The International Nosocomial Infection Control Consortium (INICC): Goals and objectives, description of surveillance methods, and operational activities

Victor D. Rosenthal, MD,[a] Dennis G. Maki, MD,[b] and Nicholas Graves, MA, PhD[c]
Buenos Aires, Argentina; Madison, Wisconsin; and Brisbane, Australia

We have shown that intensive care units (ICUs) in countries with limited resources have rates of device-associated health care-associated infection (HAI), including central line–related bloodstream infection (CLAB), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infection (CAUTI), 3 to 5 times higher than rates reported from North American, Western European, and Australian ICUs. The International Nosocomial Infection Control Consortium (INICC) is an international ongoing collaborative HAI control program with a surveillance system based on that of the US National Healthcare Safety Network. The INICC was founded 10 years ago to promote evidence-based infection control in hospitals in limited-resource countries and in hospitals of developed countries without sufficient experience in HAI surveillance and control, through the analysis and feedback of surveillance data collected voluntarily by the member hospitals. It developed from a handful of South American hospitals in 1998 to a dynamic network of 98 ICUs in 18 countries, and is the only source of aggregate standardized international data on HAI epidemiology. Herein we report the criteria and mechanisms for gaining membership in INICC; the training of personnel in INICC hospitals; the INICC protocol for *outcome surveillance* of CLABs, VAPs, and CAUTIs in ICUs, microorganism profiles, bacterial resistance, antibiotic use, extra length of stay, extra costs, extra mortality, and risk factor analysis, and for *process surveillance,* including compliance rates for hand hygiene, vascular catheter care, urinary catheter care, and measures for prevention of VAP; and the use of surveillance data feedback as a powerful weapon for control of HAIs. The INICC will continue to evolve in its quest to find more effective and efficient ways to assess patient risk and improve patient safety in hospitals. (Am J Infect Control 2008;36:e1-e12.)

Health care–acquired infections (HAIs) have been associated with significant morbidity and attributable mortality,[1-8] as well as greatly increased health care costs.[4,5,8-10] Studies conducted in the United States 30 years ago[11] and recently validated in Germany[12] have shown that an integrated infection control program, with HAI surveillance as its cornerstone, can reduce the incidence of HAIs by 30%, yielding economic benefits.

From the Medical College of Buenos Aires and Bernal Medical Center, Buenos Aires, Argentina[a]; University of Wisconsin School of Medicine and Public Health, Madison, WI[b]; and The Centre for Healthcare Related Infection Surveillance and Prevention and Queensland University of Technology, Brisbane, Queensland, Australia.[c]

Address correspondence to Victor D. Rosenthal, MD, International Nosocomial Infection Control Consortium (INICC), Lavalleja 305, Floor 9, Apt B (ZIP 1414), Buenos Aires, Argentina. E-mail: victor_rosenthal@inicc.org.

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Most studies on HAI have been conducted in hospitals in developed countries.[13-15] Relatively little data have been reported from limited-resource countries.[1-8,16-24] We have recently shown that intensive care units (ICUs) in these countries have rates of device-associated HAI, including central line–related bloodstream infection (CLAB), ventilator-associated pneumonia (VAP), and catheter-associated urinary tract infection (CAUTI), 3 to 5 times higher than rates reported from US ICUs.[1,2] Most limited-resource countries do not have laws mandating HAI control programs, and hospital accreditation is rarely required. Funds and resources for infection control are very limited,[25] nurse: patient staffing ratios are often far lower on average than in ICUs in developed countries, and there are high proportions of inexperienced nurses, all of which has been shown to have a powerful association with greatly increased risk of device-associated infections.[26] Finally, the use of outdated technology also may be a factor. For example, open intravenous infusion systems are used nearly universally in limited-resource countries instead of the closed systems that are the standard of care in developed countries.[27]

It is clear that there is an urgent need—even a moral imperative—to advance our understanding of the epidemiology and control of HAI to the many thousands of hospitals and billions of patients of the limited resources world.

HISTORY, GOALS, AND OBJECTIVES

The INICC is an international nonprofit, open, multicenter, collaborative HAI control program with a surveillance system based on that of the US National Healthcare Safety Network[13] (NHSN), formerly the National Nosocomial Infection Surveillance system (NNIS).[28] Founded in Argentina in 1998 by Dr Victor D. Rosenthal, the INICC is the first multinational research network established to control HAIs in hospitals in limited-resource countries and also at hospitals in developed countries without sufficient experience in HAI surveillance and control, through the analysis of data collected voluntarily by its member hospitals.[1,3-8,16-24]

The INICC has the following goals:

- To create a dynamic global network of hospitals in limited-resource countries and in hospitals of developed countries without sufficient experience in HAI surveillance and control, which conducts HAI surveillance through standardized definitions and established methodologies, promotes evidence-based infection control practices, and conducts infection control research
- To provide training and surveillance tools to allow individual hospitals to conduct outcome and process HAI surveillance, measure their consequences, and assess the impact of infection control practices
- To improve health care safety and quality worldwide through systematized programs to reduce rates of HAI, associated mortality, excess length of stay and costs, and bacterial resistance
- To improve the use of anti-infectives in clinical practice, with the ultimate goal of controlling antimicrobial resistance
- To train infection control personnel in individual hospitals how to design and carry out simple prospective research studies to analyze the clinical impact and cost- effectiveness of infection control interventions
- To measure trends in HAIs and antimicrobial resistance in hospitals around the world using risk-adjusted data that allows meaningful intrahospital and interhospital comparisons for local, nationwide, and global quality improvement efforts

To develop new, simple, and inexpensive but effective strategies for HAI prevention of HAI at hospitals in limited-resource countries and at hospitals in developed countries without sufficient experience in HAI surveillance and control.

