# REVIEW ARTICLE

# Infection Control: Old Problems and New Challenges

Alejandro E. Macías[a] and Samuel Ponce-de-León[b]

[a]Department of Infectious Diseases, University of Guanajuato School of Medicine at Leon, Leon, Guanajuato, Mexico
[b]Department of Hospital Epidemiology and Quality of Care, National Institute of Medical Sciences and Nutrition Salvador Zubiran,
Mexico City, Mexico

Infection control faces radical changes at the beginning of the third millennium. The first part of this review focuses on problems not yet solved, such as 1) surveillance systems, which should be active and extremely flexible; 2) infection outbreaks in hospitals and strategies to avoid them; 3) hand washing and alternatives such as rapid hand antisepsis; 4) water and food in the hospital as potential reservoirs of nosocomial pathogens; 5) upgrading of infection control programs to turn them into systems to improve the quality of care; 6) fatal Gram-negative bacteremias in hospitals from developing countries, which can be avoided with better standards of care; 7) the elemental role of the microbiology laboratory in the prevention and control of infections; 8) the unprecedented crisis due to the emergence of specific multi-resistant pathogens; 9) the risks for health-care workers, such as tuberculosis, hepatitis, HIV, SARS, and hemorrhagic fevers; and 10) the need for the consistent application of guidelines. The second part of this review focuses on new challenges for infection control, such as 1) the ever-growing number of immunocompromised patients and basic control measures to avoid opportunistic infections; 2) the concerns about the capacity of the public health systems to deal with terrorist acts; 3) the practice of high-risk procedures in facilities lacking trained personnel, efficient laboratories, and protective items; and 4) gene therapy and its potential infectious complications. Consideration is given to the asymmetric development of infection control globally. © 2005 IMSS. Published by Elsevier Inc.

Key Words: Infection control, Hospital infection, Cross infection, Quality of health care.

## First Part: Old Problems

### Nosocomial Infections: A Global Problem

Medical care faces radical changes at the beginning of the third millennium. Because infectious diseases are the second cause of death worldwide, the evolution of emerging and re-emerging diseases will heighten the impact of the changes (1). In many hospitals and healthcare-related centers, an increasing number of invasive procedures and sophisticated medical care is being offered with no regard to the risks implied. The costs of nosocomial infections (NIs), in terms of both money and human suffering, are enormous (2,3). For instance, in the U.S., they contribute to about 90,000 deaths and $5 billion in expenses per year (4).

In hospitals, the training of physicians focuses on treatment and diagnosis, with a tendency towards specialization, and infectious complications are perceived as natural and unalterable (5); for instance, for children dying of nosocomial bacteremia in developing countries, an official diagnosis of "neonatal asphyxia" is common. Paradoxically, those hospitals with the worst problems of NIs report the lowest rates; the explanation rests on inadequate surveillance.

The current situation needs a change because evidence is overwhelming: infection control is not an expense but a good investment (6–8). Infection control implies costs but pays for itself, even in countries with limited resources (9–13).

### Surveillance Systems Come in Several Flavors

The organization of a surveillance system is the logical initial step of any infection control program because subsequent

Address reprint requests to: Samuel Ponce-de-León, M.D, M.Sc., National Institute of Medical Sciences and Nutrition Salvador Zubiran, Department of Hospital Epidemiology and Quality of Care, Vasco de Quiroga # 15, Tlalpan 14000, Mexico City, Mexico. Phone and FAX: (+52) (55) 5573-8803; E-mail: sponce@quetzal.innsz.mx

changes must be based on the identification of the local problems, which may be unique (6,14). There is, however, a lack of validation of the existing menu of surveillance systems. Admittedly, passive or retrospective surveillance relying only on chart reports from physicians or nurses is very insensitive, and no hospital should now be using such a system as its only source of information.

Active surveillance methods are currently the only acceptable systems, regardless of the type of hospital or the degree of consolidation of their control programs. The building blocks of any active surveillance system comprise collecting relevant data systematically during a defined period of time, managing and organizing the data, analyzing and interpreting the data, and communicating the results to those empowered to make changes (15).

Hospital-wide, comprehensive, surveillance methods based on the National Nosocomial Infections Surveillance System (NNIS) guidelines (16) are the standard in developed countries and are being followed even in selected hospitals from developing countries. Unfortunately, these surveillance methods are labor intensive, many hospitals lack personnel for such activities, and collecting data may severely limit the time for other critical activities (17). Surveillance systems must be extremely flexible; effective infection control teams will not use a "one size fits all" approach for surveillance. Some hospitals should focus on patients at high risk, such as those hospitalized in intensive care and neonatal units (15,18). After defining the priorities of the institution, the focus could also be on specific problems, such as bacteremia or surgical site infection. Focusing on neonatal bacteremia pays high dividends because extrinsic contamination of IV fluids seems to be a common problem in many settings (19–21).

NIs are usually followed in rates, i.e., the number of patients infected divided by those who were hospitalized in a given period. These rates usually say little because the denominators are diluted by the high numbers of patients attended with little risk, such as those hospitalized for newborn delivery attention. Then, a trend is to follow NI in terms of meaningful denominators as the number of patients exposed to specific risks, such as the rates of pneumonia per 100 patient-days on a ventilator.

