SPECIAL COMMUNICATION

Requirements for infrastructure and essential activities of infection control and epidemiology in hospitals: A Consensus Panel report

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The scientific basis for claims of efficacy of nosocomial infection surveillance and control programs was established by the Study on the Efficacy of Nosocomial Infection Control project. Subsequent analyses have demonstrated nosocomial infection prevention and control programs to be not only clinically effective but also cost-effective. Although governmental and professional organizations have developed a wide variety of useful recommendations and guidelines for infection control, and apart from general guidance provided by the Joint Commission on Accreditation of Healthcare Organizations, there are surprisingly few recommendations on infrastructure and essential activities for infection control and epidemiology programs. In April 1996, the Society for Healthcare Epidemiology of America established a consensus panel to develop recommendations for optimal infrastructure and essential activities of infection control and epidemiology programs in hospitals. The following report represents the consensus panel's best assessment of needs for a healthy and effective hospital-based infection control and epidemiology program. The recommendations fall into eight categories: managing critical data and information; setting and recommending policies and procedures; compliance with regulations, guidelines, and accreditation requirements; employee health; direct intervention to prevent transmission of infectious diseases; education and training of healthcare workers; personnel resources; and nonpersonnel resources. The consensus panel used an evidence-based approach and categorized recommendations according to modifications of the scheme developed by the Clinical Affairs Committee of the Infectious Diseases Society of America and the Centers for Disease Control and Prevention's Hospital Infection Control Practices Advisory Committee. (AJIC Am J Infect Control 1998;26:47-60)

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The Panel was initiated by the Board of SHEA in April 1996 and first convened in July 1996. This report and the recommendations in it were approved formally by the SHEA and APIC boards in 1997 and endorsed by the organizations represented by the panel members: JCAHO, AHA, HIP-CDC, PIDS, IDSA, and NFID.

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Over the past 30 years, nosocomial infection surveillance, prevention, and control programs have been integrated into hospitals and other healthcare institutions to ensure the well being of patients, staff, visitors, and others in the healthcare environment. In 1958, responding to nationwide epidemics of nosocomial *Staphylococcus aureus* infections and recognizing the need for hospitals to identify problems in a timely fashion, the American Hospital Association's Advisory Committee on Infections Within Hospitals recommended that nosocomial infection surveillance become a regular hospital routine.[1] In 1970, the Centers for Disease Control and Prevention recommended that hospitals establish positions for an infection control nurse and a hospital epidemiologist.[2] The critical importance of nosocomial infections as preventable and controllable adverse hospital outcomes was highlighted in 1976 when the Joint Commission on Accreditation of Health Care Organizations (JCAHO) published standards for organization, surveillance, reporting, evaluation, record maintenance, and other requirements for infection prevention and control activities as a condition for hospital accreditation.[3] The scientific basis for claims of efficacy of nosocomial infection surveillance and control programs was established by the Study on the Efficacy of Nosocomial Infection Control (SENIC) project, conducted between 1974 and 1983.[4] The SENIC project demonstrated that, overall, 32% of nosocomial infections involving the four major sites (bloodstream, surgical wound, urinary tract, and respiratory tract) could be prevented with high-intensity infection surveillance and control programs.

In addition to the endemic infections on which the SENIC project focused, and which account for over 95%[5] of nosocomial infections, the medical literature is replete with reports of epidemic infections and successful control of them. Subsequent analyses have demonstrated nosocomial infection prevention and control programs to be not only clinically effective but also cost-effective.[6,7] Indeed, nosocomial infection prevention and control programs have been so successful that there have been numerous pleas to apply the scientific methodology upon which these programs are based to the more generic quality-assurance and risk-management activities of institutions.[8] This has led to the broadening of the use of epidemiological tools and principles from infection control to other areas of quality improvement in the healthcare setting.

The growth in infection control programs has been paralleled by the establishment and growth of a number of professional and governmental organizations with a focus on nosocomial infection prevention and control, such as the Association for Professionals in Infection Control and Epidemiology (APIC), the Society for Healthcare Epidemiology of America (SHEA), the Surgical Infection Society, and the Centers for Disease Control and Prevention (CDC)'s Hospital Infections Program and Hospital Infection Control Practices Advisory Committee (HICPAC). These organizations have used the expertise of their members to develop and publish a wide variety of useful recommendations and guidelines for infection control. However, apart from general guidance provided by JCAHO, there are surprisingly few recommendations on infrastructure and essential activities for infection control programs.[9,10] Questions then arise as to what material and administrative elements are needed to ensure a successful infection control program, what resources are needed if the traditional discipline of infection-based hospital epidemiology is to be applied successfully to quality-assurance and risk-management programs, and what are the critical functions that hospital and healthcare epidemiology programs must undertake?

The purpose of this consensus panel was to develop recommendations for the infrastructure and essential activities for infection control in hospitals.

GOALS FOR INFECTION CONTROL AND EPIDEMIOLOGY

There are three principal goals for hospital infection control and prevention programs:

- Protect the patient;
- Protect the healthcare worker, visitors, and others in the healthcare environment;
- Accomplish the previous two goals in a cost-effective manner, whenever possible.

Achieving these goals is the driving force behind every recommendation and action of the infection control program. These goals are relevant to patient-care activities in any healthcare setting where patients are cared for, not only in the acute-care hospital but also in skilled nursing facilities, nursing homes, rehabilitation units, urgent-care centers, same-day surgery facilities, ambulatory-care centers, and home-care programs. The goals, recommendations, and expected outcomes that follow represent a single standard of care for all hospitals.

The success or failure of the infection control program is defined by its effectiveness in achieving its goals. The goals of the program promote actions that are designed to limit the spread or to prevent

the occurrence of nosocomial infections. It is imperative that every healthcare institution develop specific objectives and outcome measures to determine whether or not its infection control goals have been achieved. This is mandated by JCAHO and most state licensing or credentialing organizations.[9] The outcome measures that are selected for monitoring should relate directly to the specific goals of the infection control program, namely,

- To measure the effectiveness of procedures, policies, or programs to protect patients;
- To measure the effectiveness of procedures, policies, or programs to protect healthcare providers; and,
- To determine the cost-effectiveness of these activities.