MECHANISMS OF MEMBERSHIP

Most of the current participating hospitals joined the INICC after 2002, the majority on their own volition after hearing the INICC Chairman, Dr Rosenthal, speak in their country or in International Scientific Meetings, reading a published INICC paper, watching a scientific poster at a scientific meeting, learning about the INICC from its website, or hearing from a colleague already participating in the INICC (Fig 1). Patient confidentiality is protected by coding the recorded information, with patient identities known only to the individual hospital's infection control team.

Membership in the consortium requires that each interested hospital meet the following criteria:

- Hospital interest in reducing rates of HAIs through membership in the INICC
- One or more ICUs
- A potential infection control team; with a at least 1 dedicated infection control practitioner (ICP) or any HCW willing to receive training in that role; an infectious disease specialist, epidemiologist, critical care specialist, pathologist, or any other physician willing to undergo brief training and accept responsibilities as principle investigator (PI)–hospital epidemiologist; and a microbiology laboratory using techniques and criteria for bacteriologic isolation and identification and doing standardized antimicrobial susceptibility testing
- Willingness to engage in formal infection control training, conduct surveillance, and use process feedback to improve infection control practices in the hospital.
- Willingness to publish the results of the infection control interventions in peer- reviewed journals and/or present them at scientific meetings.
- Access of the hospital infection control team to Internet electronic communication is highly desirable.

INICC requisites from the participating hospitals are as follows:

- Institutional review and approval of the INICC protocol, including by an internal Institutional Review Board/Research Committee
- Administrative approval for participation
- Institutional signature of an INICC commitment letter by a PI, an ICP and, if desired, a hospital administrator
- ICP conducting outcome and process surveillance using standardized CDC NHSN/NNIS definitions for HAI and surveillance methodologies, dedicating at least 60 minutes per day for data collection for each 15 ICU beds