### Outbreaks Are Not Lost in the Past

History reminds us that epidemics never end but recur. In fact, we are living in a worldwide pandemic in many hospitals where sophisticated protocols are performed with no attention to the risks and no control programs; under such conditions, a substantial proportion of NIs occur as outbreaks (22,23). Bacteremias cause a relevant fraction of the outbreaks; they are avoided with good nursing standards during the administration of infusates (19,24,25). Pneumonia in ventilated patients, dissemination of resistant bacteria, and some intestinal infections (as those caused by rotavirus

and *Clostridium difficile*) are best prevented and controlled with the use of barriers and isolations (26,27). Good practices during food manipulation are required to avoid common-source intestinal infections (28). As can be deduced from the actions needed, teamwork is required for the prevention and control of outbreaks (29).

Many hospitals globally lack the personnel and necessary resources to detect and avoid outbreaks of NIs. There are difficulties for washing hands and for instituting proper isolation barriers, nursing standards are poor when administering intravenous (IV) fluids, and teamwork for infection control is unheard of in many hospitals. Then, hospitals in some areas of the world may be playing a role as amplifiers of disease, rather than as consolidated institutions to alleviate community diseases.

Hospitals having outbreaks as main causes of NIs must implement programs focused on their prevention as a first step towards consolidation of their programs. Hospitals with Gram-negative bacteremia outbreaks due to infusate contamination must use their resources to solve this problem immediately; no infection control program should focus on other issues in presence of such an urgent demand.

### Hand Washing or Hand Disinfection?

Although easily removed by hand cleansing, transient flora are responsible for most NIs (30). Ignaz Semmelweis established the importance of hand washing more than 150 years ago; compliance with this routine, however, rarely exceeds 40% due to lack of time, inadequate facilities or forgetfulness (31,32). Personnel often fail due to negligence. Sinks are usually few, inconveniently located, and non-functional. Supplies of soap and paper towels are often inadequate and multiple-use cloth towels are commonly used; these towels become damp and harbor Gram-negative bacteria (17). Finally, asking for 100% compliance with hand washing has implications not generally considered: it is almost impossible to achieve, and it could even interfere with patient care as it is very time-consuming (33).

If good hand-washing compliance becomes a difficult task, the promotion of hand antisepsis with alcohol-based rubs is a good alternative; the procedure is fast and easy to adhere to. A number of commercial solutions are available for this purpose, but cheaper alternatives such as alcohol/emollient solutions can be formulated locally (for 1 L of solution, mix 980 mL of 70% isopropyl alcohol with 10–30 mL of glycerin) (17). To our knowledge, however, there is no evidence of the measurable impact of hand disinfection in hospitals from developing countries.

### Water and Food in the Hospital

Tap water is a potential reservoir of nosocomial pathogens. Besides, water supply is contaminated or interrupted in many

hospitals (34–37). Traditionally, waterborne disease is considered related to fecal pollution of water sources (38); although it may be the same in hospitals, the nature of the patients and invasive procedures obliges to consider even non-fecal Gram-negative bacteria and *Legionella* as potential sources of disease. Tap water contaminated with non-fecal Gram-negative rods or non-tuberculous mycobacteria has been correlated with bacteremia, burn infections, and surgical site infections (36,37,39). The ability of Gram-negative bacteria to survive wet environments for long periods explains their common occurrence in sink drains (34); they can pass to patients by health care workers (HCWs) whose hands become contaminated during hand washing (34,36,37).

Water sources are currently thought to be unimportant sources of infection in hospitals from developed countries as they are forced to meet strict hygienic standards. For instance, providing low-quality water in England is considered a criminal offense (38). In most hospitals from developing countries, however, those standards do not exist or are not enforced, bringing about the potential for massive outbreaks of disease. In hospitals in developing countries, infection control personnel must include in their programs periodic rounds to ensure proper functioning of sinks and adequate water chlorination.

Many hospitals do not monitor the quality of foodstuffs that they buy, and several lapses in food-handling are the rule, such as improper cooking or holding temperatures, as well as cross-contamination of foodstuff served raw from those that will sustain cooking, e.g., from meat to vegetables. Incidence of nosocomial diarrhea and its complications could be higher than generally believed (28,40). Infection control professionals should include in their programs the periodic vigilance of food preparation in their hospitals.

## The Quest for Quality

Upgrading infection control programs to turn them into systems to improve quality of care is a trend in many hospitals. Although there is little experience with these methods in hospitals from countries with low resources, programs for quality of care are well suited for use in any hospital and there is no reason for not using them in developing countries. Unfortunately, few hospitals have the experience to train and support individuals dedicated to implement and develop quality programs (41). Quality should have its hierarchical levels: leaving the hospital alive should be the fundamental priority; we must prevent outbreaks first. Leaving after suffering no complications comes close; we must prevent endemic infections and non-infectious complications. Leaving after the shortest possible hospital stay comes third; we better get involved in management. Finally, leaving after enjoying some amenities comes fourth; we can get involved with this if we have the time.

To improve their facilities and the quality of their services, maintenance and renovation is constant in hospitals. However, this is a persistent source of dust, which is a risk factor for fungal infections in immunocompromised patients (42,43). Before planning renovation activities, hospital designers of the future will have to consider indications from infection control professionals.

## Fatal Bacteremias Still a Reality

Fatal Gram-negative neonatal bacteremias are a minor issue in hospitals from industrialized countries, where they are generally described as past experiences. Gram-negative bacteremia, however, is a substantial risk in hospitals in developing countries. In our experience, important reasons are the use of big stock bottles to load burettes from several patients, the mixing of IV fluids without any care in the wards, the reusing of vials designed to be used once, the pooling of residual medication in vials, and the sharing of syringes to inject drugs into different administration sets (10,17, 19–21,25,44–46). Bacteremia associated with IV fluid contamination is usually caused by species of *Klebsiella*, *Enterobacter*, or *Serratia*, collectively members of the Tribe *Klebsiellae* (TK), as these organisms have an extraordinary ability to grow in infusates (47–50). Few data exist on the risk of nosocomial bacteremias in many developing countries, but from isolated reports it seems that they are more common and more severe than those of hospitals in developed countries (19–21,25,36).