PROTECT THE PATIENT

For patients, the ultimate value of an infection control program is measured by lower rates of infection; by higher rates of survival; by avoidance of, or decrease in, morbidity; by shorter periods of illness or hospital confinements; and by more rapid return to good health. These are the goals of all therapeutic interventions and prevention efforts. However, they are particularly relevant to the problem of nosocomial infections because these complications are, most frequently, unanticipated setbacks for patients who already are compromised by ill health and who may suffer dire consequences from the added stress of infection.

There is a plethora of data that correlate the occurrence of nosocomial infections with excess morbidity, increased mortality, and prolongation of hospital stays.[4,6,11,12] There also is a substantial body of literature confirming that effective infection control activities result in fewer infections, improved survival, decreased morbidity, and shorter duration of hospitalization.[4,11-14] Effective infection control efforts have been shown to cause dramatic reductions in the incidence of catheter-associated urinary tract infections and secondary bacteremias, hospital-acquired pneumonias, surgical-site infections, and primary bacteremias in patients who are at high risk for these infections.[4] Examples of successful interventions include the reduction in rates of clean-wound infections that have been observed when feedback is provided to surgeons or when the timing of perioperative antibiotics is controlled carefully.[15-17] The primary goal for infection control programs is to protect the patient from these types of infections, as well as from infections that might be acquired as a result of contacts with other patients or healthcare workers who may be colonized or infected with transmissible agents.

PROTECT THE HEALTHCARE WORKER, VISITORS, AND OTHERS IN THE HEALTHCARE ENVIRONMENT

The second important goal for the infection control program is to prevent the spread of infections from patients to healthcare workers. Healthcare personnel, as well as patients, are at risk for acquiring infections that are transmitted by air or by direct or indirect contact with an infected or colonized patient. Many of the functions of infection control focus on strategies for isolation, barrier precautions, case investigation, healthcare worker education, immunization services, and employee health programs that are designed to protect healthcare workers from on-the-job exposures to infections. There are many examples of infection control programs that have been successful in protecting their healthcare workers.[18-21] On the other hand, there also are many reports of epidemic infections among healthcare workers in which infection control efforts were lacking.[22]

PROVIDE COST-EFFECTIVE INFECTION CONTROL

In today's managed-care marketplace, direct and indirect costs of care have an impact on the competitiveness, and perhaps survival, of the healthcare system or hospital. Nosocomial infections frequently prolong hospital stays, increase consumption of costly resources, open the possibility of legal action against the healthcare provider and the hospital, and may have a negative impact on the marketability of the healthcare organization to its consumers. Programs that prevent nosocomial transmissions from healthcare workers to patients provide important cost savings for the institution and the healthcare insurer.[4,13,23,24] Similarly, maintenance of employee health, avoidance of infection-related absenteeism, and prevention of healthcare worker claims concerning unsafe working conditions are important health and safety goals for the healthcare system and also may provide cost savings.

Procedures and products that are introduced to prevent infections or limit their spread have the potential to increase the costs of care. Therefore, every intervention strategy that is used to prevent infections must determine that the benefits that might be gained from its use outweigh any risks or increased costs. This often is a complex calculation that balances the direct and indirect costs of the infection control intervention against the estimated costs of the infection that is being prevented. The cost calculation should include the expense of purchasing the new product, personnel time for educa-

tion, and costs for implementing or using the device. The financial cost of the infection that is prevented should include the expense of diagnosing and treating the infection, the prolongation of hospital stay, the delayed return to work, and any long-term disability or loss of life. Non-monetary outcomes, such as patient satisfaction, legal considerations, ethical issues, and negative publicity, also should be considered.

FUNCTIONS OF INFECTION CONTROL AND EPIDEMIOLOGY

The key responsibilities of infection control—problem identification, data collection and analysis, intervention through changes in policies and procedures, and ongoing data collection to monitor success—are mirrored by the "Plan-Do-Check-Act" cycle that often is applied in quality improvement.[25] To these basic activities are added the specialized knowledge of healthcare epidemiology, microbiology and transmission of infectious diseases, and biostatistics, which are integral to the practice of infection prevention and control.

Thus the principal functions of infection control and healthcare epidemiology are to protect the patient and healthcare worker and to ensure the optimal operation of the healthcare system by means of the following:

1. Managing critical data and information, including surveillance of nosocomial infections;
2. Setting and recommending policies and procedures;
3. Intervening directly to interrupt the transmission of infectious diseases; and,
4. Educating and training healthcare workers and providers.

Additional functions may need to be considered in light of program requirements. These include participating in a monitoring program for antibiotic usage,[26] consultation to the microbiology laboratory, advice on product evaluation, input into facility design, coordination with safety and other quality-assurance programs, and research activities. Tailoring of specific functions for the infection control program need to be performed by each healthcare facility.

MANAGING CRITICAL DATA AND INFORMATION

Developing, implementing, and monitoring surveillance

The most important data-management activity of infection control programs is the surveillance of nosocomial infections and other adverse events. Surveillance always is conducted to monitor definable events, such as surgical-site infections, in a specific population. The collection, analysis, and dissemination of surveillance data has been shown to be the single most important factor in the prevention of nosocomial infections.[4]

A well-designed surveillance program, based on sound epidemiological principles, is essential for performing all of the other necessary activities of the infection control program. Facilities must tailor surveillance systems to balance the availability of resources with priorities for data collection, population needs, and institutional objectives. Traditionally, many programs have included surveillance of nosocomial infections and antibiotic-resistance patterns and also may monitor other adverse outcomes (including noninfectious events such as medication errors and falls). Integrating the infection control surveillance systems within the framework of the institution's other quality-improvement efforts can facilitate functional collaboration between and among programs working to improve patient care.