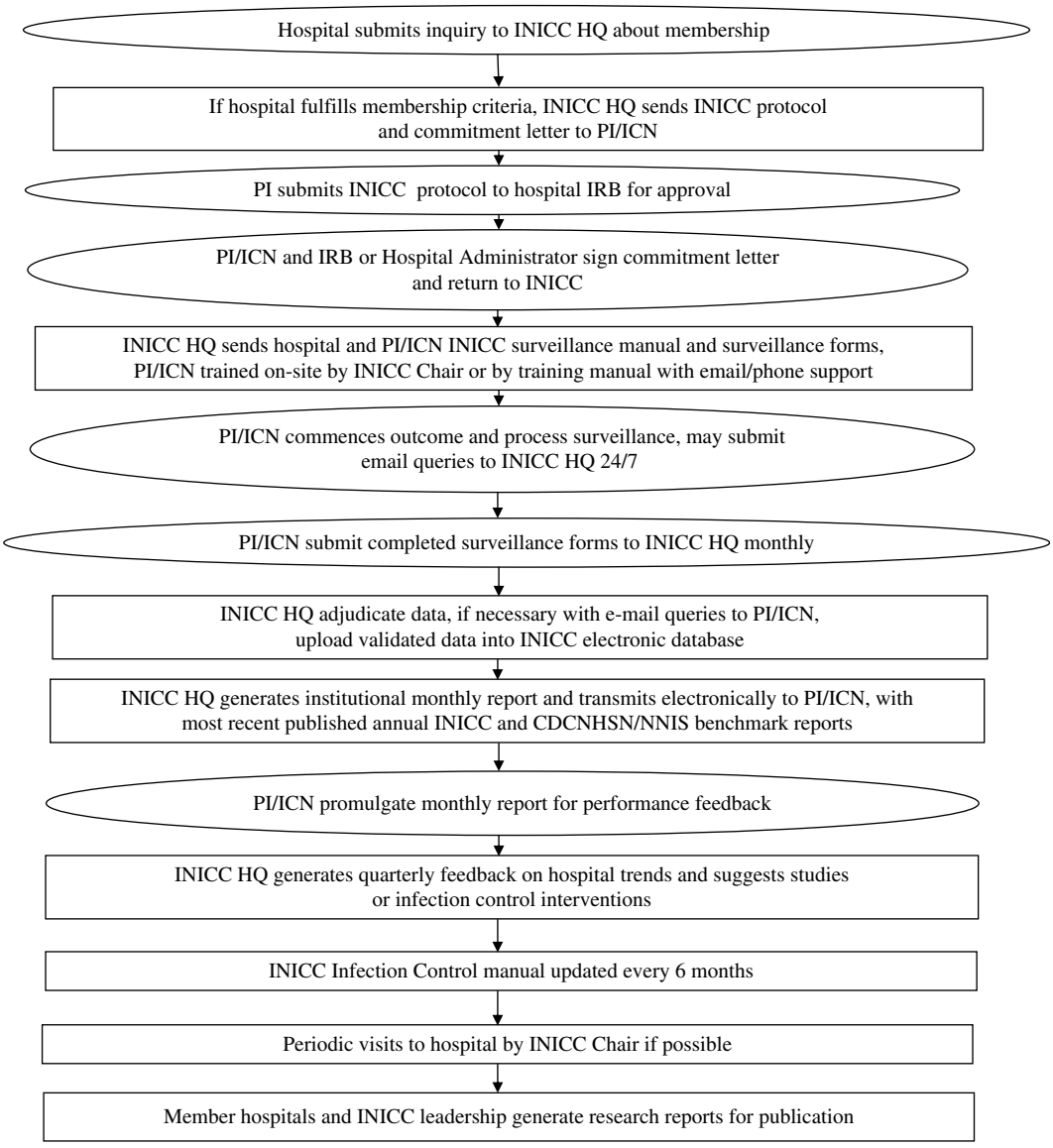

Fig 1. INICC methodology for gaining membership and operational procedures. *HQ*, Headquarters; *PI*, principal investigator; *ICN*, infection control nurse; *IRB*, institutional review board; *CDC*, Centers for Diseases Control and Prevention; *NHSN*, National Healthcare Safety Network; *NNIS*, National Nosocomial Infection Surveillance System.

- Monthly submission of data to INICC headquarters in Buenos Aires and monthly and quarterly posting of INICC institutional reports for process feedback
- Prompt response to INICC queries and surveys
- Vigorous promotion of evidence-based infection control practices locally that can be applied for the prevention of HAIs
- Willingness to carry out infection control research studies.

Active membership of participant hospitals provide following major benefits in terms of hospital safety and improved care:

- Training of hospital PIs and ICPs in basic hospital epidemiology, surveillance methods, and basic data analysis
- Immediate access to current scientific knowledge relevant to the diagnosis, surveillance, prevention, and control of HAIs
- Training and tools to be able to conduct outcome and process surveillance that can permit timely recognition of patient safety problems and intervention with appropriate control measures, to assess the clinical and economic impacts of HAIs in their hospital, and to assess the impact of specific infection control practices

- Training to detect relevant trends in HAIs and make intrahospital and interhospital comparisons with risk-adjusted data that can be used for local, regional, and nationwide quality improvement activities
- Improved safety and quality of health care through implementation of systematized programs to reduce HAI rates, associated mortality, excess lengths of stay, excess costs, and bacterial resistance
- Training of PIs and ICPs to design and undertake simple hypothesis-driven applied research
- Ongoing support and advice on surveillance activities and control programs I
- Improved use of anti-infectives for prophylaxis and therapeutic use, with the goal of helping to control antimicrobial resistance
- Advice regarding clinical cost-effectiveness of new technologies relevant to infection control
- Ongoing central analysis of surveillance data at INICC headquarters, with monthly feedback institutional surveillance reports
- Reduced HAI rates, length of stay (LOS), extra costs due to HAI, and antimicrobial resistance
- Opportunity to coauthor research reports for publication in peer-reviewed journals yearly.

BASIC STRUCTURE OF THE INICC

The INICC structure includes the following: researchers in each member hospital, the INICC Country Coordinators, the INICC Headquarters Team, and the INICC Advisory Board. The researchers are the ICPs who collect surveillance data and submit completed data forms to Buenos Aires headquarters and implement infection control activities in their hospital, and the PI–hospital epidemiologist who directs the institutional program. The Country Coordinators are regional representatives of INICC and board members of local infection control societies who aid in recruiting and advising local hospitals. The INICC Headquarters Team trains the researchers in each member hospital and advises them on an ongoing basis, answers queries and supports researchers, adjudicates the surveillance data on HAIs, uploads the data using specially designed software, analyzes the data, generates a monthly report for each hospital and forwards it electronically, and edit abstracts and manuscripts to be submitted to scientific meetings and peer-reviewed journals. The INICC Advisory Board, international leaders in infection control and public health, serve in an advisory capacity. Two INICC Country Coordinators and INICC Advisory Board meetings are held annually. The identity of all INICC hospitals, cities, and countries is confidential, in accordance with the INICC charter.

From its inception, INICC has used the surveillance methods and definitions for HAI developed by the CDC's long-standing NNIS/NHSN program in US hospitals,[13,28] and has vigorously promoted the consistent implementation of simple, inexpensive, high-priority evidence-based measures for prevention of HAI.[7,16-18,20,27,29]

The lack of knowledge regarding HAI worldwide, especially in the limited-resource countries, and at hospitals in developed countries without enough experience in HAI surveillance and control, the need for more precise measurements of HAI risks and outcomes in specific patient groups, and the basic importance of surveillance to a hospital program that can successfully reduce the risk of HAI led to the conceptualization, development, and implementation of the 2 INICC surveillance components: *outcome surveillance* and *process surveillance*. INICC hospitals can design their own surveillance programs by selecting the surveillance components or modules to use for the period of time that they desire. This report describes the current methods used by the INICC to collect and analyze surveillance data and facilitate its use in feedback to individual hospitals to reduce the incidence of HAI in their ICUs.