In developing nations, a national program should be initiated against Gram-negative bacteremias because they may be the most preventable cause of death in hospitals. To start with, guidelines must discourage the use of IV therapy or nutrition when not strictly necessary. Peripheral catheters should be preferred over central catheters, and percutaneous insertion should be preferred over venous dissection or umbilical catheterization. The use of premixed IV fluid should be preferred; preparation of infusates should be done only in designated areas, away from potential sources of contamination, such as diapers or bedpans. Parenteral nutrition solutions must be prepared only by specially trained personnel and administered promptly. Guidelines should discourage the use of stock bottles to load burettes for several patients, the reuse of single dose vials, the pooling of residual medication in vials, and the sharing of syringes to inject drugs to different administration sets (51).

## Help Wanted: Skilled Microbiologists

The role of the microbiology laboratory in the prevention and control of NIs cannot be overemphasized. The success of the hospital infection control efforts hinges to a large extent on the active involvement of the laboratory in many aspects of the program (2,52,53). Laboratory duties include

identifying the organisms responsible for NIs and their antimicrobial susceptibility, reporting timely data relevant to infection control, and supporting the investigations of infectious problems. The most dramatic advances are the procedures for typing hospital organisms for similarity or difference, which helps for tracking bacterial sources (54). Against these sophisticated developments, even now most hospitals globally lack a microbiology laboratory with well-trained technologists. In fact, most hospitals do not draw blood cultures in a routine fashion (36,44), and bottles to inoculate them are a rare commodity. Many of the few existent microbiology laboratories work isolated from any clinical feedback and report mainly colonizing bacteria because of the dependency on non-critical cultures, i.e., not drawn with a needle. This is true even in many tertiary-care centers, with relatively high budgets.

Guidelines should stress the importance of having a microbiology laboratory with skilled personnel in every hospital. Priority should be given to cultures drawn with a needle. Bacteremia is defined by a laboratory report, and blood culture bottles must always be available, mainly in the neonatal and intensive care areas. In cultures not taken with a needle, reporting saprophytes should be avoided in order to prevent antibiotic abuse. Screening cultures from the environment, personnel or even patients are rarely indicated (2,55). Unfortunately, non-critical, environmental, and screening cultures from the personnel plague many laboratories from developing countries, draining a substantial part of their limited resources.

### Antibiotic Resistance and De-escalation

In less than a blink of history's eye, the promise that all bacterial infections would disappear with antibiotics has gone; new, resistant, organisms are replacing the old, susceptible ones (56,57). The costs for developing and approving new antibiotics continue to escalate and, with the rapid emergence of resistance, the incentive to develop new ones diminishes (58). Hospitals are facing an unprecedented crisis due to the emergence of specific pathogens such as *Staphylococcus* resistant to methicillin, *Enterococcus* resistant to vancomycin, multi-resistant Gram-negative rods, and fluconazole-resistant *Candida* (58,59). Most of the NIs that occur in intensive care units are due to microorganisms that are resistant to several antibiotics. Moreover, hospitals in countries with few resources can serve as reservoirs for the dissemination of antimicrobial-resistant pathogens in the community, where misuse of antibiotics is common by pharmacists, patients, parents, and doctors (60,61).

Controlling outbreaks of antibiotic resistance depends on early detection, hand hygiene and implementation of barrier precautions. It sounds straightforward, but most hospitals globally lack a policy for detection and control of antibiotic resistance. A restrictive policy must allow the prescription of some antibiotics only to a few individuals, such as infectious disease specialists or directors of areas. These antibiotics generally include new cephalosporins, quinolones, vancomycin, and imipenem/meropenem, due to their potential to increase high-level resistance (62). A strategy to limit the use of some antibiotics is to restrict information about the susceptibility pattern of the isolates obtained in the hospital, so that clinicians can prescribe only those antibiotics that are authorized by the infectious disease department. Of course, this strategy requires an efficient microbiology laboratory.

Prophylaxis constitutes a substantial proportion of the antibiotics used in the hospital, and many errors are commonly associated with this practice. These errors include improper selection of the drug, use after surgery, and excessive number of doses. A consensus for the use of preoperative prophylactic antibiotics should be worked with surgeons, indicating the specific cases in which antibiotics would be used and the drug to administer.

Some authors suggest that antibiotic therapy should be instituted in the hospital as soon as sepsis is suspected in critically ill patients. Because of the outbreak of methicillin-resistant *Staphylococcus* and multi-resistant Gram-negative rods, they suggest adding vancomycin to a carbapenem as initial empirical therapy (63). Such a regimen is modified against specific pathogens when the results of microbial investigation become available (de-escalation antimicrobial chemotherapy). This shotgun policy is already offered in many hospitals, but should be considered in the context of its high cost and potential to cause new resistances. Of course, de-escalation is out of the question in hospitals lacking a high-quality microbiology laboratory, so this should not be recommended in most hospitals globally.

Another approach to limit the resistance is to evaluate the potential usefulness of cycling antibiotics and also the selection of antibiotics with a lower potential to stimulate the appearance of extended-spectrum β-lactamases (64).

### Employees Are Valuable Assets

Healthcare workers are valuable assets, and we cannot afford to lose them to infections acquired in hospitals, such as tuberculosis, hepatitis, HIV/AIDS, SARS, and hemorrhagic fevers such as Ebola. The risks of occupational transmission are increased by common unsafe practices, such as the administration of unnecessary injections and the reuse of non-sterile needles when supplies are low (65,66).