External reporting of infection rates

Increasingly, healthcare institutions and healthcare providers are being asked to benchmark, or compare their rates of key events to other similar institutions. This may be a more complex and difficult undertaking than is immediately obvious, because the rate of nosocomial infections may be affected by a variety of factors, some of which, such as the underlying health status of the population served by the hospital or health plan, are outside the control of the institution.[27-29] However, ongoing monitoring and benchmarking of nosocomial infection rates have been used to implement quality-improvement activities that have resulted in improved patient outcomes, as manifested by a lower incidence of nosocomial infections.[30] Although much of the methodology for accurate benchmarking of nosocomial infection rates is under development, the use of clinical performance indicator systems to assess quality is now commonplace. The need to adjust for case mix, severity of illness, socioeconomic status, and other risk factors should be understood. JCAHO will require reporting of such data as part of the accreditation process beginning in 1999. All hospitals and health plans should ensure that infection control professionals (ICPs) and hospital epidemiologists are consulted routinely to provide expert guidance in the selection of indicators, in the oversight of data

collection, and in the analysis of indicators that are used for interhospital comparison.[28]

SETTING AND RECOMMENDING POLICIES AND PROCEDURES TO PREVENT ADVERSE EVENTS

Assuring the appropriateness and feasibility of policies and procedures

Policies and procedures must be based on scientifically valid infection prevention and control measures that have a positive impact on process and prevent nosocomial infections. They must be practical to implement and must be reviewed regularly to maintain accuracy and validity.[31] They must be written to serve as a resource for providers responsible for their implementation. Policies and procedures generally are provided at two levels: (1) those that are organization-wide and applicable to all employees and (2) specific policies and procedures applicable to a unique worksite. Policies and procedures should reflect analysis of applicable data, the institution's experience, and a management framework designed to protect the health and safety of patients and caregivers.

Information sources to be consulted during policy and procedure development include surveillance data; appropriate literature; professional practice guidelines and standards; HICPAC, SHEA, and APIC guidelines; legal requirements; and regulatory standards from state and local licensing bodies and federal agencies such as the Occupational Safety and Health Administration (OSHA), the Food and Drug Administration, and the Environmental Protection Agency, and others.[31,32]

Compliance with regulations, guidelines, and accreditation requirements

All healthcare organizations are subject to regulation and oversight by various agencies, authorities, and governing bodies.[33-36] Healthcare organizations are subject to legal requirements, such as licensure, as well as guidelines or recommendations that do not carry the force of law but are recognized as standards of care and place the institution at risk of liability if not followed. Some nonlegislative standards are absolute requirements for the continued functioning of the hospital.[37] JCAHO standards, for example, are incorporated into some state licensing regulations, as well as into Medicare and Medicaid regulations.

Infection control personnel are responsible for ensuring that the hospital's administration and management are aware of the institution's compliance with all legal and accreditation standards, as well as with other guidelines and recommendations that pertain to the appropriate practice of infection control.

Employee health

People who work in healthcare settings are exposed more frequently to infectious diseases. They also may pose a risk to patients and other healthcare workers if they develop a communicable disease. Healthcare workers or personnel who work directly with, or in close proximity to, patients have the greatest risk of exposure. In addition to employees, this may include medical, nursing, and other health students; volunteer workers; religious clergy; and visitors. Facility-associated prehospital and posthospital personnel, such as home health care, nursing home, clinic, day-care, funeral home workers, and emergency medical technicians, also should be considered as being at risk. The employee or occupational health program of a healthcare facility is charged with developing and implementing systems for diagnosis, treatment, and prevention of infectious diseases in healthcare workers. It plays an important role in infection control within the facility.[18-20] The infection control program and the employee health or occupational health program need to work collaboratively to develop policies and procedures for healthcare personnel, such as placement evaluations, health and safety education, immunization programs, evaluation of potentially harmful infectious exposures and implementation of appropriate preventive measures, coordination of plans for managing outbreaks among personnel, provision of care to personnel for work-related illnesses or exposures, education regarding infection risks related to employment or special conditions, development of guidelines for work restrictions when an employee has an infectious disease, and maintenance of health records on all healthcare workers.[38]

Many of the communicable diseases of healthcare workers are vaccine-preventable; appropriate vaccine use protects both the healthcare worker and the patients. Immunization programs have been found to be highly cost-effective and are a critical component of the employee health effort.[18,19,38,39]

INTERVENING DIRECTLY TO PREVENT THE TRANSMISSION OF INFECTIOUS DISEASES

Outbreak investigation and control

The most common setting in which ICPs and hospital epidemiologists must intervene directly

in patient-care activities is in the control of an outbreak of nosocomial infections. An outbreak may be defined as an increase in the incidence of a disease, complication, or event above the background rate. Thus, each healthcare facility must have baseline surveillance data on the incidence of nosocomial infections in order to identify outbreaks.[27]

The availability of appropriate microbiology laboratory capacity is essential to the detection and investigation of outbreaks.[40] Outbreaks of unusual species of microorganisms will not be identified unless clinical microbiology personnel are able to recognize that an unusual pathogen is present and to perform appropriate microbiological testing to identify the microorganism. Similarly, clusters of commonly isolated species of microorganisms (e.g., *S. aureus, Escherichia coli, Pseudomonas aeruginosa)* may not be detected unless the isolates can be shown to be a single strain or clonal variant.[41-44] Clinical microbiology personnel must be able to perform or obtain appropriate testing to make these determinations. Such findings support epidemiological data pointing toward either a common source or a linked chain of transmission.

Appropriate clinical specimens must be obtained and sent for culture. Infection control personnel should ensure that medical and surgical staff are familiar with the indications and the necessity for obtaining appropriate cultures prior to initiating antimicrobial therapy in patients with nosocomial infections. Microbiology laboratory records must be kept in a manner that permits retrieval of information (preferably from a computerized database) by type of microorganism, antibiotic-susceptibility pattern, type of clinical specimen, ward, service, attending physician or surgeon, and date the culture was obtained.

