Control of Nosocomial Antimicrobial-Resistant Bacteria: A Strategic Priority for Hospitals Worldwide

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The rapid emergence and dissemination of antimicrobial-resistant microorganisms in hospitals worldwide is a problem of crisis dimensions. The root causes of this problem are multifactorial, but the core issues are clear. The emergence of antimicrobial resistance is highly correlated with selective pressure that results from inappropriate use of antimicrobial agents. Dissemination of resistant organisms is facilitated by person-to-person transmission due to inconsistent application of basic infection control practices by hospital personnel. While control strategies exist, the interventions are not likely to be successful unless hospital leaders assume the responsibility for control of antimicrobial resistance. Strategic goals for the control of resistant organisms should be formulated on the basis of multidisciplinary input from hospital personnel. Processes and outcomes relevant to these strategic goals should be measured, and the resultant data should be used to design, implement, and evaluate systematic measures to increase the appropriate use of antimicrobial agents and basic infection control practices. This approach is as relevant to hospitals in countries with limited resources as it is to in fully industrialized countries.

The Worldwide Problem of Antimicrobial Resistance

Papers presented at the workshop of the World Health Organization Scientific Working Group in 1994 amply demonstrate that the rapid emergence and dissemination of antimicrobial-resistant microorganisms in hospitals worldwide is a problem of crisis dimensions. Methicillin-resistant Staphylococcus aureus strains are endemic in numerous hospitals and chronic care institutions. Since the majority of coagulase-negative staphylococcal isolates have been resistant to methicillin for some time, vancomycin is the sole effective prophylactic and therapeutic agent for staphylococcal infections in many patients. As a result, the use of vancomycin has increased dramatically, which has led to increased costs and contributed to the emergence of enterococcal resistance to this agent.

Vancomycin resistance in enterococci had not been reported before 1989, but >10% of hospital-acquired enterococci isolated from patients in intensive care units (ICUs) participating in the National Nosocomial Infections Surveillance program of the Centers for Disease Control and Prevention (CDC) are now resistant to vancomycin [1]. Treatment of infections due to vancomycin-resistant enterococci has become extraordinarily difficult because many of the strains are also resistant to most other available agents, including β-lactams and aminoglycosides [2].

Intensive use of broad-spectrum antibiotics has likewise facilitated the emergence of resistance among gram-negative bacteria. Enterobacteriaceae, Pseudomonas species, and other gram-negative bacilli have become increasingly resistant to most first-line antibiotics, including third-generation cephalosporins, monobactams, aminoglycosides, and quinolones [3–5]. Strains of Pseudomonas and Serratia that elaborate extended-spectrum β-lactamas capable of inactivating carbapenems have recently been recovered in Japan [6, 7].

The gravity of the situation is exemplified by the problems encountered at a hospital in Queens, New York [8]. Faced with a strain of Acinetobacter that was resistant to aminoglycosides, clinicians at this institution began increasingly to administer third-generation cephalosporins. An outbreak of a Klebsiella strain that was resistant to cephalosporins ensued. Therefore, imipenem, to which the organism was susceptible, was substituted for cephalosporins; shortly thereafter, however, a strain of Acinetobacter that was resistant to imipenem reemerged.

Of course, some of the world’s most pressing resistance problems, such as multidrug resistance in Streptococcus pneumoniae, Neisseria gonorrhoeae, and Salmonella species, are not primarily hospital based. However, hospitals can serve as reservoirs for the dissemination of antimicrobial-resistant pathogens in the community. For example, what was regarded as "endemic" salmonellosis in a community in São Paulo, Brazil, was demonstrated by molecular epidemiological techniques to be a series of small outbreaks of infection caused by antimicrobial-resistant Salmonella typhimurium that was spread from the hospital to the community by recently discharged patients [9]. On the other hand, nosocomial outbreaks...
of penicillin-resistant pneumococci have demonstrated that antimicrobial-resistant microorganisms can spread from the community to the hospital [10].

**Root Causes of the Emergence and Dissemination of Antimicrobial Resistance**

Hospital epidemiologists, infection control professionals, and infectious diseases specialists have watched the emergence and spread of antimicrobial resistance with alarm, frustration, and an increasing sense of failure. The reasons that their efforts have failed are multifactorial, but the core issues are clear.

The excessive and inappropriate use of antimicrobials is the principal cause of the emergence of resistance. This misuse has occurred despite the existence of published guidelines regarding the appropriate use of antimicrobial agents that have been issued by respected governmental and professional groups and despite the implementation of antimicrobial restriction policies in many hospitals [11–14].

