Device-associated nosocomial infections in limited-resources countries: Findings of the International Nosocomial Infection Control Consortium (INICC)

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Need: The rates of health care-associated infections (HAIs) and bacterial resistance in developing countries are 3 to 5 times higher than international standards. HAIs increase length of stay (10 days), costs (US $5000 to US $12,000), and mortality (by a factor of 2 to 3).

Organization: The International Nosocomial Infection Control Consortium (INICC), founded in 1998, is the only source of aggregated international data on the epidemiology of device-associated infections (DAIs). Its advisory board includes 12 representatives from developed countries, who help guide INICC's activities, and 8 country coordinators. The INICC network has about 5400 active researchers in 98 intensive care units (ICUs) in 18 countries on 4 continents that conduct infection control research and surveillance using standardized DAI surveillance definitions and methodologies.

Surveillance: Participating hospitals use the Centers for Disease Control and Prevention (CDC) surveillance method and DAI definitions. Unlike the CDC, the INICC collects data from patients with and without DAI and matches patients to evaluate risk factors, attributable mortality, length of stay, and costs and conducts process surveillance to measure and improve compliance with infection control guidelines.

Results: INICC's surveillance at 98 ICUs in 18 limited resources countries on 4 continents for 10 years has significantly improved infection control guidelines compliance and reduced DAI rates and mortality rates. After 11 years of implementing process surveillance intervention in 77 ICUs of 34 cities of 14 countries, including observation of 88,661 opportunities for hand hygiene, education, performance monitoring, feedback, and peer support from high-level hospital administrators, hand-hygiene compliance among ICU healthcare workers increased from 35.1% to 60.7% (RR 1.73, $P < 0.01$). In 78 ICUs of 37 cities of 13 countries, by implementing outcome and process surveillance interventions, INICC reduced central line associated bloodstream infection (CLAB) rates from 16.1 to 10.1 CLABs per 1000 CL days (RR: 0.63, $P < 0.01$), ventilator associated pneumonia (VAP) from 22.5 to 18.6 VAPs per1000 device days (RR: 0.83, $P < 0.01$), and catheter associated urinary tract infections (CAUTI) rates from 8.2 to 6.9 CAUTIs per 1000 device days (RR: 0.85, $P = 0.02$).

Conclusion: Implementation of INICC outcome and process surveillance, education, monitoring and performance feedback methodologies increases compliance with hand hygiene and other infection-control interventions and reduces rates of DAIs. (Am J Infect Control 2008;36:S171.e7-S171.e12.)

Health care-associated infections (HAIs) increase mortality, length of stay, costs of care, bacterial resistance, antibiotic usage, and other adverse events.[1-14] The International Nosocomial Infection Control Consortium (INICC), founded in 1998, focused its initial efforts on surveillance of device-associated infections (DAIs) in the intensive care unit (ICU) to address the health care setting with the most vulnerable patients, the most exposure to invasive devices, and the highest rates of DAIs. The lack of knowledge regarding DAIs in developing countries and the need for more accurate measurement of DAI risks and outcomes in specific patient groups led to the introduction of the INICC surveillance components. Hospitals participating in the INICC have the flexibility to design their own surveillance programs by selecting components and modules to be used for the period of time they desire.[15] The INICC began when selected hospitals were invited to routinely report their HAI surveillance data for aggregation into an international database[1-14] and is the only source of aggregated international data on the epidemiology of DAIs worldwide.

INICC

Mission

The INICC is an international scientific community that works interactively through a network aiming at reducing HAIs.[15]

Values

The INICC considers HAIs to pose a global problem that requires the attention of the international scientific community and considers that infection control is feasible on the basis of evidence-based medicine; heeding regional diversity; educating and providing the medical community with enlightening information; and providing tools eligible for systematic measurement, control, and prevention. The INICC considers that health care safety and quality are inalienable rights of the patient and the patient's environment that cannot be violated or ignored. The INICC considers that extra costs attributable to extra length of hospital stay and consumption are avoidable, and, therefore, public and hospital policies should assume responsibility for them. We trust the promotion of scientific research to find effective and legitimate answers.[15]

Vision

The INICC vision is of a society with the minimum incidence of HAIs, a society that recognizes the legitimate right of a hospitalized patient to be delivered safe health care, and a society in which the scientific and medical community works for the safeguard of good infection control and surveillance practices.[15]