It is imperative that outbreaks be investigated by personnel trained in infection control, infectious disease epidemiology, and applied statistical analysis. Failure to appreciate the complexity of outbreaks in the healthcare setting can lead to nontreatment or mistreatment and to substantial increases in expenditures.[21,22,44] To investigate the outbreak fully and identify all possible cases, infection control personnel must have unrestricted access to necessary information, including medical, nursing, and administrative records within the institution. In an outbreak setting, decision making must be immediate, and decisions must be implemented expeditiously. Access to the medical literature is crucial, and public health support also may be necessary. Therefore, it is essential that infection control personnel have direct access to administrative, medical, and nursing personnel with authority to direct changes in institutional policies and practices necessary to achieve immediate control of the outbreak. Administrators need to be involved in, and ensure adequate support for, the infection control program.[9]

Education and training

The prevention of nosocomial infections requires an organized educational and training program in all healthcare facilities. Ongoing education in the area of infection control is necessary for several reasons. All healthcare workers need to be aware of new scientific innovations in the area of infection control. For example, the proper implementation of technological innovations, such as improved personal protection devices, demands learning new knowledge and skills. Regulatory agencies and accrediting entities such as OSHA and JCAHO require that workers receive ongoing training in a variety of areas, depending on their job duties. This training includes instruction on isolation precautions, aseptic practices, and prevention of blood and body fluid exposure.[38,45]

Ongoing monitoring of patient-care practices is required to identify areas of continued concern and to assess effectiveness of educational interventions. Through the nosocomial infection surveillance program, information will be available to inform hospital personnel about problems occurring in their facility. In addition, ongoing surveillance provides both the ICP and the healthcare worker with feedback on results of changes instituted to address those problems. This feedback serves as an educational tool to stimulate change in patient-care practices.[46,47]

Education and reinforcement of policies and procedures are essential to prevent nosocomial infections. Training techniques need to be applicable to adult learning styles that will stimulate behavior change. Providing specific information to healthcare personnel regarding infection risk, such as reporting surgical-site infection rates to individual surgeons, also has been effective in reducing nosocomial infection rates.[15,48] Infection control education should be simple, clear, and relevant to the policies of the healthcare facility. Teaching formats should be varied through use of individualized programmed educational units utilizing video and computer technology, face-to-face

discussions with infection control personnel, and practical demonstrations in order to meet the needs of healthcare workers with varying educational backgrounds and work responsibilities.[38,45]

Resources

The personnel and nonpersonnel (physical) resources for infection control and epidemiology in hospitals should be proportional to the size, sophistication, case mix, and estimated risk of the populations served by the institution. Institutions must comply with basic accreditation standards and the state and local licensing standards of their community. Coordination and sharing of support with other quality-improvement services should be encouraged, but not at the risk of limiting adequate basic services for the scientifically well-supported infection control components of the process. Housing of these units at a common geographic site within the institution will encourage the communication and cross-fertilization that will enhance the quality of the individual and joint programs.

PERSONNEL RESOURCES

The hospital epidemiologist

Overall, SENIC, conducted by the CDC, found the trained hospital epidemiologist to be an essential component of an effective hospital infection control program.[4] However, SENIC did not quantify or specify the type of training for hospital epidemiologists. Although most hospital epidemiologists did not have formal training in epidemiology at the time of the SENIC study, there is no question that such training is helpful, and the increasing sophistication of the published literature argues that it is essential. Most current hospital epidemiologists are clinicians with training in internal medicine or pediatrics and in infectious diseases. Some pathologists with a primary interest in clinical microbiology or sterilization and disinfection also have been involved in hospital epidemiology programs. Increasingly, additional training in epidemiology has been obtained. Continuing education in hospital epidemiology can be accomplished by reading recently published texts, journals such as *Infection Control and Hospital Epidemiology, AJIC: American Journal of Infection Control,* and the *Journal of Hospital Infection;* by attending the annual meetings of relevant professional organizations; or with formal training in hospital epidemiology such as provided by the SHEA/CDC training course. Hospital epidemiologists should be compensated adequately and appropriately for their work by the healthcare facility or entity utilizing their services.

The infection control professionals and surveillance personnel

The SENIC study found that ICPs (formerly known as infection control practitioners), many of them nurses, were essential components of an effective program. The SENIC study suggested that having one ICP per 250 occupied beds was associated with an effective program.[4] However, in recent years, the amount and complexity of the ICP's work has burgeoned due to increases in the intensity and complexity of patient care delivered, increased severity of illness of the patient population at risk, and increased activity in healthcare delivery beyond the hospital. Therefore, the old ratio of one ICP per 250 beds is no longer adequate, because the notion of a ratio tied to beds is now insufficient to define the scope of the work of an ICP. In most acute-care hospitals today, the scope of work of ICPs is much greater than that provided by the old ratio.

The ICP most often has been a registered nurse, often with a bachelor's degree. Other ICPs are medical technologists, and some may have master's degrees in epidemiology or other related fields. ICPs often receive training in infection surveillance and control and in epidemiology through basic training courses offered by professional organizations or healthcare institutions. Many individuals in such positions have obtained Certification in Infection Control by the Certification Board of Infection Control.[49]

Less highly trained individuals are used by some hospitals as surveillance technicians (e.g., licensed practical nurses or medical-care associates). With on-the-job training and close supervision by an ICP, such individuals may function effectively in surveillance and compliance monitoring but may have limited abilities to provide education and consultation, especially for senior healthcare staff; however, their presence provides an ability to expand surveillance functions and frees ICPs for additional education and consultation activities.

Secretary

Secretarial service is essential for the infection control program. Computer data entry, typing of minutes, policies, and a variety of other documents and correspondence can be done most efficiently by appropriate support staff. Other support and communication functions, such as

answering the telephone and arranging meetings, also are appropriate support responsibilities.

Computer support personnel

Computer support personnel are a requisite for the management and analysis of the administrative and clinical data of the modern hospital and for the hospital epidemiology and infection control programs. Such personnel should be available to facilitate education in, and use of, computer hardware and appropriate software programs. Healthcare institutions and hospital epidemiology programs should be aware of the goals of the Institute of Medicine report *The Computer-Based Patient Record: An Essential Technology for Health Care.*[50]

NONPERSONNEL SUPPORT

Office support

The hospital epidemiology and infection control program should have sufficient office space to house members of the program. Contiguous space with other quality-improvement programs will foster interstaff communication, encourage development of shared programs, and make efficient use of secretaries. This space should be convenient to the clinical services under surveillance.

In addition to standard office equipment, appropriate furnishings should include communication tools sufficient to support the program. A minimal system would include telephones, pagers, fax and copying services, and basic office supplies.