The reasons for the misuse of antimicrobials are fairly obvious. First, as resistance becomes more prevalent, anxious clinicians rely on the latest, most potent broad-spectrum agents for prophylaxis and treatment of infections. Second, increasing numbers of critically ill and immunocompromised patients are now being treated in hospitals. Because these patients are susceptible to a broad range of pathogens, physicians are more likely to administer broad-spectrum agents for empirical treatment of presumptive infection. Third, physicians tend to overinterpret the implications of colonization.

For instance, gram-negative bacteria frequently colonize the upper respiratory tract and endotracheal tube during mechanical ventilation, but the mere presence of these organisms does not indicate infection. However, because pneumonia is difficult to diagnose in critically ill, mechanically ventilated patients and has a high attributable mortality, physicians often err on the side of treatment when pneumonia is even a remote possibility; this is especially true when an aggressive pathogen like *Pseudomonas aeruginosa* has already been isolated from a patient's endotracheal tube aspirate. Although the use of broad-spectrum antimicrobial agents is sometimes justified in these situations, fear rather than reason appears to be the guiding principle in many cases.

Dissemination of resistant strains in hospitals occurs primarily via person-to-person transmission that results from inconsistent application of basic infection control techniques by hospital personnel. Despite extensive efforts at behavior modification, caregivers often neglect to wash their hands before or after most contacts with patients. Gloves are not used when contact precautions are indicated, and hands are not washed when gloves are removed. In some cases, caregivers have even been observed caring for a series of patients while wearing the same pair of gloves.

The risk of person-to-person transmission of antimicrobial-resistant pathogens via the contaminated hands of caregivers tends to be greatest in overcrowded, understaffed ICUs. Nosocomial pathogens circulating in these units quickly colonize the respiratory and gastrointestinal tracts of patients, where their numbers may reach billions per milliliter of respiratory secretions or billions per gram of feces within a few days.

Factors including mechanical ventilation, indwelling urinary catheters, and incontinence increase the likelihood that caregivers who do not adhere to fastidious infection control techniques will contaminate their hands. Even if personnel wash their hands, recent studies suggest that both antimicrobial-resistant gram-positive cocci and gram-negative bacilli will persist unless a soap containing an antimicrobial agent is used [15, 16].

Environmental contamination with relatively hardy gram-positive pathogens such as staphylococci and enterococci adds another dimension to the containment problem. Gloves must be worn not only during care of patients colonized with resistant bacteria but also when potentially contaminated objects in the environment are being handled. Equipment must be adequately disinfected before and after exposure to each patient. Containers of medications and other solutions can easily be contaminated by resistant gram-negative bacilli, leading to devastating common source epidemics of infection. Finally, patients who are harboring antimicrobial-resistant pathogens may not be identified because most colonized patients do not develop clinically apparent infections. This silent reservoir must be taken into account in prevention and control efforts.

**Efforts to Control Dissemination of Resistant Organisms**

In the United States, an increasingly popular approach to the control of resistant organisms is so-called body substance isolation (BSI); this approach is based on universal application of stringent barrier techniques in the care of all patients whose wounds, mucous membranes, secretions, and excretions must be handled, regardless of whether the patients are known to be colonized or not [17]. Unfortunately, evidence that this system works in practice is scant. Moreover, when caregivers rely on BSI, the possible contribution of the environment to nosocomial transmission of resistant microorganisms may be ignored. The beguiling simplicity of this precautionary system may also result in a generation of health care providers who do not understand the basic mechanisms of disease transmission in the hospital.

Another approach to preventing dissemination of resistant pathogens by colonized patients is to perform comprehensive microbiological screening of patients receiving care in high-risk wards, with prompt institution of barrier (contact) precautions when colonization is detected. Routine screening of patients in ICUs, oncology wards, and other high-risk units may seem expensive, but the cost can be reduced substantially if laboratory personnel use specific screening media containing
antimicrobials such as vancomycin, oxacillin, gentamicin, or ceftazidime, depending on the resistance pattern of interest. Furthermore, screening may be quite cost-effective in the long run, since it is far cheaper and easier to contain a newly introduced resistant pathogen when it has colonized only a few patients on a single ward.

Once a resistant microorganism has become established throughout a hospital, it may be difficult, if not impossible, to control the problem. This event may lead not only to expensive control efforts but also to increased empirical use of expensive broad-spectrum antimicrobials, increased length of hospitalization, and costly diagnostic and therapeutic interventions for patients who develop clinical infection. In addition, there is the threat of adverse publicity and litigation.