There must be an occupational health program operational in any healthcare setting. Such a program must implement and develop systems for diagnosis, treatment, and prevention of infectious disease not only in healthcare workers but also in volunteer workers and visitors (67). A program should be implemented to increase awareness of the risks involved in handling needles and body fluids, to accept hepatitis B vaccination, and to use adequate protective measures to avoid injury or contagion. Educational materials should

be appropriate in content to the educational level, literacy, and language of the employee (68,69). It is important to follow standard precautions with any patient during interactions when there is potential for blood exposure, an approach that does not require knowledge of the patient's blood-borne infections status. It is important also to test source patients after an occupational exposure, for optimal post-exposure management. International guidelines are needed to define inappropriate uses of injections and to educate the public to dispel much of the myth about their advantages. Standards must be established for the management and disposal of needles and sharps.

Vaccination programs should be in place in every hospital. Medical evaluation must be done before hiring, obtaining histories, performing physical examinations, and determining immunization status (65,69). Baseline PPD testing will identify those who have been previously infected with tuberculosis.

### Writing What We Do; Doing What Is Written

Evidence shows that the consistent application of guidelines reduces the risks of NI. Guidelines should be written and followed in every institution as every medical center is unique, making hard to translate practices from one to another (70). Apart from hospitals in developed countries, however, most hospitals lack guidelines to organize and develop infection control programs. This challenge cannot be faced with money but with hard desk work. To start with, guidelines should be realistic, lean and simple to read, adapted to the nature of the institutions; those transcribed from hospitals in developed countries will not be operative in different settings. For institutions with few resources and personnel, one should start with a minimalist vision rather than a baroque one, striping infection control of complex definitions, unattainable isolations, and intensive surveillance. Writing what we will not do is a sure way to the unfortunate position of trying to change the institution to meet a series or preconceived regulations not appropriate

for the hospital; when this happens, guidelines become dead words collecting dust on shelves.

Up to this point, we have described old problems on infection control. Before going into future challenges that infection control faces, it is convenient to stress the disparities prevalent between hospitals with consolidated programs and those whose programs are incipient or non-existent. Table 1 describes some of those differences.

## Second Part. New Challenges

### The Ever-Growing Number of Immunocompromised Patients

There is a growing number of immunocompromised patients because of the use of intensive therapeutic regimens in patients with cancer and organ transplantation, besides those with HIV infection. Improvements in patient survival have been observed in all categories, but the risks of infection related to immunodeficiency continue to be substantial by either resident or environmental bacterial, fungal, viral, and protozoal parasites (71). Even low-virulence microbes (opportunistic pathogens) may invade, proliferate, and cause disease in the immunodeficient host. Furthermore, newer organisms previously considered as contaminants or harmless colonizers have now emerged as significant human pathogens in the immunocompromised host. Prevention of infection and, failing this, prompt diagnosis and treatment remain the cornerstones of management. The importance of basic infection control measures cannot be over-emphasized. In addition, appropriate prophylactic agents, rapid diagnostic techniques and the early institution of appropriate therapy are essential (72). Against what is conventionally believed, no benefit of protective isolation has been found in hospitals, even for patients with severe immunodeficiency (73).

### Getting Ready for Bioterrorist Acts

The terrorist acts in the U.S. during 2001 renewed concerns about the capacity of the public health systems to deal with them. Hospital plans that addressed bioterrorism

**Table 1.** Differences prevalent between consolidated and non-consolidated programs for hospital infection control

| Characteristic | Consolidated programs | Non-consolidated programs |
| --- | --- | --- |
| Surveillance | Active | Passive |
| Infection outbreaks | Not common, detected | Common, often undetected |
| Hospital water | Meets standards | Does not meet standards |
| Sinks | Functional, accessible | Non-functional, non-accessible |
| Food handling | Compliant with guidelines | Non-compliant with guidelines |
| Source of bacteremias | Mostly from the catheters | Mostly from infusate contamination |
| Microbiology laboratory | Procedures and reports with clinical relevance | Non-existent or reporting with little clinical relevance |
| Antibiotic prophylaxis, for surgery | Adequate drugs, used before the surgery | Inadequate drug or used after the surgery |
| New and costly antibiotics | Available. Few doctors can prescribe them | Often unavailable. When available, prescribed by any doctor |
| Risks for healthcare workers | Policies for prevention and education | Lack policies for prevention and education |
| Guidelines | Realistic and followed | Absent, unrealistic, or not followed |

increased significantly as did the awareness of the community (74–76). Even small hospitals are obliged now to have bioterrorism preparedness plans in the U.S., monitoring critical or unexplained deaths, training on bioterrorism agents, integrating criminal investigations of bioterrorism incidents, developing emergency response plans, and implementing strategies for mass vaccination and treatment of bioterrorism victims. Health care providers will be the first responders during a biologic attack and will be called upon to diagnose diseases such as anthrax, tularemia or smallpox.

The benefits of bioterrorism preparedness, however, should not be honored without question. Just seeing the pains of persons through airports in the U.S. shows the extremes of measures taken, of dubious value. By the same token, some health programs have contributed to death, illness, and great expense without apparent benefit. Several serious illnesses have resulted from the U.S. smallpox vaccination program; yet there is no clear evidence that a threat of smallpox exposure ever existed (77,78). Deaths occurred after vaccinations, but cause-effect relationships are unclear. The anthrax spores released in 2001 have been linked to secret U.S. military laboratories; then, resultant problems could have been avoided if those laboratories were not in operation in the first place.