Computing support

A preferred system would include a desktop or laptop computer and a printer. Available software should include word processing, spreadsheet, database management, and basic statistical programs. Many commercial software programs are available at modest cost. An important consideration is to budget for sufficient training so that the software is used appropriately. For infection control programs with extensive educational responsibilities, use of a software for slide preparation and program presentation may be advantageous. Establishment of a network to allow single entry, primary-source capture of healthcare data should be a strategic goal for the efficient handling, analysis, and distribution of infection control and other institutional data within the institution and throughout the integrated healthcare system.

With Internet services available in most areas of the country, a modem is essential for access to the Internet and e-mail. The ability to contact and download information from regional medical libraries, the vast resources of the National Library of Medicine, the CDC, the *Federal Register,* and the Internet pages of professional organizations such as SHEA, APIC, and the Infectious Diseases Society of America are of tremendous added value at minimal cost.

Semiautomated backup systems may be added at small cost and will assist in preventing the unfortunate loss of critical data with electrical or equipment (e.g., hard disk) failure.

Audiovisual support

Inservice education is a vital component of infection control and epidemiology programs. A 35 mm slide projector, an overhead projector, and a television monitor with a VCR are basic resources. Newer technology, such as computer projection equipment and software support programs, is being utilized increasingly.

Microbiology laboratory support

Microbiology laboratory reports from patient clinical specimens should be made readily available to assist in the surveillance of nosocomial infections. Hospital microbiology laboratories should comply with the relevant accrediting standards.

A microbiology budget sufficient for investigation of outbreaks at no charge to the patient should be available to the infection control program.[40]

Pathology services

Adequate pathology services should be available, including microbiology testing for postmortem investigations, with reports routinely directed to the infection control program.

Reference laboratory testing

Reference immunology and microbiology laboratory testing, including appropriate molecular typing of organisms, should be available on request and in a timely fashion from regional public health, commercial, or university-based laboratories.[51] These nonroutine tests may be essential for conducting epidemiological or outbreak investigations.

Connecting links and the future

The terms *infection control* and *hospital epidemiology* often have been used synonymously. Although epidemiology—the study of disease in

the population—is the science that supports prevention and control efforts for all diseases of public health importance, hospital epidemiology has been limited, for the most part, to the description and analysis of the occurrence of nosocomial infections. However, with the increasing reliance on "health outcomes" as a measure of the quality of health services, interest in the quantitative assessment of patient care and healthcare support services has broadened. Thus, the application of epidemiology or of related statistical methods drawn from industrial process control to areas outside infection control now has become commonplace.[52-54]

This consensus paper focuses on the requirements and activities of infection control programs in hospitals. Although among the many changes occurring in healthcare is a marked increase in out-of-hospital services, such as ambulatory and other nonhospital care, the Consensus Panel believes that the preponderance of the risk of nosocomial infections still is found among the sickest patients, those who will continue to occupy acute-care hospitals. Despite shorter hospital stays and a decreasing census, there is, in fact, an increased potential for nosocomial infections due to the changing demographics of the population and new, increasingly invasive technology. Patients in hospitals will be sicker; there will be new antibiotic-resistant microorganisms; there will be new instruments and procedures; and there will be new infectious diseases. Thus, the need for infection control as a specialty practice in the hospital will continue to increase.

Hospital infection control is a quality-improvement activity that focuses on improving the care of patients and protecting the health of staff.[53] Professionals in infection control and quality improvement recognize that the methods used in each of these fields derive from similar basic principles and have many common elements, although the implementation and application of the methods used by each of these disciplines may be somewhat different. Infection control professionals have adapted and used the theories and tools of continuous quality improvement to focus on improving healthcare delivery processes, sometimes with dramatic improvements in patient care.[54] This link between infection control and the performance-measurement and -improvement activities in a healthcare facility is crucial. The epidemiological and statistical methods used by hospital epidemiologists and ICPs often can provide crucial insights into the evaluation and analysis of problems encountered in outcomes management.[55] The epidemiological strategies that are used successfully in infection control programs are the same as those stressed in statistical-process control and quality-improvement theories.[56,57]

The infection control program always has been a critical part of the hospital's strategy to conserve resources by prevention and control of adverse infections outcomes. Prevention and control of nosocomial infections has allowed institutions to decrease length of stay, decrease morbidity, decrease costs, maximize appropriate use of materials, and increase patient satisfaction.[4,12,13] In addition, prevention of adverse infections outcomes in healthcare workers has resulted in decreased days off work, decreased personnel costs, and increased employee satisfaction with better worker morale.[18-20,38,39]

Rose notes that ICPs can be instrumental in defining a set of indicators for adverse outcomes, developing methods of case-finding, and subjecting these indicators to careful scientific scrutiny.[54] A scope of practice that encompasses many areas of quality improvement, including infection control, may be an area of interest for many ICPs.

One of the limitations of the hospital-focused approach has been that infection control prevention efforts, those intervention efforts that constitute the "effector arm" of the infection control program, are restricted to the patient's experience in the hospital. By expanding epidemiology programs throughout the continuum of care, new prevention opportunities are opened for reducing the risk of nosocomial infections, by reducing both the patient's susceptibility and the risk of exposure. This may be particularly important to prevent the further spread of antimicrobial-resistant microorganisms between nursing homes and acute-care hospitals, as well as within the community. In addition, this expansion beyond the hospital will help improve in-hospital care through improved data upon which to base assessments, as with postdischarge surveillance of surgical-site infections.

Infection control and quality-improvement programs conduct their activities according to a similar paradigm: ongoing data collection and analyses, problem identification and definition, intervention to improve outcomes, and reassessment to ensure that the intervention has led to the desired result. The intense interest in measurement of health outcomes in recent years confirms the critical role of data collection and analysis in the quality process.

Table 1. Recommendation categories

I. Strongly recommended	Strongly recommended for implementation based on: •Evidence from at least one properly randomized, controlled trial, or •Evidence from at least one well-designed clinical trial without randomization, or •Evidence from cohort or case-control analytical studies (preferably from more than one center), or •Evidence from multiple time-series studies.
II. Recommended	Recommended for implementation based on: •Published clinical experience or descriptive studies, or •Reports of expert committees, or •Opinions of respected authorities.
III. Recommended when required by government rules or regulations	

This critical activity also is the most problematic because of the inherent difficulty in acquiring and maintaining data in a complex healthcare setting and because the marked variability of populations and systems confounds comparison between institutions. These aspects of quality management have been studied and refined in the field of infection control for over 30 years and have led to some remarkably sophisticated analyses.