Goals

The INICC has the following goals:

- Create a global network to conduct DAI surveillance using standardized surveillance definitions and methodologies, promote evidence-based infection control practices that can be used locally to prevent DAIs, and to conduct infection control research;
- assist hospitals and other health care organizations in developing surveillance methods that permit timely recognition of patient safety problems and intervention with appropriate control measures;
- provide training and tools to hospitals and other health care organizations to conduct outcome and process surveillance to measure DAIs, their consequences, and the impact of implementing infection control practices;
- improve the safety and quality of care at health care facilities through implementation of programs to reduce health care worker and patient DAI rates,

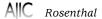associated mortality, lengths of stay, costs, and bacterial resistance;
- measure relevant trends in DAIs in hospitals globally and facilitate intra- and interhospital comparisons with risk-adjusted data that can be used for local and national quality improvement activities;
- train health care workers to improve their skills for research activities;
- support and advise infection control personnel in individual hospitals on research projects;
- design and coordinate prospective studies to analyze the clinical impact and cost-effectiveness of proven and new low-cost infection control interventions;
- produce innovative, relevant, scientific, evidence-based knowledge for the diagnosis, surveillance, prevention, and control of DAIs; and
- improve the therapeutic and prophylactic use of anti-infective agents to help control antimicrobial resistance.[15]

Resources

The INICC organizational structure includes researchers, headquarters team (HQT), INICC country coordinators, and INICC Advisory Board members. Their approximately 5400 researchers worldwide are infection control professionals (ICPs) and hospital epidemiologists (HEs) who collect data from ICUs and send the completed forms to INICC headquarters in Buenos Aires. The 9-person HQT supports researchers by validating and adjudicating the DAIs, entering the data into specialized software, analyzing the data, generating charts, sending charts to researchers on a monthly basis, and answering queries. Approximately 30 scientific abstracts and 5 manuscripts are drafted at INICC headquarters every year and submitted to scientific meetings and peer review journals, respectively. The INICC country coordinators are 8 representatives and the board members of local infection control societies, who recruit and advise local hospitals worldwide. The INICC Advisory Board is composed of 12 representatives from infection control international organizations in developed countries, who guide and advise INICC activities. INICC holds 2 meetings every year with the country coordinators and advisory board members.[15]

METHODS

Since the inception of the INICC, participating hospitals have applied the surveillance method and DAI definitions developed by the Centers for Disease Control and Prevention (CDC), Atlanta, GA.[16-18] Unlike the CDC National Nosocomial Surveillance System (NNIS), the INICC collects data from patients with and without DAIs; detects risk factors; matches patients to evaluate

attributable mortality, length of stay, and costs; and conducts process surveillance to measure and improve compliance with infection control guidelines.

ADJUDICATION

The CDC National Healthcare Safety Network (NHSN) in United States hospitals and the surveillance systems implemented in several other countries use one data form to collect device-days and bed-days of an ICU population and another form to collect data from patients with DAIs acquired in the ICU. INICC uses DAI adjudication to determine the accuracy of the ICPs and HEs to detect DAIs at the hospital level. For this reason, unlike the NHSN system, INICC surveillance forms are designed to collect data from all patients, with or without DAIs.[19] Because the forms provide an overview of what is happening every day to every patient in the ICU, they continuously prompt the surveillance officer to suspect DAIs. Outcome surveillance form No. 1 is used to collect daily data including (1) the patient's temperature; (2) blood pressure, (3) exposure to invasive devices central line, (4) urinary catheter, (5) mechanical ventilator, (6) antibiotic use, (7) cultures, and (8) presence of clinical pneumonia. The INICC also collects (9) culture results and (10) bacterial resistance profiles. Each month, the INICC HQT reviews all submitted forms and compares cases of suspected DAIs with the diagnosis made by the ICPs and HEs at every participating hospital. INICC HQT sends the ICPs and HEs a list of queries concerning the patients with suspected infections, and the ICPs and HEs again review the medical charts and laboratory reports to validate the presence or absence of suspected DAIs. This approach is especially useful in cases in which cultures have not been done or the culture results are equivocal or negative, as with pneumonia or sepsis, and otherwise might not be recognized as DAIs.[15]