CHARACTERISTICS OF PARTICIPATING HOSPITALS

The hospitals participating in the INICC provide general medical-surgical inpatient services to adult, children, and newborns requiring acute care. They may be of any size and ownership, affiliated or unaffiliated with a medical school, and located anywhere worldwide. Although participation is voluntary, hospitals must apply for membership in the INICC and have adequate personnel and support for infection control, as well as approval from hospital administration to participate in the INICC (Fig 1). A total of 98 ICUs from 18 countries in Latin America, Asia, Africa, and Europe currently participate in the INICC.[2]

The goal of the INICC is to achieve a membership with at least 5 countries per continent, 5 cities per country, and 1 hospital per city, which would constitute a representative sample of the limited-resource countries and hospitals of the world.

Infection control practices

Hand hygiene compliance varies widely in the different countries and ICUs, ranging from 20% to 70%.[7,16-18,20] A recent study in participating INICC ICUs found an overall 50% rate of hand hygiene compliance,[30] similar to recent studies in the United States and Europe.[31] Use of sterile dressings on central venous catheter (CVC) insertion sites also ranges widely.[7,17] Open infusion systems (rigid or semirigid containers that must admit air to empty) rather than closed infusion systems (flexible collapsing containers that do not admit air) or

combinations of open and closed systems are still used for administration of intravenous fluids and medications in all of the member hospitals.[27]

Laboratory techniques

Ventilator-associated pneumonia. A deep tracheal aspirate from the endotracheal tube is obtained for gram-stain, and aerobic culture or a bronchoscopic specimen is obtained.

CVC-associated bloodstream infection. CVCs are removed aseptically, and the distal 5 cm of the catheter is amputated and cultured, using the standardized semiquantitative method.[32] Concomitant blood cultures are drawn percutaneously.

Catheter-associated urinary tract infection. A urine sample is aseptically aspirated from the sampling port of the urinary catheter and cultured quantitatively.

As noted earlier, in all hospitals, standard laboratory methods are used to identify microorganisms, and standardized susceptibility testing is performed.[33]

TRAINING OF THE PI AND ICP

In Argentina, Brazil, China, Colombia, Costa Rica, Croatia, India, Malaysia, Mexico, Peru, and Turkey, the INICC Founder and Chairman, Dr Rosenthal, personally trained the PI and ICP in each member hospital. In Cuba, El Salvador, Kosovo, Lebanon, the former Yugoslav Republic of Macedonia, Morocco, Nigeria, Pakistan, Philippines, and Uruguay, the institutional investigators were self-trained by a manual specifying how to conduct surveillance and complete surveillance forms. Some (eg, Chile) had previous long-term training in HAI control and hospital epidemiology at the time their hospital joined the INICC.

Institutional investigators have continuous telephone or e-mail access to a support team at the INICC Central Office in Buenos Aires, which responds to all inquiries within 24 hours. Queries and responses are reviewed by the Chairman (Fig 1).

Definitions

Clinically defined pneumonia. A patient with a chest radiograph that shows new or progressive infiltrates, consolidation, or cavitations, and at least 1 of the following: fever, leukocytosis, leucopenia, or altered mental status with no other cause in $\geq$ 70 years old; and at least 1 of the following: new onset of purulent sputum, change in character of sputum, new onset or worsening cough, dyspnea, tachypnea, rales, bronchial breath sound, or worsening gas exchange.[34]

Laboratory-confirmed bloodstream infection. *Criterion 1:* Patient has a recognized pathogen cultured from 1 or more blood cultures, and organism cultured from blood is not related to an infection at another site. *Criterion 2:* Patient has at least 1 of the following: fever, chills, or hypotension; positive laboratory results are not related to an infection at another site; and common skin contaminant is cultured from 2 or more blood cultures drawn on separate occasions.[34]

Clinical sepsis. A patient with a central line with at least 1 of the following: fever, hypotension, or oliguria; blood cultures were either not obtained or no organisms were recovered from blood cultures; there is no apparent infection at another site; and the physician institutes antimicrobial therapy.[34]

Symptomatic urinary tract infection. *Criterion 1:* Patient has at least 1 of the following with no other recognized cause: fever, urgency, frequency, dysuria, or suprapubic tenderness; and a positive urine culture, that is, $\geq 10^5$ microorganisms per mL of urine with no more than 2 species. *Criterion 2:* Patient has at least 2 of the following with no other recognized cause: fever, urgency, frequency, dysuria, or suprapubic tenderness; and at least 1 of the following: positive dipstick for leukocyte esterase and/or nitrate; pyuria; organisms seen on Gram's stain of unspun urine; at least 2 urine cultures with repeated isolation of the same uropathogen with $\geq 10^2$ colonies/mL in nonvoided specimens; $\leq 10^5$ colonies/mL of a single uropathogen in a patient being treated with an effective antimicrobial agent for a urinary tract infection; physician diagnosis of a urinary tract infection; physician institutes appropriate therapy for a urinary tract infection.[34]

Crude excess mortality. The difference between the crude overall case fatality of patients with a device-associated infection and the crude case fatality of patients hospitalized in the ICU during that period who did not acquire a device-associated infection.

INICC SURVEILLANCE COMPONENTS

INICC's first efforts were focused on surveillance and control of device-associated infection in the ICU because it addresses the health care setting with the most vulnerable patients, who have the heaviest exposure to invasive devices and highest HAI rates.[35] Data are collected from the following types of ICU: burn, surgical cardiothoracic, medical, medical-surgical, pediatric, neurosurgical, surgical, trauma, and high-risk nursery.