Globally, we must follow realistic policies on bioterrorism preparedness; injudicious expansion of preparedness programs may squander health resources and increase the dangers of accidental release of pathogens (76,77).

### The State of the Art at the State of Siege

The continuous scientific and technological developments are rapidly changing the therapeutic field in diverse areas. Invasive procedures, immunosuppressive treatments, biologic and genetic interventions, biologic and synthetic implants, transplantation and xenotransplantation are just a few of a variety of high-risk procedures where infection control should be participating. A serious problem is the practice of high-risk procedures in facilities lacking trained personnel, efficient laboratories, and protective items. Examples of this reality are the sporadic occurrence of SARS in laboratories lacking the pertinent barriers and guidelines (79) and the risk of health care workers to acquire tuberculosis as has been reported in specialty microbiological laboratories lacking basic barriers (80).

Performing critical interventions in under-budgeted hospitals is a common event in developing countries, often with fatal consequences. For instance, liver and bone-marrow transplants are performed in hospitals lacking infectious disease specialists or microbiology support, or pancreatic cell from piglets are transplanted to humans, without any official control. As noted earlier, sophisticated procedures are common in neonatal intensive care units where no trained personnel are available or even access to sinks with soap and potable tap water. Under such circumstances, a potential risk procedure becomes a tragedy generally associated with extremely high rates of mortality (36).

Even though there is a gap between the development of scientific knowledge and its clinical applications, new biological interventions come in growing numbers. However, the ability of clinicians to learn about the risks of these new interventions is extremely limited. Given the characteristics and cost of these new biologic treatments, the possibilities to complete methodologically sound research is poor. Potentially, biological modifiers such as tumor necrosis factor antagonists could imply a high risk of infectious complications (81). Tuberculosis and other bacterial and viral infections have been reported with an increased frequency in studies done in populations with a low incidence, and then the expected frequency in countries with high prevalence of tuberculosis could be even higher as could happen for other infectious complications.

### Gene Therapy: Deliberate Therapeutic Infections

The first *ex vivo* gene therapy protocol was approved in the U.S. in 1989, and the first *in vivo* protocol with a virus administered into a human lung was carried out in 1993 (82). Many human diseases have been targeted for gene therapy, from monogenic diseases to neoplastic, degenerative, and infectious diseases. The possibility to identify a therapeutic gene and introduce it to the patient through a viral vector is now more alluring than ever, and the number of protocols proposed is escalating. The infectivity and pathogenic potential of viruses has taken gene therapy into the sphere of infection control (83).

Although gene therapy is currently limited to a few high-quality medical centers, it will be a frequent procedure in the future even in not-so-well-organized institutions all over the world. The potential for even unexpected complications should be a real concern as the number of viral vectors for delivering the genes is substantial and growing. Although the recommendations for infection control in gene therapy are still tentative, we better err on the side of caution. As happened with adenoviral vectors, once data on vector safety become available, the stringent infection control procedures used initially can be relaxed (83).

### Conclusions

Health care is being streamlined to be highly effective and efficient. As a result, infection control has seen remarkable advances leading to more sophisticated data collection and analyses, and more efficient strategies for intervention in the hospitals. However, infection control is still under construction due to the introduction of new and sophisticated invasive procedures dictated by scientific developments which are changing the face of medicine. Additionally, challenges are great because the consolidation of infection

**Table 2.** An outline of useful actions for hospitals with little or no experience in prevention and control of infectious diseases

1. Organize a committee and establish the best active surveillance method for your institution.
2. Check for the quality of the hospital's tap water (proper chlorination).
3. Break barriers for hand washing or alcohol rubs and educate for compliance.
4. Promote cultures taken with a needle (blood cultures are essential!).
5. If Gram-negative pediatric bacteremias are still common, control such an emergency first (avoid infusate mixtures!).
6. Develop your own guidelines. Be realistic and escalate them.
7. Check for the type and quality of antiseptics used for surgery.
8. Supervise timely antibiotic prophylaxis for wound infection.
9. Control the use of carbapenems, new cephalosporins, quinolones, and vancomycin.
10. Educate about risks for the personnel. Promote hepatitis B vaccination and be aware of tuberculosis in hospital personnel.

control programs is very asymmetrical globally. In hospitals without consolidated infection control programs, it is easy to become enchanted with the impressive results of advanced programs from institutions that have decades of experience. In such circumstances, we must remember that the basics of an elemental program are still applicable today and that we must start small and aim big. We need a renewed commitment to help ensure the safety of our patients. To say that "we must prevent, educate and train" is rather vague; to avoid clichés, we must establish specific points for initial action in hospitals without a tradition of infection control, as those described in Table 2.