Additional infection-control guidelines developed by national organizations are not likely to be effective. National guidelines do not translate well to the unique health care delivery systems and practice patterns of local hospital environments, and experience has demonstrated that such guidelines are rarely incorporated into practice. Educational programs may have a beneficial effect, but their impact is not long-lasting. Restrictive antimicrobial prescribing forms and behavioral modification techniques, such as counter-detailing, while potentially useful, have not been applied widely. Attempts to improve handwashing habits have been demonstrated to have a temporary—usually modest—impact on practice.

The control measures described above are important, but infection control practitioners and infectious diseases specialists cannot be expected to conquer the antimicrobial resistance problem by themselves. They do not preside over the complex systems or the multiple departments and disciplines that need to be involved in a successful effort to influence the emergence, spread, and persistence of antimicrobial-resistant microorganisms. They cannot coerce other clinicians to weigh the costs and consequences of their prophylactic and therapeutic decisions; they cannot monitor every staff member for proper handwashing and barrier technique; they cannot improve performance in the microbiology laboratory or designate additional resources for detecting and reporting resistance; and they cannot revamp hospital systems for recording, analyzing, and reporting critical data.

The responsibility for describing, analyzing, and improving these systems (i.e., for making the campaign against antimicrobial resistance a strategic priority and mobilizing the necessary personnel and resources) lies with hospital leadership, not any one department or individual. The proper role for infection prevention specialists is as consultants to the hospital, particularly with regard to data collection and interpretation.

Unfortunately, the antimicrobial resistance problem is not high on the strategic agenda at many hospitals, which is surprising given the costs and consequences of infectious diseases due to antimicrobial-resistant microorganisms. Despite the high stakes, most hospital leaders appear to be content to approach prevention and control of antibiotic resistance and nosocomial infection as they have for several decades—i.e., by delegating the task to a few overworked members of their staffs who do not have the span of administrative control, influence, or resources to achieve success.

Making Control of Antimicrobial Resistance a Strategic Hospital Priority

In an effort to provide hospitals and their quality improvement programs with a framework for tackling their antimicrobial resistance problems, the National Foundation for Infectious Diseases and the Hospital Infections Program of the National Center for Infectious Diseases of the CDC cosponsored a workshop entitled “Antimicrobial Resistance in Hospitals: Strategies to Improve Antimicrobial Use and Prevent Nosocomial Transmission of Antimicrobial-Resistant Microorganisms,” held in Atlanta on 12–14 September 1994 [18]. The purpose of this workshop was not to develop yet another guideline but rather to reach consensus on high-priority strategic goals that would be likely to have a significant impact on the resistance problem if addressed successfully by hospital officials.

The meeting was designed to model the process of selecting priorities and initiating an action plan for a hospital quality improvement program. The methods used by the workshop participants were based on widely accepted quality improvement principles, with special emphasis on the model for rapid organizational change described by Langley et al. [19].

This model has the following components: first, ask the question, “What are we trying to accomplish?” This step should result in a mission statement and specific goals. Then ask and answer the question, “How will we know that change is an improvement?” This step emphasizes the critical importance of measurement and data analysis with use of appropriate epidemiological and biostatistical techniques. An experimental cycle, commonly referred to as PDCA (Plan a targeted intervention, Do [implement] the intervention, Study the impact of the intervention by monitoring and data analysis, and Act to change the intervention based on the data analysis), is the third step; the cycle is repeated until the desired degree of improvement is achieved.

Participants in the workshop were divided into two panels (quality improvement teams): one panel focused on increasing the appropriate use of antimicrobials, and the other concentrated on improving measures for preventing and controlling nosocomial transmission of resistant organisms. With the help of trained facilitators, each team first developed a list of five high-priority, actionable strategic goals, which, if accomplished, would be likely to have an impact on antimicrobial resistance (table 1) [18]. Next, the teams developed specific measures of process and outcome for each strategic goal [18]. These measures were intended to serve as examples to guide the work of hospital quality improvement teams and to emphasize the importance of a data-driven approach to...
Table 1. Strategic goals developed by two quality improvement teams participating in the workshop, “Antimicrobial Resistance in Hospitals: Strategies to Improve Antimicrobial Use and Prevent Nosocomial Transmission of Antimicrobial-Resistant Microorganisms,” cosponsored by the National Foundation for Infectious Diseases and the Centers for Disease Control and Prevention