Two types of surveillance data are collected, outcome surveillance data and process surveillance data. The *outcome surveillance component* includes the following modules: CLAB, VAP, and CAUTI rates per 1000 device-days in adult ICUs,[19,21-24,36,37] pediatric ICUs and newborn ICUs, microorganism profile, bacterial resistance,[19,21-24,36,37] antibiotic use, extra length of stay, extra costs,[4,5,8] extra mortality,[3,4,7,24,36] and risk factor analysis. The *process surveillance component* includes compliance rates of the following four modules: hand

hygiene,[16,18] vascular catheter care,[7,17] urinary catheter care,[29] and measures for prevention of VAP.[20]

Individual surveillance components or modules may be used singly or simultaneously, but once selected, must be carried out for a minimum of 1 calendar month. Each hospital decides which surveillance components or module to use and for how long.

All infections reported to the INICC must have occurred in patients who were admitted to a hospital ICU and remained in the unit for at least 24 hours. Infections are categorized by HAI sites using standard CDC definitions that include clinical and laboratory criteria.[34]

Data are collected on both infected and uninfected patients. Hospitals also have the option to collect additional data of special interest on infected patients for their own use. Denominator data include the number of patients (and total patient-days) in the unit and number of days of exposure to a central line, urinary catheter, and mechanical ventilator. Data reported to the INICC must conform to the protocol of the selected surveillance component or module before they are entered into the central INICC international database.

Outcome surveillance forms

The INICC's surveillance forms are designed to gather data from all patients in the ICU, both those with and those without HAIs to continuously prompt the ICP and PI to suspect HAIs, because the form provides a continuous picture of every patient's course in the ICU: daily data regarding the patient's maximum temperature, lowest blood pressure, exposure to invasive devices, cultures done, imaging studies, and antibiotic use. Outcome surveillance forms should be requested by e-mail to Dr Rosenthal to victor_rosenthal@inicc.org

Severity of illness scores, APACHE II, and Average Severity Illness Score (ASIS)[28] are recorded for each patient at ICU admission. The ASIS is recorded using the CDC NNIS/NHSN criteria. Points are totaled, with 1 point for surgical patients requiring routine postoperative observation only, 2 points for physiologically stable nonsurgical patients requiring overnight observation, 3 points for patients needing continuous nursing and monitoring, 4 points for physiologically unstable patients requiring intensive nursing and medical care, with the need for frequent reassessment and adjustment of therapy, and 5 points for physiologically unstable patients in coma or shock who require cardiopulmonary resuscitation or intensive medical and nursing care with frequent reassessment.

Central adjudication of each reported HAI and reporting

Each HAI reported by a hospital is adjudicated (ie, scrutinized to be certain that criteria are fulfilled to justify its recording as a HAI); the adjudication process also includes the scrutiny of data reported for putatively uninfected patients to permit detection of unreported but true HAIs. When discrepancies are encountered, the INICC hospital team is contacted by e-mail by the INICC headquarters team to resolve the difference; the judgment of the PI and ICP of the participant hospital is final.

Adjudication is a unique feature of INICC outcome surveillance component and is considered essential for maximizing the accuracy of surveillance data. Also essential is to assess on an ongoing basis the capacity of the ICP and PI at each hospital to accurately identify HAIs by comparing the discrepancies between the HAIs reported by the hospital team and those identified by the INICC headquarters team after reviewing the surveillance work sheets.

The INICC headquarters team prepares and sends to each participating hospital a final monthly report on their institutional rates of device-associated infection, microorganism profile, bacterial resistance, LOS, and mortality in their ICUs, and rates of compliance with hand hygiene, CVC and urinary catheter care, and measures to prevent pneumonia.

OUTCOME SURVEILLANCE COMPONENT

Outcome surveillance module: HAIs per 1000 device-days in adult and pediatric ICUs

The outcome surveillance component focuses on patients hospitalized in adult and pediatric ICUs. Data are prospectively gathered during the study period from all patients whose ICU LOS exceeds 24 hours. A HAI is an infection that was not present or incubating at the time of the patient's admission to the ICU but became apparent during the ICU stay or within 48 hours after transfer from the ICU.[34] Patients are followed for 48 hours after discharge from the ICUs to detect infections acquired in the ICU but manifesting only after transfer to a non-ICU patient care unit.

The ICP at each INICC hospital is responsible for extracting patients' data prospectively from medical record, charts, patient inspection, and laboratory results, including radiographs and all cultures done. Data collection sheets are checked by the PI to confirm each HAI diagnosis.

Hospitals with more than 1 ICU may carry out surveillance in any or all ICUs, but in the selected units, every patient is monitored for CLAB, CAUTI, and VAP. The denominator data collected are the total number of patients in the ICU during the month, total number of patient-days, urinary catheter-days, central line-days, and ventilator-days. Calculation of site-specific infection rates is based on the appropriate denominator (eg,

number of CAUTIs divided by the total number of indwelling urinary catheter-days).[28]

On admission, every patient in the unit is assessed by direct observation of surveillance personnel, who assign an APACHE II score and ASIS score, and individual patient scores are combined and averaged into a monthly severity of illness score for the unit.

To provide feedback to ICU staff in the unit, the INICC headquarters team send charts on a monthly basis to the ICP and PI, providing a running record of rates of device-associated infections compiled by the ICP, which are then reviewed at monthly staff meetings and posted in a prominent location in the ICU.