# References

1. Fauci AS. Infectious diseases: considerations for the 21st century. Clin Infect Dis 2001;32:675–685.
2. Emori TG, Gaynes RP. An overview of nosocomial infections, including the role of the microbiology laboratory. Clin Microbiol Rev 1993;6:428–442.
3. Plowman R, Graves N, Griffin MA, Roberts JA, Swan AV, Cookson B, Taylor L. The rate and cost of hospital-acquired infections occurring in patients admitted to selected specialties of a district general hospital in England and the national burden imposed. J Hosp Infect 2001;47:198–209.
4. Burke JP. Infection control. A problem for patient safety. N Engl J Med 2003;348:651–656.
5. Ponce-de-León S. The needs of developing countries and the resources required. J Hosp Infect 1991;18(Suppl A):376–381.
6. Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, Hooton TM. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985;121:182–205.
7. Wenzel RP. The economics of nosocomial infection. J Hosp Infect 1995;31:79–87.
8. Rose R, Hunting KJ, Townsend TR, Wenzel RP. Morbidity/mortality and economics of hospital acquired bloodstream infections: a controlled study. South Med J 1977;70:1267–1269.
9. Khan MM, Celik Y. Cost of nosocomial infection in Turkey: an estimate based on the university hospital data. Health Serv Manage Res 2001;14:49–54.
10. Orrett FA, Brooks PJ, Richardson EG. Nosocomial infections in a rural regional hospital in a developing country: infection rates by site, service, costs, and infection control practices. Infect Control Hosp Epidemiol 1998;19:136–140.
11. Starling C, Khann MM, Celik R. Costs of nosocomial infection in Turkey: an estimate based on the university hospital data. Health Serv Manage Res 2001;14:49–54.
12. Berg DE, Hershow RC, Ramírez CA, Weinstein RA. Control of nosocomial infections in an intensive care unit in Guatemala City. Clin Infect Dis 1995;21:588–593.
13. Cavalcante MD, Braga OB, Teofilo CH, Oliveira EN, Alves A. Cost improvements through the establishment of prudent infection control practices in a Brazilian general hospital, 1986–1989. Infect Control Hosp Epidemiol 1991;12:649–653.
14. Ling ML, Ang A, Wee M, Wang GC. A nosocomial outbreak of multiresistant *Acinetobacter baumannii* originating from an intensive care unit. Infect Control Hosp Epidemiol 2001;22:48–49.
15. Pottinger JM, Herwaldt LA, Perl TM. Basics of surveillance—an overview. Infect Control Hosp Epidemiol 1997;18:513–527.
16. Emori TG, Culver DH, Horan TC, Jarvis WR, White JW, Olson DR, Banerjee S, Edwards JR, Martone WJ, Gaynes RP. National nosocomial infections surveillance system (NNIS): description of surveillance methods. Am J Infect Control 1991;19:19–35.
17. Huskins WC, O'Rourke EJ, Rhinehart E. Infection control in countries with limited resources. In: Mayhall G, ed. Hospital Epidemiology and Infection Control. 2nd ed. Philadelphia: Lipincott Williams & Wilkins;1999. pp. 1489–1513.
18. Wenzel RP, Osterman CA, Donowitz lg Hoyt JW, Sande MA, Martone WJ, Peacock JE Jr, Levine JI, Miller GB Jr. Identification of procedure-related nosocomial infection in high-risk patients. Rev Infect Dis 1981;3:701–707.
19. Macías-Hernández AE, Hernández-Ramos I, Muñoz-Barrett JM, Vargas-Salado E, Guerrero-Martínez J, Medina-Valdovinos H, Hernández-Hernández J, Ponce-De-León-Rosales S. Pediatric primary Gram-negative nosocomial bacteremia: a possible relationship with infusate contamination. Infect Control Hosp Epidemiol 1996;17:276–280.
20. Macías-Hernández AE, Ortega-González P, Muñoz-Barrett JM, Hernández-Ramos I, Caly y Mayor Turnbull I, Guerrero Martínez FJ, Gollaz Mares PG, Hernández Hernández J, Ponce de León Rosales S. Pediatric nosocomial bacteremia. Potential usefulness of culturing infusion liquids. Rev Invest Clin 1994;46:295–300.
21. Hernández-Ramos I, Gaitán-Meza J, Gaitán-Gaitán E, Leon-Ramirez AR, Justiniani-Cedeno N, Avila-Figueroa C. Extrinsic contamination of intravenous infusates administered to hospitalized children in Mexico. Pediatr Infect Dis 2000;19:888–890.
22. Beck-Sague C, Jarvis WR, Martone WJ. Outbreak investigations. Infect Control Hosp Epidemiol 1997;18:138–145.
23. Ostrosky-Zeichner L, Baez-Martínez R, Rangel-Frausto S, Ponce de Leon S. Epidemiology of nosocomial outbreaks: 14-year experience at a tertiary-care center. Infect Control Hosp Epidemiol 2000;21:527–529.
24. Wenzel RP, Thompson RP, Landry SM, Russell BS, Miller PJ, Ponce de Leon S, Miller GB Jr. Hospital-acquired infections in intensive care unit patients: an overview with emphasis on epidemics. Infect Control 1983;4:371–375.
25. Jarvis WR, Cookson ST, Robles B. Prevention of nosocomial bloodstream infections: a national and international priority. Infect Control Hosp Epidemiol 1996;17:272–275.
26. Widdowson MA, van Doornum GJ, van der Poel WH, de Boer AS, Mahdi U, Koopmans M. Emerging group-A rotavirus and a nosocomial outbreak of diarrhoea. Lancet 2000;356:1161–1162.
27. Hanna H, Raad I, Gonzalez V, Umphrey J, Tarrand J, Neumann J, Champlin R. Control of nosocomial *Clostridium difficile* transmission in bone marrow transplant patients. Infect Control Hosp Epidemiol 2000;21:226–228.

28. Molina Gamboa JD, Ponce de Leon RS, Guerrero Almeida ML, Carvalho AC, Romero-Oliveros C, Baez-Martinez R, Huertas-Jimenez M, Osornio-Silva G, Ortiz R, Dominguez-Sosa F, Quinones-Falconi F, Ruiz-Palacios G. Salmonella gastroenteritis outbreak among workers from a tertiary care hospital in Mexico City. Rev Invest Clin 1997; 49:349–353.