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<tr>
<th>Strategies to optimize the prophylactic, empirical, and therapeutic use of antimicrobials in the hospital</th>
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<td>1. Optimize antimicrobial prophylaxis for operative procedures.</td>
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<td>2. Optimize choice and duration of empirical antimicrobial therapy.</td>
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<td>3. Improve antimicrobial prescribing practices by educational and administrative means.</td>
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<td>4. Establish a system to monitor and provide feedback on the occurrence and impact of antibiotic resistance.</td>
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<td>5. Define and implement institutional or health care delivery system guidelines for important types of antimicrobial use.</td>
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<th>Strategies for detecting, reporting, and preventing transmission of antimicrobial-resistant microorganisms</th>
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<td>1. Develop a system to recognize and promptly report significant changes and trends in antimicrobial resistance to hospital and physician leaders; medical, nursing, infection control, and pharmacy staffs; and others who need to know.</td>
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<td>2. Develop a system for rapid detection and reporting of resistant microorganisms in individual patients to appropriate personnel (caregivers and infection control staff) and for rapid response by caregivers.</td>
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<td>3. Increase adherence to policies and procedures, especially hand hygiene, barrier precautions, and environmental control measures.</td>
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<td>4. Incorporate the detection, prevention, and control of antimicrobial resistance into institutional strategic goals and provide required resources (e.g., by providing adequate facilities and resources for hand washing, isolation, and environmental hygiene; funding ongoing monitoring and data collection, including infection control and hospital epidemiology and quality improvement in the planning process; and setting managerial goals and accountability for reductions in colonization and infection with resistant microorganisms).</td>
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<td>5. Develop a plan for identifying, transferring, discharging, and readmitting patients colonized with specified antimicrobial-resistant microorganisms.</td>
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Note. Table is adapted from [18].

- Each hospital should specify a list of problematic pathogens, such as methicillin-resistant Staphylococcus aureus, vancomycin-resistant enterococci, enterococci with high-level resistance to penicillin, and gram-negative bacilli resistant to third-generation cephalosporins and aminoglycosides.

The strategic goals developed in the workshop (table 1) are broad and intentionally leave considerable room for hospital leaders to develop programs that are appropriate for their own healthcare delivery systems, patient populations, and medical practices. What, then, is the role of traditional expert guidelines in addressing antimicrobial resistance problems? If guidelines are crafted so that they address important strategic goals and can be incorporated easily into local quality improvement efforts, they will have far more impact than if they are issued in a void. The Hospital Infection Control Practices Advisory Committee (HICPAC) of the CDC recently issued “Recommendations for Preventing the Spread of Vancomycin Resistance,” which meet this standard [19]. These recommendations state explicitly that “Hospitals, in collaboration with their quality improvement and infection control programs, pharmacy and therapeutics committees, microbiology laboratories, clinical departments, and nursing, administrative, and housekeeping services, should develop a comprehensive, institution-specific strategic plan . . . [They should involve] the hospital’s quality assurance/improvement department at the outset in order to identify specific problems in hospital operations and patient-care systems and to design, implement, and evaluate appropriate changes in the system” [20].

The CDC recommendations, like the document produced by the workshop on antibiotic resistance in hospitals, cite two principal areas that must be addressed in hospitals: prudent use of antimicrobials (in this case, vancomycin) and prevention and control of nosocomial transmission of vancomycin-resistant enterococci (VRE). With respect to vancomycin, the recommendations list clinical situations in which the use of this agent would be inappropriate as well as situations in which its use should be discouraged. In the section on prevention and control of transmission of VRE, intensive educational efforts are recommended to alert staff to the importance of VRE colonization and infection and to the policies and procedures necessary to curtail their spread. Appropriate barrier precautions, including the need to wear a gown and gloves when contact with colonized or infected patients and potentially contaminated environmental objects and surfaces is expected, are described in detail.

The dedicated use of non-critical-care items, such as stethoscopes and electronic rectal thermometers, for individual colonized or infected patients is recommended, as is disinfection of equipment that must be shared. Aggressive screening of patients on high-risk wards is strongly encouraged, especially in hospitals where VRE have already been detected in patients as well as tertiary care centers where many critically ill patients receive care. Even in hospitals where VRE have not yet appeared and where relatively small numbers of patients at high risk for VRE colonization or infection are treated, vancomycin susceptibility testing should be performed on enterococcal isolates from all types of clinical specimens, including those from nonsterile body sites such as open wounds.