Outcome surveillance module: HAIs in high-risk nurseries

The high-risk nursery (HRN) surveillance component provides the option of surveillance in level III nurseries, which are defined as nurseries that provide multisystem support or critical care for unstable neonates and are staffed by a full-time pediatrician with special qualifications in neonatal medicine and by nurses specially trained in perinatal care. In the HRN component, all neonates in the level III nursery are monitored for infection. An HRN-associated infection is one that was not present or incubating at the time of the neonate's admission into the HRN but that became apparent during the HRN stay or within 48 hours after transfer from the HRN. Very early neonatal infections thought to have been acquired during parturition are included as HAIs, whereas those considered most likely to have been acquired in utero are not.[34,38]

Denominator data are stratified for each of the following 5 birth weight categories: $\leq$ 1000 g, 1001 to 1500 g, 1501 to 2500 g, and $>$ 2500 g, and include the total number of patients in the HRN during the month, total number of patient-days, umbilical catheter/central line-days, and ventilator-days). Site-specific infection rates are calculated per 1000 device-days by the INICC headquarters team.

Outcome surveillance module: Microbiological profile of HAI and bacterial resistance

The INICC includes surveillance of the microbiological profile of HAI in the participating ICUs that are confirmed microbiologically in CLABs, CAUTIs, and VAPs, and antimicrobial susceptibilities are recorded on a designated form.[18,20-23,35,36]

Outcome surveillance module: Extra LOS and evaluation of HAI costs

The ICU LOS is recorded for each infected and uninfected patient, and the timing of the onset of infection is recorded. To date, the effect of HAI on LOS has been estimated by matching patients in the same ICU during the surveillance period by age, sex, ASIS score, and other variables. Differences in LOS have been attributed to HAIs.[4,5,8] This method is widely used but has some weaknesses.[39] Many factors are associated with ICU/hospital LOS. Matching on more than 7 factors excludes infected patients for whom no match can be found, which will induce a selection bias. Matching on 6 factors, or even fewer, is unlikely to control much of the variation among LOS outcomes, inducing another source of bias.[39] The INICC is currently developing statistical models of LOS that mitigate these problems and provide better estimates. Three issues are being addressed:

1. Nonnormal distribution of LOS: LOS data are not normally distributed with a small number of observations demonstrating very long ICU/hospital LOS.
2. Feedback effects: Infection is associated with LOS, yet increased LOS increases the risk of HAIs.[40]
3. Timing of events is important; defining HAI as a time-dependent covariate is important for models that predict LOS in hospital.[41,42]

Valid estimates of the excess LOS due to HAI are powerful data. They can be used to show the number of bed-days that will be released by preventing HAIs. Preventing HAIs will not save much money, because most of the costs of running a hospital cannot be easily avoided in the short term (ie, they are fixed costs).[43] Instead, the cost savings from infection control are the value of the bed-days released to decision makers. How much decision makers are willing to pay to access more bed-days will vary by country. In health care systems where this is excess demand for hospital services, this value is likely to be positive. INICC is committed to using rigorous economic methods[43] to estimate the changes to costs from preventing HAIs.

Outcome surveillance module: Excess mortality

In the INICC, hospital mortality is also recorded for each patient. The crude excess mortality is defined as the difference between the overall case-fatality of patients hospitalized in the ICU during the surveillance period with a HAI and the case-fatality of patients hospitalized in the ICU during that period who did not acquire a HAI. To date, excess mortality has been estimated using a matching procedure.[3,4,7,24,36] Like cost outcomes, the process of estimating the independent effect of infection on mortality is complex and is addressed in ongoing INICC research activities.

Decision making and infection control

If infection control can be shown to reduce costs and improve health outcomes, then a failure to implement infection control is unethical. Excess costs are incurred

while simultaneously harming patients. Adopting infection control is an economic ''win–win'' situation, as costs are saved and patient welfare increases. Infection control still can be cost-effective if costs increase overall (ie, infection control does not pay for itself), and health benefits increase. The ratio of these numbers (ie, the cost per unit of health outcome) must fall below the decision makers' threshold. Building these arguments is complex, and only good-quality data and modeling methods should be used.[44]

PROCESS SURVEILLANCE COMPONENT

Process surveillance is an essential feature of the INICC, designed to monitor compliance with important, easily measurable control measures, such as hand hygiene, vascular catheter care, urinary catheter care, and measures to prevent VAP. Process surveillance forms should be requested from Dr Rosenthal by e-mail at victor_rosenthal@inicc.org

Process surveillance module: Hand hygiene compliance

Hand hygiene compliance by HCWs is monitored by the ICP through randomly selected 1-hour observations 3 times a week, during all working shifts and including all HCWs according to a specific sequence set forth in the INICC protocol.[16,18] The ICP is well-known to the ICU staff, and, although the HCWs are aware that hand hygiene practices will be monitored, they are not informed when these observations are taking place. The ICP records the opportunities for hand hygiene and compliance before contact with each patient; hand hygiene process surveillance data are recorded on a designated form. The INICC recorded more than 85,000 opportunities for hand hygiene in 16 countries over a 10-year period and found 50% compliance.[2,30]