RESULTS

For 10 years, the INICC has conducted outcome and process surveillance at 98 ICUs in 18 developing countries on 4 continents. This has significantly improved infection control guidelines compliance, DAI rates, and mortality rates.[13]

Outcome surveillance

Medical-surgical ICUs. Analysis of data from medical-surgical ICUs in the INICC showed rates of 8.92 catheter-associated bloodstream infections (CLABs)/1000 CL-days, 19.8 ventilator-associated pneumonia (VAP)/1000 ventilator-days, and 6.49 catheter-associated urinary tract infections (CAUTIs)/1000 urinary catheter-days.[13] The infection rates in CDC NHSN medical-surgical ICUs published in 2007 were 2.4 CLABs/1000 CVC-days, 3.4 CAUTIs/1000 catheter-days, and 3.62 VAPs/1000 ventilator-days.[19] The INICC found that in developing countries, the CR-BSI rate is 4.86 times higher, the VAP rate is 5.5 times higher and, CAUTI rate 1.9 times higher than CDC NHSN rates.

Coronary ICUs. In coronary ICUs of the INICC, analysis of data showed rates of 9.9 CLABs/1000 CVC-days, 20.2 VAPs/1000 ventilator-days, and 6.4 CAUTIs/1000 urinary catheter-days.[13] By comparison, in CDC NHSN coronary ICUs, the rates were 2.8 CR-BSIs/1000 CVC-days, 4.6 CAUTIs/1000 catheter-days, and 2.8 VAPs/1000 ventilator-days.[13] The INICC found that in developing countries, the rate of CLABs are 3.5 times higher; VAPs are 7.2 times higher; and CAUTIs are 1.39 times higher than the CDC NHSN rates.

Pediatric ICUs. In pediatric ICUs in the INICC, analysis of data found the following rates: 6.9 CLABs/1000 CVC-days, 7.98 VAPs/1000 ventilator-days, and 4.03 CLABs/1000 urinary catheter-days.[9,18-21] In CDC-NHSN pediatric ICUs, the rates were 5.3 CLABs/1000 CVC-days, 5.2 CAUTIs/1000 catheter-days, and 2.5 VAPs/1000 ventilator-days.[17] The INICC found that in developing countries, the CLAB rate is 1.3 times higher; VAP is 3.16 times higher, and CAUTI is 0.76 times lower than the CDC-NHSN rates.

Neonatal ICUs. In the neonatal ICUs in the INICC, analysis of data showed the following rates: 15.2 CLABs/1000 CVC-days, and 6.68 VAP/1000 ventilator-days.[13] In the CDC NHSN neonatal ICUs (birth weight, 1.500-2.500 g) showed the following rates: 4.2 CLAB/1000 CVC-days and 1.1 VAP/1000 ventilator-days.[17] The INICC found that in developing countries, the CLAB rate is 3.6 times higher and the VAP rate is 6.07 times higher than the CDC NHSN rates.

Resistance rates. Aggregated data from all INICC ICUs showed the following resistance rates: 80.8% of all *Staphylococcus aureus* were methicillin-resistant *Staphylococcus aureus (*MRSA), 36.6% of *Pseudomonas* spp were resistant to imipenem, 52.4% were resistant to ciprofloxacin/ofloxacin, 56.8% of *Enterobacter* spp were resistant to ceftazidime, and 68.2% of *Klebsiella* spp were resistant to ceftazidime.[13] In CDC NNIS ICUs, the resistance rates published in 2004 showed that 52.9% of all *Staphylococcus aureus* were MRSA, 19.1% of *Pseudomonas* spp were resistant to imipenem, 34.8% were resistant to ciprofloxacin/ofloxacin, 27.7% of *Enterobacter* spp were resistant to third-generation cephalosporins, and 6.2% of *Klebsiella* spp were resistant to third-generation cephalosporins.[20] The INICC found that MRSA was 1.52 higher, *Pseudomonas* spp resistance to imipenem was 1.91 higher, resistance to ciprofloxacin/ofloxacin was 1.45 higher, resistance of *Enterobacter* spp to

third-generation cephalosporins was 2.05 higher, and *Klebsiella* spp resistance to third-generation cephalosporins was 11 higher than in CDC NNIS ICUs.