Emergence and Dissemination of Antimicrobial Resistance in Hospitals in Developing and Newly Industrialized Countries

Although the problem of antimicrobial resistance in developing and newly industrialized countries is not as well de-
scribed, it appears to be significant [21]. The previous dis-


tersion discussing the emergence and dissemination of

amicrobial resistance pertains as much, if not more so, to these countries. However, there are additional con-

cerns.

The recommendations promulgated by HICPAC and the


group that participated in the workshop on antibiotic resistance

in hospitals are based on the assumption that the basic infra-

structure and human, material, and financial resources required

for a successful prevention and control effort are in place.

Although model hospitals certainly exist in developing coun-

dies, many hospitals in such countries and in newly industrial-

ized countries do not have such resources. Organized, effective

infection control programs may not be in place or are in

the initial stages of development; thus, it may be difficult to tackle

a multidimensional problem such as antimicrobial resistance.

When formal isolation precautions are present, the concur-

rent need for the use of barrier techniques and attention to

placement of patients infected or colonized with antimicrobial-

resistant flora is often not acknowledged. Person-to-person

transmission of antimicrobial-resistant microorganisms is facil-

itated further by overcrowding.

In developing countries, in contrast with the United States

and Europe, the number of nurses per patient in the hospitals

is much lower; this is particularly true for nurses whose level of

education and training is consistent with that of registered

nurses in the United States. Lack of compliance with recom-

mendations for handwashing and use of barrier techniques is

understandable when a single nurse may be responsible for

performing procedures, such as dressing changes, for an entire

ward. Even if the clinical staff has the knowledge and desire
to comply with handwashing recommendations, facilities and

supplies for handwashing are often inadequate, and cheap, wa-
terless hand antiseptics (e.g., 70% alcohol plus an emollient)
are unavailable or underused.

While the resources to control dissemination of antimicrobial

resistance in developing countries are limited, factors that facili-
tate emergence of resistance often are abundant, particularly

in referral hospitals. The introduction of high-tech invasive

medical technologies increases the risk of nosocomial infection
dramatically because this technology is seldom accompanied by

equivalent resources for infection prevention.

Many hospital pharmacies are stocked with broad-spectrum

antimicrobial agents that are used liberally, in part because of a

lack of restrictions and in part because of an already-established

problem with resistant hospital flora. Although restrictions on

the use of antimicrobial agents have been instituted at some

hospitals, to be effective these programs must be administered

by physicians with special knowledge of the appropriate use

of antimicrobials and with the time and desire to perform the

burdensome task of reviewing individual case histories and

approving the use of restricted drugs.

Other factors contribute to the emergence of antimicrobial

resistance in developing countries. Clinicians often cite the lack

of adequate microbiological support as a deterrent to their preven-
tion efforts. Some clinicians do not bother to obtain speci-

mens for culture from infected patients because timely, accurate

results are not expected. In some cases, clinicians' distrust of

their laboratories leads them to ignore available culture and

susceptibility data when making prophylactic and therapeutic

treatment decisions. However, we have found that clinical lab-

oratory services often are far better than clinicians believe and

are generally good enough to guide bedside practice.

The control of antimicrobial resistance may appear nearly

impossible against this background, but we are not pessimistic.

We believe that antimicrobial resistance can be controlled in

hospitals in developing countries if an organized approach, as

outlined in the discussion of the proceedings of the workshop

on antimicrobial resistance in hospitals discussed above, is
developed.

At Children’s Hospital in Boston, we have developed a strat-
yegy for addressing the problem of nosocomial infection, includ-
ing transmission of antibiotic-resistant microorganisms. This

program, which is called INQUAL (International Quality As-

sessment and Infection Prevention Program), is based on the

following three premises: (1) because the number of trained

infection prevention professionals is insufficient in most hospi-
tals in developing and newly industrialized nations, expert

consultative guidance is necessary to achieve meaningful im-

provement in infection control; (2) recommendations for im-

provement must be based on a comprehensive, on-site evalua-
tion of the current status of infection prevention and a hospital’s

resources that will be perceived as informed and pertinent by

hospital officials; and (3) hospital personnel must participate

in the process by providing their own insights and developing

the infection-prevention and problem-solving skills necessary

to create a sustainable, independent prevention program.

We have accordingly designed and validated comprehensive,

structured survey instruments for evaluating hospital infection

prevention programs. These instruments include a series of

structured interviews with key hospital personnel; standardized

direct observations of facilities, equipment, supplies, and prac-
tices; and a point-prevalence survey of nosocomial infections

and the use of invasive medical devices and antibiotics.