The recommendations of this document establish the current essential elements of infection control programs as a foundation for bridging the science of healthcare epidemiology from hospital infection control to infection control in other sites of healthcare delivery and to other aspects of patient care and healthcare support services beyond infection control. The successors to this panel will develop a follow-up article that will describe infection control programs in various out-of-hospital settings, such as long-term care, home care, and ambulatory care. These are the most rapidly expanding areas of healthcare industry in the United States, and there is a clear need for infection control programs that are adapted to the differences between those settings and the hospital. It also would be useful for another panel to outline the transition from using epidemiology primarily for infection control practice to an expanded use of epidemiological principles and methods for the prevention and control of other adverse events, as well as to a more general understanding of quality assessment and outcomes measurement.

The Consensus Panel Recommendations are as follows:

REQUIREMENTS FOR INFRASTRUCTURE AND ESSENTIAL ACTIVITIES OF INFECTION CONTROL AND EPIDEMIOLOGY IN HOSPITALS

Where possible, the panel used an evidence-based approach. Recommendations therefore are categorized in Table 1, using a modification of the scheme developed by the Clinical Affairs Committee of the Infectious Diseases Society of America and the CDC HICPAC classification scheme[58,59]:

FUNCTIONS

Managing critical data and information

Recommendation 1: Surveillance of nosocomial infections must be performed. *Category I*

The surveillance process should incorporate at least the following elements:

- Identification and description of the problem or event to be studied;
- Definition of the population at risk;
- Selection of the appropriate methods of measurement, including statistical tools and risk stratifications;
- Identification and description of data sources and data collection personnel and methods;
- Definition of numerators and denominators;
- Preparation and distribution of reports to appropriate groups; and
- Selection of specific events to be monitored should be guided by validated, nationally available benchmarks appropriately adjusted for patient risks, so that meaningful comparisons can be made.

Recommendation 2: Surveillance data must be analyzed appropriately and used to monitor and improve infection control and healthcare outcomes. *Category I*

Recommendation 3: Clinical performance and assessment indicators used to support external comparative measurements should meet the criteria delineated by SHEA and APIC.[28] *Category II*

Specifically, these indicators and their analyses must address the following parameters:

- Relation to outcome or process;
- Ability to measure variation in quality;
- Definition of numerators and denominators;
- Reliability, completeness, and feasibility of data collection;

- Appropriate risk adjustment;
- Comparability of populations; severity and case-mix adjustments for external comparison;
- Training required for indicator implementation; and,
- Applicable benchmarks of standards of care.

Setting and recommending policies and procedures

Recommendation 4: Written infection prevention and control policies and procedures must be established, implemented, maintained, and updated periodically. *Both Categories II and III*

- The policies and procedures should be scientifically valid.
- The policies and procedures should be reviewed for practicality and cost.
- The policies and procedures should lead to improved prevention or improved patient outcomes.

Recommendation 5: Policies and procedures should be monitored periodically for performance. *Both Categories II and III*

Compliance with regulations, guidelines, and accreditation requirements

Recommendation 6: Healthcare facilities should use infection control personnel to assist in maintaining compliance with relevant regulatory and accreditation requirements. *Category II*

Recommendation 7: Infection control personnel should have appropriate access to medical or other relevant records and to staff members who can provide information on the adequacy of the institution's compliance with regard to regulations, standards, and guidelines. *Category II*

Recommendation 8: The infection control program should collaborate with, and provide liaison to, appropriate local and state health departments for reporting of communicable diseases and related conditions and to assist with control of infectious diseases. *Both Categories II and III*

Employee health

Recommendation 9: The infection control program personnel should work collaboratively with the facility's employee health program personnel. *Category II*

- The infection control program should review and approve all policies and procedures developed in the employee health program that relate to the transmission of infections in the hospital.
- Infection control personnel should be available to the employee health program for consultation regarding infectious disease concerns.

Recommendation 10: At the time of employment, all facility personnel should be evaluated by the employee health program for conditions relating to communicable diseases. *Both Categories II and III*

The evaluation should include the following:

- Medical history, including immunization status and assessment for conditions that may predispose personnel to acquiring or transmitting communicable diseases;
- Tuberculosis skin testing;
- Serologic screening for vaccine-preventable diseases, if indicated;
- Such medical examinations as are indicated by the above.

Recommendation 11: Appropriate employees or other healthcare workers should have periodic medical evaluations to assess for new conditions related to infectious diseases that may have an impact on patient care, the employee, or other healthcare workers, which should include review of immunization and tuberculosis skin-test status, if appropriate. *Both Categories II and III*

- All facilities should maintain confidential medical records on all healthcare workers.
- The employee health program should have the capability to track employee immunization and tuberculosis skin-test status.

Recommendation 12: Employees must be offered appropriate immunizations for communicable diseases. *Both Categories I and III*

- Immunizations should be based on regulatory requirements and Advisory Committee on Immunization Practices recommendations for healthcare workers.

Recommendation 13: The employee health program should develop policies and procedures for the evaluation of ill employees, including assessment of disease communicability, indications for work restrictions, and management of employees who have been exposed to infectious diseases, including postexposure prophylaxis and work restrictions. *Category I*

Intervening directly to prevent transmission of infectious diseases

Recommendation 14: All healthcare facilities must have the capacity to identify the occurrence of outbreaks or clusters of infectious diseases.

Category I

- Infection control personnel should review microbiology records regularly to identify unusual clusters or a greater-than-usual incidence of certain species or strains of microorganisms.
- In patient areas of the healthcare facility in which active prospective surveillance is not conducted, infection control programs should maintain regular contact with clinical, medical, and nursing staff in order to ascertain the occurrence of disease clusters or outbreaks, to assist in maintenance and monitoring of infection control procedures, and to provide consultation as required.