Process surveillance module: Vascular catheter care

Vascular catheter care compliance also is monitored, and the following data are recorded on a standardized form 5 days a week: hand hygiene before and after catheter insertion or redressing an intravascular catheter; presence of a sterile gauze or polyurethane dressing on insertion sites; the date of catheter insertion and the last administration set change; replacement of the gauze dressing every 48 hours and transparent semipermeable membrane dressings at least every 7 days, with date and time of dressing changes recorded; replacement of peripheral intravenous catheters within 72 to 96 hours; administration change set replacements at least every 72 hours; and others.[7,17]

Process surveillance module: Urinary catheter care

Urinary catheter care compliance also is monitored, and the following data are recorded on a standardized form: silicone catheter, closed catheter drainage, unobstructed catheter position above (not below) the leg, urine collecting bag below the level of the bladder, no contact of the collection bag with the floor are recorded 5 days a week, and others.[29]

Process surveillance module: Mechanical ventilator care

Mechanical ventilator care compliance also is monitored 5 days a week: noninvasive ventilation, if feasible, orotracheal rather than nasotracheal tube, suction port above the endotracheal cuff, elevation of head of the patient's bed 30 to 45 degrees (unless contraindicated medically), heat-moisture exchanger humidification, absence of pooled fluid within the ventilator tubing, absence of obstruction by mucous, presence of a water trap, nonturbid fluid in the humidifier reservoir, closed-system endotracheal suctioning, oral care at least daily, absence of pooled pharyngeal secretions, and others.[20]

Process surveillance monitoring performance feedback and outcome surveillance feedback

The INICC headquarters team prepares and sends to each INICC participant hospital monthly reports, showing bar charts with global rates per 100 patients and per 1000 bed-days, HAIs per 1000 device-days (CLABs per 1000 central line-days, CAUTIs per 1000 catheter-days, and VAPs per 1000 ventilator-days), microbiological profile, bacterial resistance, extra mortality by type of HAI, extra LOS, hand hygiene compliance, central line and urinary catheter care compliance, and measures to prevent pneumonia to post them in the ICU in a prominent location, to provide feedback to the ICU HCWs. The data also are reviewed at monthly meetings of ICU staff (Fig 2).[16,18,30]

STATISTICAL METHODS

INICC uses EpiInfo version 6.04b and SAS software to analyze hospital data. Device utilization rates are calculated by dividing the total number of device-days by the total number of ICU patient-days. Rates of VAP, CLAB, and CAUTI per 1000 device-days are calculated by dividing the total number of HAIs by the total number of specific device-days and multiplying the result by 1000.[28] Differences among treatment groups are analyzed using the χ^2 test or, when appropriate, Fisher's exact test for dichotomous variables, and Student's

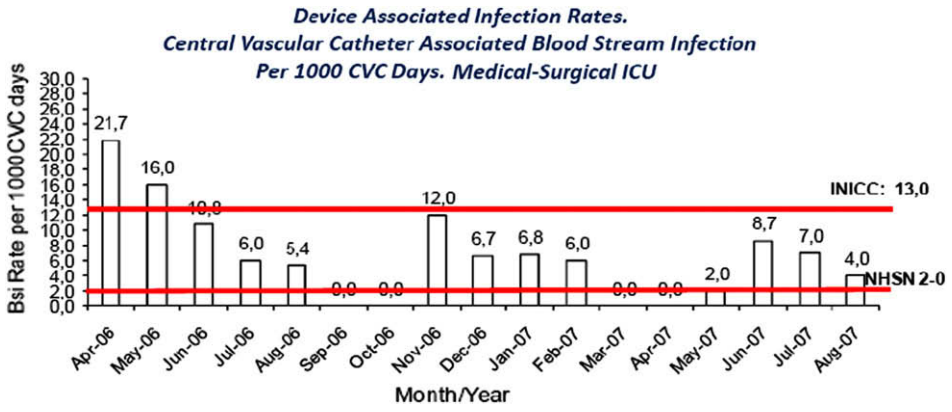

Fig 2. INICC outcome surveillance report to a member hospital on CLAB over a 16-month period.

t-test for continuous variables. Relative risk ratios, 95% confidence intervals, and *P* values are determined for primary and secondary outcomes. The INICC also is using survival analyses, competing-risks models, and multistate models.[41]

DISCUSSION

Surveillance of HAIs, especially in high-risk hospital settings such as the ICU,[13] has become an integral feature of infection control and quality assurance in developed countries hospitals since the capacity of surveillance to reduce the risks of HAIs was demonstrated in the CDC's SENIC Study more than 30 years ago.[11] Standards for institutional surveillance have been adopted in the United States,[13] the United Kingdom,[45] Australia,[46] Germany,[12] and others.

There is a vast body of literature showing that HAIs are a major cause of patient morbidity and mortality in the developed countries,[9] and device-associated infections, particularly VAP,[47] CLAB,[48] and CAUTI,[10] pose the greatest threat to hospital safety in the ICU.[49] Surveillance of device-associated HAIs has been standardized by the CDC's NNIS/NHSN study by providing simple, unambiguous definitions.[34,38] Targeted surveillance and calculation of device-associated infection rates per 1000 device-days allows benchmarking with other similar hospitals and detection of unique institutional problems in need of redress.