Process surveillance

Hand-hygiene compliance. Over the past 11 years, the INICC has collected data on 88,661 hand hygiene (HH) opportunities in 14 limited resources countries (Argentina, Brazil, Colombia, Costa Rica, El Salvador, India, Kosovo, Nigeria, Mexico, Morocco, Pakistan, Peru, Philippines, and Turkey). The overall HH rate was 54.7%. Stratified by variable, HH compliance was 56.9% for women and 49.1% for men (RR 1.16, *P* < 0.01); 58.3% for nurses, 50.3% for physicians, and 44.9% for ancillary staff (nurses vs. physicians: RR 1.16, *P* < 0.01; nurses vs. ancillary staff: RR 1.3, *P* < 0.01; physicians vs. ancillary staff: RR 1.12, *P* < 0.01); 54.2% in adult ICUs, 56.9% in pediatric ICUs, and 64.6% in neonatal ICUs (neonatal vs. adult: RR 1.19, *P* < 0.01; neonatal vs. pediatric: RR 1.14, *P* < 0.01; pediatric vs. adult: RR 1.05, *P* < 0.12); 60.1% before invasive procedure and 51.9% before non-invasive procedure (RR 1.16, *P* < 0.01).[21]

Implementation of an INICC intervention that included HH observation, education, performance monitoring, feedback, and peer support from high-level hospital administrators significantly increased HH compliance from 35.1% to 60.7% (RR, 1.73; *P* < 0.01) among ICU health care workers.[21]
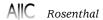
Outcome improvement

The goal was to determine the effect of outcome and process surveillance (intervention) on the rate of DAI in 78 ICUs, of 37 cities, of 13 limited resources countries (Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, India, Macedonia, Mexico, Morocco, Philippines, Peru, and Turkey). For CLAB and CAUTI reduction analysis the INICC included those ICUs that were in the study for at least 6 months, and for VAP reduction analysis the INICC included those ICUs that were in the study for at least 16 months. Patient's characteristics were similar over the two periods. CLAB rates were reduced significantly from 16.1 to 10.1 CLABs per 1000 CL days (RR, 0.63; 95% CI, 0.57–0.70; *P* < 0.01). CAUTI rates were reduced significantly from 8.2 to 6.91 CAUTIs per 1000 device days (RR, 0.85; 95% CI, 0.73–0.98; *P* < 0.01). VAP rates were reduced significantly from 22.5 to 18.6 VAPs per 1000 device days (RR, 0.83; 95% CI, 0.74–0.92; *P* < 0.01).[22]

Global outcomes

- INICC has successfully achieved its goals.

- INICC is now an international research organization comprising advisory board members, country coordinators, and researchers collecting hospital-level data.
- INICC has networked 5400 researchers in 98 ICUs in 18 countries on 4 continents, conducted surveillance using standardized DAI surveillance definitions and methodologies, promoted evidence-based infection-control practices used locally to prevent DAIs, and carried out infection-control research.
- INICC has assisted hospitals and other health care organizations such as the World Health Organization, infection-control societies, ministries of health, universities, and medical colleges in developing surveillance and other methods that permit timely recognition of patient safety problems and intervention with appropriate control measures.
- INICC has provided training and tools to 98 ICUs and other health care organizations to conduct outcome and process surveillance to measure DAIs, their consequences, and the impact of implementing infection control practices.
- INICC has improved the safety and quality of health care at health care facilities through the implementation of systematic programs to reduce DAI rates, associated mortality, excess lengths of stay and costs, and bacterial resistance.
- INICC has measured relevant trends in DAIs in hospitals around the world and facilitated intra- and inter-hospital comparisons with risk-adjusted data that can be used for local and nationwide quality improvement activities.
- INICC has trained health care workers to improve their skills for research activities.
- INICC has supported and advised infection control personnel in individual hospitals on research projects.
- INICC has conducted studies to analyze the impact and cost effectiveness of low-cost infection control interventions.
- INICC has produced innovative, relevant, scientific, evidence-based knowledge with regard to the diagnosis, surveillance, prevention, and control of DAIs.
- INICC has reduced and improved antibiotic usage to help control antimicrobial resistance.
- INICC has published in peer review journals and presented at scientific meetings previously unknown DAI rates, attributable mortality, increased length of stay, increased costs, microorganism profile, and bacterial resistance.
- INICC has significantly increased HH compliance and invasive devices care compliance.
- INICC has achieved substantial reductions in DAI rates and in the morbidity and mortality associated with DAIs.