29. Ling ML, Ang A, Wee M, Wang GC. A nosocomial outbreak of multiresistant *Acinetobacter baumannii* originating from an intensive care unit. Infect Control Hosp Epidemiol 2001;22:48–49.

30. Pittet D. Improving compliance with hand hygiene in hospitals. Infect Control Hosp Epidemiol 2000;21:381–386.

31. Heseltine P. Why don't doctors and nurses wash their hands? Infect Control Hosp Epidemiol 2001;22:199–200.

32. Albert RK, Condie F. Hand-washing patterns in medical intensive-care units. N Engl J Med 1981;304:1465–1466.

33. Voss A, Widmer AF. No time for handwashing!? Handwashing versus alcoholic rub: can we afford 100% compliance? Infect Control Hosp Epidemiol 1997;18:205–208.

34. Rutala WA, Weber DJ. Water as a reservoir of nosocomial pathogens. Infect Control Hosp Epidemiol 1997;18:491–514.

35. Nettleman MD. Global aspects of infection control. Infect Control Hosp Epidemiol 1993;14:643–648.

36. Macías AE, Muñoz JM, Bruckner DA, Candelas A, Rodriguez A, Guerrero FJ, Medina H, Gallaga JC, Cortes G. Parenteral infusions contamination in a multi-institutional survey in Mexico. Considerations for nosocomial mortality. Am J Infect Control 1999;27:185–190.

37. Pegues DA, Arathoon EG, Samayoa B, Del Valle GT, Anderson RL, Riddle CF, O'Hara CM, Miller JM, Hill BC, Highsmith AK. Epidemic Gram-negative bacteremia in a neonatal intensive care unit in Guatemala. Am J Infect Control 1994;22:163–171.

38. Emmerson AM. Emerging waterborne infections in health-care settings. Emerg Infect Dis 2001;7:272–276.

39. Kolmos HJ, Thuesen B, Nielsen SB, Lohmann M, Kristoffersen K, Rosdahl VT. Outbreak of infection in a burns unit due to *Pseudomonas aeruginosa* originating from contaminated tubing used for irrigation of patients. J Hosp Infect 1993;24:11–21.

40. Zaidi M, Ponce-de-León S, Ortiz RM, Ponce de Leon S, Calva JJ, Ruiz-Palacios G, Camorlinga M, Cervantes LE, Ojeda F. Hospital-acquired diarrhea in adults: a prospective case-controlled study in Mexico. Infect Control Hosp Epidemiol 1991;12:349–355.

41. Huskins WC, Soule BM, O'Boyle C, Gulacsi L, O'Rourke EJ, Goldmann DA. Hospital infection prevention and control: a model for improving the quality of hospital care in low and middle income countries. Infect Control Hosp Epidemiol 1998;19:125–135.

42. Carter CD, Barr BA. Infection control issues in construction and renovation. Infect Control Hosp Epidemiol 1997;18:587–596.

43. Pegues CF, Daar ES, Murthy R. The epidemiology of invasive pulmonary aspergillosis at a large teaching hospital. Infect Control Hosp Epidemiol 2001;22:370–374.

44. Macias AE. Optimal frequency of changing IV administration sets: is it safe to prolong use beyond 72 hours? (letter). Infect Control Hosp Epidemiol 2001;22:475.

45. Muñoz JM, Macías AE, Guerrero FJ, Hernández I, Medina H, Vargas E. Control of pediatric nosocomial bacteremia by a program based on culturing of parenteral solutions in use. Salud Pub Mex 1999;41(Suppl 1):s32–s37.

46. Abulrahi HA, Bohlega EA, Fontaine RE, al-Seghayer SM, al-Ruwais AA. *Plasmodium falciparum* malaria transmitted in hospital through heparin locks. Lancet 1977;349:23–25.

47. Crichton EP. Infusion fluids as culture media. Am J Clin Pathol 1973; 59:199–202.

48. Maki DG, Rhame FS, Mackel DS, Bennett JV. Nationwide epidemic of septicemia caused by contaminated infusion products. I. Epidemiologic and clinical features. Am J Med 1976;60:471–485.

49. Maki DG, Martin WT. Nationwide epidemic of septicemia caused by contaminated infusion products. IV. Growth of microbial pathogens in fluids for intravenous infusion. J Infect Dis 1975;131:267–272.

50. Macías AE, Bruckner DA, Hindler JA, Muñoz JM, Medina H, Hernandez I, Guerrero FJ. Parenteral infusions as culture media from a viewpoint of nosocomial bacteremia. Rev Invest Clin 2000;52: 39–43.

51. Macias AE, Muñoz JM, Galvan A, Gonzalez JA, Medina H, Alpuche C, Cortes G, Ponce de Leon S. Nosocomial bacteremia in neonates related to poor standards of care. Ped J Infect Dis. 2005. In press.

52. Emori TG, Gaynes RP. An overview of nosocomial infections, including the role of the microbiology laboratory. Clin Microbiol Rev 1993;6:428–442.

53. McGowan JE, Metchock BG. Basic microbiologic support for hospital epidemiology. Infect Control Hosp Epidemiol 1996;17:298–303.

54. McGowan JE Jr. New laboratory techniques for hospital infection control. Am J Med 1991;91:245S–251S.

55. Mallison GF, Haley RW. Microbiologic sampling of the inanimate environment in the U.S. hospitals, 1976–1977. Am J Med 1981;70: 941–976.