As noted earlier, most of the published studies of ICU-acquired infection come from hospitals in the industrialized Western countries,[15] and far less data have been reported from limited-resource countries, especially rates of ICU device-associated infections using standardized definitions.[3-8,16-24] We reported the initial findings of INICC surveillance from 2002 through 2006, pointing up very high rates of HAI in the ICUs of limited-resource countries.[1,2]

Since the inception of organized programs for control of HAIs in the United States in the late 1960s, surveillance has been advocated for recognizing HAI problems and for targeting preventive measures.[50] Its efficacy in helping to reduce HAI has been reported by multiple investigators,[51] and surveillance has been promoted by the American Hospital Association, the Joint Commission, and the Health Care Financing Administration.[52,53] Although the Joint Commission established infection surveillance as a responsibility of the medical staff in 1964, a standardized approach to conducting surveillance generally was not available until 1969, when the CDC reported its first surveillance study of HAIs.[54,55]

The INICC's surveillance form is designed to collect data from *all* patients, both those with and those without HAI (Fig 2). The CDC's NNIS/NHSN program in US hospitals and surveillance systems used in other countries collect data only from patients with infections acquired in the ICU.[12,13,28] In contrast, the form used by the INICC is specifically designed to continuously prompt the surveillance officer to suspect HAI, because the form provides a panoramic view of what is happening each day to *every* patient in the ICU in terms of vital signs, exposure to invasive devices, culture results, and antibiotic therapy. This approach is especially useful in cases in which no cultures have been done or the culture results are equivocal or negative, such as with pneumonia or sepsis, and that may not be otherwise recognized as a HAI.[1,19,21-24,36,37] Furthermore, by collecting data on all patients in the ICU, it is possible to easily match patients with and without HAI for such features as age, sex, underlying diseases, service, admission diagnosis, severity of illness score, time of year, exposure to specific invasive devices, and several others to calculate added LOS and costs of hospitalization, attributable mortality, and risk factors for infection.[3-5,8,24,36] We believe that the INICC methodology further improves the accuracy of surveillance because

each reported infection is adjudicated externally; however, the vast majority of ICU-acquired infections in both the CDC NNIS/NHSN system and the INICC are based on positive cultures, and we doubt whether the 2 surveillance systems differ materially in their sensitivity for detecting device-associated infections, except perhaps for VAP or clinical sepsis.

The INICC's surveillance system has some limitations. First, we do not yet consider the data to be adequate to represent any entire single country; however, with data now being collected in 98 ICUs in 18 limited-resource countries, we believe that our findings are becoming representative of the developing world and most likely underestimate the magnitude of the problem, because we believe that the INICC participants generally represent the best hospitals in their countries, hospitals with the most resources and commitment to patient safety in terms of controlling HAIs. Second, we must rely on the member hospitals' laboratories to reliably identify infecting pathogens and delineate bacterial resistance patterns. Different laboratories have varying levels of expertise and resource availability; however, similar concerns can be raised about any multi-institutional surveillance program or study. Finally, the frequency of culturing and the use of other diagnostic tests are beyond the control of infection control programs; in hospitals where culturing and other laboratory testing is infrequent and suspected infections are treated empirically, the capacity of the surveillance program to detect most nosocomial infections is likely to be low. The limitations of INICC data need to be considered in such endeavors. Nonetheless, 10 years of INICC surveillance have been valuable for conducting outcome and process surveillance, with the results used in feedback and education to prevent HAIs.

Surveillance of HAIs—defining the magnitude and nature of the problem—is the first step toward reducing the risk of infection in vulnerable hospitalized patients. The next step is to implement more consistently essential infection control practices that have been shown to prevent HAIs.[56-61] We are confident that knowledge of the magnitude of the problem of device-associated infections in the INICC ICUs will continue to provide a powerful impetus for instituting needed change, and we have already seen ample evidence of productive change; process surveillance, targeted performance feedback programs for hand hygiene and central venous catheter, ventilator, and urinary catheter care have already translated to documentation of major reductions in the incidence of ICU-acquired infections in individual member hospitals,[7,16-18,20] and we have recently documented a highly significant (46%) reduction in CLABs ($P < .001$) in 73 INICC ICUs during their first 8 months as members of the Consortium.[62] INICC data are now being used by national health care planners in the member countries to develop strategies and target resources for control of HAIs.

The INICC's goals for the future include:

1. Strengthening infection control activities in the member hospitals, eliminating practices of dubious value and adding more key evidence-based control measures[58]
2. Expanding outcome and process surveillance to include surgical site infections and key process measures that govern the efficacy of surgical antimicrobial prophylaxis[60]
3. Incorporating biohazardous exposures and their management into outcome and process surveillance
4. Addressing more restrictive and improved antibiotic utilization[63]
5. Undertaking multicenter comparative trials of promising control measures and novel inexpensive technologies for prevention of device-associated HAIs
6. Developing an online database for uploading and retrieving surveillance data.

Clearly, HAI is a huge and largely unrecognized threat to patient safety in the hospitals of the developing world, a far greater threat than in the developed countries, we believe, rivaling the huge burden of diarrhea of childhood, tuberculosis, and malaria. It is our hope that the initial successes of the INICC, combined with our ongoing efforts to more consistently implement simple, inexpensive measures for prevention, will lead to wider acceptance of infection control practices and continued reductions in device-associated infections, not only in the hospitals of the consortium, but also in their innumerable neighboring hospitals as well.

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