The widely used structure-process-outcome model that is

familiar to quality assessment professionals has been applied to

the development of these instruments. For example, in evalu-

ating handwashing habits, an assessment of structure includes

determination of the availability of the physical resources

necessary for proper handwashing (i.e., sinks with running wa-
ter, soap, towels, and waterless antiseptic handwashing agents).

The assessment of process involves observing actual prac-
tices—in this case, the frequency of handwashing by hospital

personnel. Finally, rates of nosocomial infection or coloniza-
tion by antimicrobial-resistant bacteria provide relatively sim-
ple outcome measures.

The results of a typical survey sometimes provide clear guid-
ance to hospital personnel in terms of specific areas of improve-
ment. Advocating the use of waterless hand antiseptics is an obvious example. However, hospital officials generally need a more systematic, structured plan of action. Therefore, we have constructed detailed algorithms (decision trees) for a number of critical aspects of infection prevention such as provision of adequate handwashing equipment and supplies and for implementing or improving an organized, effective infection prevention program.

These algorithms, which are driven by data generated by the evaluation process, serve as decision aids for consultants and hospital personnel who must select practical, institution-specific measures. The algorithm-based recommendations include practical, cost-effective interventions that will substantially reduce transmission of nosocomial pathogens and the incidence of nosocomial infections and that will result in the elimination of unnecessary or wasteful practices.

The algorithms are a particularly valuable component of the education program we provide concurrently for key hospital personnel. The algorithms clearly demonstrate the critical questions involved in making decisions regarding infection prevention, with enforcement of a step-by-step, logical decision-making process. We also provide training in the basic epidemiological and biostatistical tools required to investigate outbreaks of infection, perform infection surveillance, and calculate infection rates and trends over time. Since outbreaks of nosocomial infection are especially numerous and severe in hospitals with limited resources, we emphasize strategies for detecting, investigating, and controlling such problems, especially the critical role of microbiological support. Problem-solving exercises based on simulated outbreaks are provided as well.

If hospital officials are ready to make a strategic commitment to infection prevention, we demonstrate how the principles of continuous quality improvement can be used to achieve specific goals by improving hospital systems. Continuous improvement is particularly well suited to reducing the rate of endemic infection that results from deficiencies in multiple processes involving diverse hospital departments and disciplines. We provide ongoing consultative support until a hospital infection prevention program becomes self-sustaining.

Our experience has demonstrated that infection prevention initiatives in individual hospitals can be successful if they receive adequate backing from the hospital administrators and are supported by trained, dedicated professionals. Unfortunately, hospital leadership may not make infection prevention a priority, have the influence to persuade diverse elements of the hospital community to coordinate their efforts, or be able to tap into resources that are controlled by officials at a higher governmental layer of the health care bureaucracy. In addition, there is rapid turnover among hospital administrators in some countries, and a commitment to infection prevention may not be transferable to their successors.

We believe that long-term success in infection control is far more likely if local hospital programs are initiated in the context of a coordinated national infection prevention effort. It is important to note that even in industrialized countries like the United States, infection prevention activities were restricted to a few academic centers until the CDC and the Joint Commission on Accreditation of Healthcare Organizations developed comprehensive training programs, guidelines, and accreditation standards.

When suitably condensed and modified, the assessment and measurement methods developed by INQUAL for use in individual hospitals form the basis for national surveillance, assessment, education, and, most important, accreditation programs. The assessment instruments and algorithms can be used by public health officials after a short training period. It is important for public health authorities to select a limited number of practical, valid monitors (widely called "indicators" in quality improvement circles) for key infection prevention processes and outcomes.

The monitoring tools suggested at the workshop on antimicrobial resistance in hospitals may be appropriate for this purpose, but the indicators should initially be as easy to measure as possible, and they should be tailored specifically to the infection control problems in newly industrialized countries. It is important to emphasize that although it is critical to monitor and report rates of nosocomial infection and antibiotic resistance, these activities are not enough. Hospital infection prevention programs themselves must be monitored in terms of basic programmatic elements, procedures, processes, and practices that are essential for success. Again, the ultimate goal is the development of a comprehensive national quality assessment and accreditation system, coupled with appropriate allocation of resources to hospitals. We believe strongly that infection prevention, with its emphasis on valid outcome and process measurement, provides an excellent model for broader quality assessment efforts at the local and national level.

References