal VD, Guzman S, Migone O, Safdar N. The attributable cost and length of hospital stay because of nosocomial pneumonia in intensive care units in 3 hospitals in Argentina: a prospective, matched analysis. *Am J Infect Control* 2005;33(3):157-161.
 147. Rosenthal VD, Guzman S, Migone O, Crnich CJ. The attributable cost, length of hospital stay, and mortality of central line-associated bloodstream infection in intensive care departments in Argentina: a prospective, matched analysis. *Am J Infect Control* 2003;31(8):475-480.
 148. Higuera F, Rangel-Frausto M, S., Rosenthal V, et al. The attributable cost, and length of hospital stay of central line associated blood stream infection in intensive care units in Mexico: a prospective, matched analysis. *Infect Control and Hospital Epidemiology* 2006.
 149. Centers for Disease Control and Prevention. *Hospital infections cost U.S. billions of dollars annually*. March 6, 2000.
 150. 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(2):182-205.
 151. Kohn L, Corrigan J, Donaldson M. *To err is human: building a safer health system*. Washington, DC: Institute of Medicine, National Academy Press, 1999.
 152. MHA Keystone Center for Patient Safety and Quality. October 13, 2005.
 153. www.theifc.org. [accessed March 6, 2006.]
 154. Rosenthal V, Chakravarthy M, Salomao R, et al. Device-associated nosocomial infections rates at hospitals members of the International Nosocomial Infection Control Consortium (INICC) in Argentina, Brazil, Colombia, India, Mexico, Morocco, Peru, and Turkey. October 13-16, 2005, Istanbul, Turkey.