56. Cohen ML. Epidemiology of drug resistance: implications for a post-antimicrobial era. Science 1992;257:1050–1055.

57. Neu HC. The crisis of antibiotic resistance. Science 1992;257:1064–1073.

58. Goldmann DA, Weinstein RA, Wenzel RP, Tablan OC, Duma RJ, Gaynes RP, Schlosser J, Martone WJ. Strategies to prevent and control the emergence and spread of antimicrobial-resistant microorganisms in hospitals. A challenge to hospital leadership. JAMA 1996;275: 234–240.

59. Sifuentes-Osornio J, Donís-Hernández J, Arredondo-Garcıa JL. Report on bacterial resistance: pilot study of six Mexican centers. In: Salvatierra-González R, Benguigui Y, eds. Antimicrobial Resistance in the Americas: Magnitude and Containment of the Problem. Washington, DC: Pan American Health Organization;2000. pp. 150–153.

60. Isturiz RE, Carbon C. Antibiotic use in developing countries. Infect Control Hosp Epidemiol 2000;21:394–397.

61. Macías AE, Herrera LE, Muñoz JM, Medina H. Antimicrobial resistance of fecal *Escherichia coli* from healthy children. Induced by antibiotic use? (Article in Spanish). Rev Invest Clin 2002;54:108–112.

62. Patterson JE, Hardin TC, Kelly CA, Garcia RC, Jorgensen JH. Association of antibiotic utilization measures and control of multiple-drug resistance in *Klebsiella pneumoniae*. Infect Control Hosp Epidemiol 2000;455–458.

63. Antonelli M, Mercurio G, Di Nunno S, Recchioni G, Deangelis G. De-escalation antimicrobial chemotherapy in critically ill patients: pros and cons. J Chemother 2001;13(Spec No 1:1):218–223.

64. Patterson JE, Hardin TC, Kelly CA, Garcia RC, Jorgensen JH. Association of antibiotic utilization measures and control of multiple-drug resistance in *Klebsiella pneumoniae*. Infect Control Hosp Epidemiol 2000;21:455–458.

65. Sagoe-Moses C, Pearson RD, Jagger J. Risks to health care workers in developing countries. N Engl J Med 2001;345:538–541.

66. Khuri-Bulos NA, Toukan A, Mahafzah A, Al Adham M, Faori I, Abu Khader I, Abu Rumeileh ZI. Epidemiology of needle stick and sharp injuries at a university hospital in a developing country: a 3-year prospective study at the Jordan University Hospital, 1993 through 1995. Am J Infect Control 1997;25:322–329.

67. Scheckler WE, Brimhall D, Buck AS, Farr BM, Friedman C, Garibaldi RA, Gross PA, Harris JA, Hierholzer WJ Jr, Martone WJ, McDonald LL, Solomon SL. Requirements for infrastructure and essential activities of infection control and epidemiology in hospitals: a consensus report. Society for Healthcare Epidemiology of America. Infect Control Hosp Epidemiol 1998;19:114–124.

68. Wang FD, Chen YY, Liu CY. Analysis of sharp-edged medical-object injuries at a medical center in Taiwan. Infect Control Hosp Epidemiol 2000;21:656–658.

69. Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchmann SD. Guideline for infection control healthcare personnel, 1998. Infect Control Hosp Epidemiol 1998;19:407–463.

70. Rhinehart E, Goldman DA, O'Rourke EJ. Adaptation of the Centers for Disease Control guidelines for the prevention of nosocomial infection in a pediatric intensive care in Jakarta, Indonesia. Am J Med 1991; 91(Suppl 3B):213–221.

71. Dunn DL. Hazardous crossing: immunosuppression and nosocomial infections in solid organ transplant recipients. Surg Infect 2001;2: 103–110.

72. Murphy OM, Gould FK. Prevention of nosocomial infection in solid organ transplantation. J Hosp Infect 1999;42:177–183.

73. Dekker AW, Verdonck LF, Rozenberg-Arska M. Infection prevention in autologous bone marrow transplantation and the role of protective isolation. Bone Marrow Transplant 1994;14:89–93.

74. Braun BI, Darcy L, Divi C, Robertson J, Fishbeck J. Hospital bioterrorism preparedness linkages with the community: improvements over time. Am J Infect Control 2004;32:317–326.

75. Murphy JK. After 9/11: priority focus areas for bioterrorism preparedness in hospitals. J Healthc Manag 2004;49:227–235.

76. Ponce de Leon RS, Lazcano-Ponce E, Range-Frausto S, Sosa-Lozano HA, Huertas-Jimenez M. Bioterrorismo: apuntes para una agenda de lo inesperado. Salud Publica Mex 2001;43:589–603.

77. Cohen HW, Gould RM, Sidel VW. The pitfalls of bioterrorism preparedness: the anthrax and smallpox experiences. Am J Public Health 2004;94:1667–1671.

78. Staiti AB, Katz A, Hoadley JF. Has bioterrorism preparedness improved public health? Issue Brief Cent Stud Health Syst Change 2003;65:1–4.

79. Orellana C. Laboratory-acquired SARS raises worries on biosafety. Lancet Infect Dis 2004;4:64.

80. Ponce de León S, Leal P, Huertas M, Romero C, Jiménez ME. Risk of tuberculosis at hospital: infection, disease and prevention. 11th ICID Abstracts. Int J Infect Dis 2004;8(S1):S137.

81. Imperato AK, Bingham CO III, Abramson SB. Overview of benefit/risk of biological agents. Clin Exp Rheumatol 2004;22:S108–114.

82. Evans ME, Lesnaw JA. Infection control in gene therapy. Infect Control Hosp Epidemiol 1999;20:568–576.

83. Evans ME, Lesnaw JA. Infection control for gene therapy: a busy physician's primer. Clin Infect Dis 2002;35:597–605.