Recommendation 15: All healthcare facilities must have access to the services of personnel trained and experienced in conducting outbreak investigations. *Category II*

Recommendation 16: When an outbreak occurs, the infection control team must have adequate resources and authority to ensure a comprehensive and timely investigation and the implementation of appropriate control measures. *Category II*

Education and training of healthcare workers

Recommendation 17: Healthcare facilities must provide ongoing educational programs in infection prevention and control to healthcare workers. *Both Categories II and III*

- Infection control personnel with a knowledge of epidemiology and infectious diseases should be active participants in the planning and implementation of the educational programs.

Recommendation 18: Educational programs should be evaluated periodically for effectiveness, and attendance should be monitored. *Both Categories II and III*

- Educational programs should meet the needs of the group or department for which they are given and must provide learning experiences for people with a wide range of educational backgrounds and work responsibilities.

RESOURCES

Personnel

Recommendation 19: The personnel and supporting resources, including secretarial services, available to the hospital epidemiology and infection control program should be proportional to the size, complexity, and estimated risk of the population served by the institution. *Category II*

Recommendation 20: All hospitals should have the continuing services of a trained hospital epidemiologist(s) and ICP(s). *Category I*

Recommendation 21: ICPs should be encouraged to obtain Certification in Infection Control. *Category II*

Nonpersonnel

Recommendation 22: Healthcare facilities should provide or make available in a timely fashion, sufficient office space and equipment, statistical and computer support, and clinical microbiology and pathology laboratory services to support the nosocomial infection surveillance, prevention, and control program of the institution. *Category II*

Recommendation 23: Resources should be provided for continuing professional education of hospital epidemiologists and ICPs. *Category II*

REFERENCES

1. American Hospital Association. Prevention and control of *Staphylococcus* infections in hospitals. In: US Public Health Service—Communicable Disease Center and National Academy of Sciences-National Research Council. Proceedings of the National Conference on Hospital-Acquired Staphylococcal Disease. Atlanta (GA): Communicable Disease Center; 1958. p. XXIII-XXVI.
2. Garner JS, Bennett JV, Scheckler WE, Maki DG, Brachman PS. Surveillance of nosocomial infections. In: Centers for Disease Control. Proceedings of the International Conference on Nosocomial Infections. Atlanta (GA): Centers for Disease Control; 1970. p. 277-81.
3. Joint Commission on Accreditation of Hospitals. Accreditation Manual for Hospitals. Chicago (IL): Joint Commission on Accreditation of Hospitals; 1976.
4. Haley RW, Culver DH, White J, Morgan WE, Amber TG, Mann VP, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol 1985;121:182-205.
5. Haley RW, Tenney JH, Lindsey JO II, Garner JS, Bennet JV. How frequent are outbreaks of nosocomial infection in hospitals? Infect Control 1985;6:233-6.
6. Haley RW, Morgan WE, Culver DH, White J, Amber TG, Mosser J, et al. Update from the SENIC project. Hospital infection control: recent progress and opportunities under prospective payment. Am J Infect Control 1985;13:97-108.
7. Wenzel RP. The economics of nosocomial infections. J Hosp Infect 1995;31:79-87.
8. Crede W, Hierholzer WJ. Linking hospital epidemiology and quality assurance: seasoned concepts in a new role. Infect Control Hosp Epidemiol 1988;9:42-4.
9. Joint Commission on Accreditation of Health Care Organizations. 1997 Comprehensive Accreditation Manual for Hospitals. Oakbrook Terrace (IL): Joint Commission on Accreditation of Health Care Organizations; 1997.

10. Farr BM. Organization of infection control programs. In: Abrutyn E, editor. Saunders Infection Control Reference Service. Philadelphia (PA): WB Saunders; 1997. p. 13-5.
11. Epidemiology and prevention of nosocomial infections of organ systems. Section III. In: Mayhall CG, editor. Hospital epidemiology and infection control. Baltimore (MD): Williams & Wilkins; 1996. p. 139-269.
12. Perspectives. Section 1. In: Wenzel RP, editor: Prevention and control of nosocomial infections. 3rd ed. Baltimore (MD): Williams & Wilkins; 1997. p. 1-54.
13. Miller PJ, Farr BM, Gwaltney JM Jr. Economic benefits of an effective infection control program: case study and proposal. Reviews of Infectious Diseases 1989;11:284-8.
14. Nyström B. Impact of handwashing on mortality in intensive care: examination of the evidence. Infect Control Hosp Epidemiol 1994;15:435-6.
15. Peter JE, Cruse MB, Foord R. The epidemiology of wound infection: a 10-year prospective study of 62,939 wounds. Surg Clin North Am 1980;60:2740.
16. Condon RE, Schulte WJ, Malangoni MA, Anderson-Teschendorf MJ. Effectiveness of a surgical wound surveillance program. Arch Surg 1983;118:303-7.
17. Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. N Engl J Med 1992;326:281-6.
18. Diekema DJ, Doebbeling BN. Employee health and infection control. Infect Control Hosp Epidemiol 1995;16:292-301.
19. Polder JA, Tablan OC, Williams WW. Personnel health services. In: Bennett JV, Brachman PS, editors. Hospital infections. 3rd ed. Boston (MA): Little, Brown; 1992. p. 31-61.
20. Falk P. Infection control and employee health service. In: Mayhall CG, editor. Hospital epidemiology and infection control. Baltimore (MA): Williams & Wilkins; 1996:1094-9.
21. Anglim AM, Collmer JE, Loving TJ, Beltran KA, Coyner BJ, Adal K, et al. An outbreak of needlestick injuries in hospital employees due to needles piercing infectious waste containers. Infect Control Hosp Epidemiol 1995;16:570-6.
22. Faoagali JL, Davey D. Chickenpox outbreak among the staff of a large urban adult hospital: costs of monitoring and control. Am J Infect Control 1995;23:247-50.
23. Haley RW, White JW, Culver DH, Hughes JM. The financial incentive for hospitals to prevent nosocomial infections under the prospective payment system. An empirical determination from a nationally representative sample. JAMA 1987;257:1611-4.
24. Ehrenkranz NJ. The efficacy of a Florida hospital consortium for infection control, 1975-1982. Infect Control 1986;7:321-6.
25. Shewhart WA. Statistical method from the viewpoint of quality control. Washington (DC): Graduate School of the Department of Agriculture; 1939. Reprinted New York (NY): Dover; 1986.
26. Garibaldi RA, Burke J. Surveillance and control of antibiotic use in the hospital. Am J Infect Control 1991;19:164-70.
27. National Nosocomial Infection Surveillance Systems. Nosocomial infection rate for interhospital comparison: limitations and possible solutions. Infect Control Hosp Epidemiol 1991;12:609-21.
28. The Quality Indicator Study Group. An approach to the evaluation of quality indicators of outcome of care in hospitalized patients, with a focus on nosocomial infection indicators. Infect Control Hosp Epidemiol 1995;16:308-16.
29. Keita-Perse O, Gaynes RP. Severity of illness scoring systems to adjust nosocomial infection rates: a review and commentary. Am J Infect Control 1996;24:429-34.
30. Gaynes RP, Solomon S. Improving hospital-acquired infection rates: the CDC experience. Journal of Quality Improvement 1996;22:457-67.
31. Brennan PJ, Abrutyn E. Developing policies and guidelines. Infect Control Hosp Epidemiol 1995;16:512-7.
32. Abrutyn E, Goldmann DA, Scheckler WE, editors. Saunders Infection Control Reference Service. Philadelphia (PA): WB Saunders; 1997.
33. Kaunitz KRK, Kaunitz AM. Legal aspects of hospital infections. In: Bennett JV, Brachman PS, editors. Hospital infections. 3rd ed. Boston: Little, Brown; 1992. p. 533-73.
34. Bobinski MA. Legal issues in hospital epidemiology and infection control. In: Mayhall CG, editor. Hospital epidemiology and infection control. Baltimore (MD): Williams & Wilkins; 1996. p. 1138-45.
35. McDiarmid M, Gamponia MJ, Ryan MAK, Hirshon JM, Gillen NA, Cox M. Tuberculosis in the workplace: OSHA's compliance experience. Infect Control Hosp Epidemiol 1996;17:159-64.
36. Valenti AJ, Decker MD. OSHA inspections. Infect Control Hosp Epidemiol 1995;16:478-82.
37. Nettleman MD. Preparing for and surviving a JCAHO inspection. Infect Control Hosp Epidemiol 1995;16:236-9.
38. Centers for Disease Control and Prevention. Draft guideline for infection control in healthcare personnel, 1997, Centers for Disease Control. Federal Register September 8, 1997;62:47275-327.
39. Nichol KL, Lind A, Margolis KL, Murdoch M, McFadden R, Hauge M, et al. Effectiveness of vaccination against influenza in healthy working adults. N Engl J Med 1995;333:889-93.
40. McGowan JE Jr, Metchock BG. Basic microbiologic support for hospital epidemiology. Infect Control Hosp Epidemiol 1996;17:298-303.
41. Beck-Sague C, Jarvis WR, Martone WJ. Outbreak investigations. Infect Control Hosp Epidemiol 1997;18:138-45.
42. Barg NL. An introduction to molecular hospital epidemiology. Infect Control Hosp Epidemiol 1993;14:395-6.
43. Jarvis WR. Usefulness of molecular epidemiology for outbreak investigations. Infect Control Hosp Epidemiol 1994;15:500-3.
44. Ehrenkranz NJ, Richter EI, Phillips PM, Shultz JM. An apparent excess of operative site infections: analysis to evaluate false-positive diagnosis. Infect Control Hosp Epidemiol 1995;16:712-6.
45. Hoffmann KK, Clontz EP. Education of health care workers in the prevention of nosocomial infections. In: Mayhall CG, editor. Hospital epidemiology and infection control. Baltimore (MD): Williams & Wilkins; 1996. p. 1086-94.
46. Haley RW. The development of infection surveillance and control programs. In: Bennett JV, Bachman PS, editors. Hospital infections. 3rd ed. Boston: Little, Brown; 1992. p. 63-77.
47. Centers for Disease Control. Public health focus: surveillance, prevention and control of nosocomial infections. MMWR 1992;41:783-7.
48. Wong ES. Surgical site infections. In: Mayhall CG, editor. Hospital epidemiology and infection control. Baltimore (MD): Williams & Wilkins; 1996. p. 154-75.

49. Certification Board of Infection Control. CBIC candidate handbook. Lenexa (KS): Certification Board of Infection Control; 1996. p. 1-28.
50. Institute of Medicine. Dick RS, Steen EB, editors. The computer-based patient record: an essential technology for healthcare. Washington (DC): National Academy Press; 1991.
51. Tenover FC, Arbeit RD, Goering RV. How to select and interpret molecular strain typing methods for epidemiological studies of bacterial infections: a review for healthcare epidemiologists. Infect Control Hosp Epidemiol 1997;18:426-39.
52. Massanari RM, Wilkerson K, Swatzendruber S. Designing surveillance for infectious outcomes of medical care. Infect Control Hosp Epidemiol 1995;16:419-26.
53. Wenzel R, Carlson B. Hospital epidemiology: beyond infection control and toward quality assurance. Clinical Microbiology News 1988;10:7-9.
54. Rose RC III. Infection control to quality improvement: the right time, the right place, the work to be done. Clinical Performance and Quality Health Care 1997;5:16-9.
55. Rutala WA, Weber DJ. Epidemiology: a critical tool for infection professionals. Am J Infect Control 1997; 25:193-4.
56. Brewer JH, Gasser CS. The affinity between continuous quality improvement and epidemic surveillance. Infect Control Hosp Epidemiol 1993;14:95-8.
57. Sellick JA Jr. The use of statistical process control charts in hospital epidemiology. Infect Control Hosp Epidemiol 1993;14:649-56.
58. Gross PA, Barrett TL, Dellinger EP, Krause PJ, Martone WJ, McGowan JE, et al. Infectious Diseases Society of America quality standards for infectious diseases. Purpose of quality standards for infectious diseases. Clin Infect Dis 1994;18:421.
59. Pearson ML, the Hospital Infection Control Practices Advisory Committee. Guideline for prevention of intravascular-device–related infections. Infect Control Hosp Epidemiol 1996;17:438-73.