Key events

- October 2006: The INICC published its first Global Report in the *Annals of Internal Medicine* and became the standard benchmark for HAI rates in developing countries.
- February 2007: The INICC established a research foundation, which will conduct fundraising to help hospitals without resources to conduct HAI surveillance and to finance INICC headquarters and new INICC developments.
- April 2007: The INICC convenes twice-yearly meetings with INICC Advisory Board members and country coordinators.
- July 2008: The INICC web page is available in English, Spanish, and Mandarin.
- November 2008: The INICC published its first annual report in AJIC.
- November 2008: The INICC published its goals, methods, and operational procedures in AJIC.
- February 2009: Launch of the new online software database developed by INICC enables INICC researchers to upload data and retrieve epidemiologic and statistical information in the form of tables and charts. The database enables the researchers worldwide to retrieve mathematical; epidemiologic; and statistical analyses stratified by ICU, work shift, gender, age, severity of illness score, and many other variables as tables, charts, and other reports.

CONCLUSION

In developing countries, rates of DAIs and bacterial resistance are 3 to 5 times higher than international standards. DAIs increase length of stay (10 days), costs (US $5000 to US $12,000), and mortality by 2-fold. Implementation of INICC process surveillance, education, and performance feedback methodologies increased compliance with HH and other infection-control interventions and reduced DAI rates.

References

1. Rosenthal VD, Guzman S, Migone O, Crinch CJ. The attributable cost, length of hospital stay and mortality of central line-associated bloodstream infection in intensive care departments in Argentina: A prospective, matched analysis. Am J Infect Control 2003;31:475-80.
2. Rosenthal VD, Guzman S, Orellano PW. Nosocomial infections in medical-surgical intensive care units in Argentina: attributable mortality and length of stay. Am J Infect Control 2003;31:291-5.
3. Rosenthal VD, Guzman S, Crnich C. Device-associated nosocomial infection rates in intensive care units of Argentina. Infect Control Hosp Epidemiol 2004;25:251-5.
4. Rosenthal VD, Guzman S, Migone O, Safdar N. The attributable cost and length of hospital stay because of nosocomial pneumonia in intensive care units in 3 hospitals in Argentina: a prospective, matched analysis. Am J Infect Control 2005;33:157-61.
5. Moreno CA, Rosenthal VD, Olarte N, Gomez WV, Sussmann O, Agudelo JG, et al. Device-associated infection rate and mortality in intensive care units of 9 Colombian hospitals: findings of the International Nosocomial Infection Control Consortium. Infect Control Hosp Epidemiol 2006;27:349-56.
6. Ramirez Barba EJ, Rosenthal VD, Higuera F, Oropeza MS, Hernandaz HT, Lopez MS, et al. Device-associated nosocomial infection rates in intensive care units in four Mexican public hospitals. Am J Infect Control 2006;34:244-7.
7. Rosenthal VD, Maki DG, Salomao R, Moreno CA, Mehta Y, Higuera F, et al. Device-associated nosocomial infection in 55 intensive care units of 8 developing countries. Ann Intern Med 2006;145:582-91.
8. Mehta A, Rosenthal VD, Mehta Y, Chakravarthy M, Todi SK, Sen N, et al. Device-associated nosocomial infection rates in intensive care units of seven Indian cities. Findings of the International Nosocomial Infection Control Consortium (INICC). J Hosp Infect 2007; 67:168-74.
9. Leblebicioglu H, Rosenthal VD, Arikan OA, Ozgultekin A, Yalcin AN, Koksal I, et al. Device-associated hospital-acquired infection rates in Turkish intensive care units. Findings of the International Nosocomial Infection Control Consortium (INICC). J Hosp Infect 2007;65:251-7.
10. Higuera F, Rangel-Frausto MS, Rosenthal VD, Soto JM, Castanon J, Franco G, et al. Attributable cost and length of stay for patients with central venous catheter-associated bloodstream infection in Mexico City intensive care units: a prospective, matched analysis. Infect Control Hosp Epidemiol 2007;28:31-5.
11. Pawar M, Mehta Y, Purohit A, Trehan N, Rosenthal VD. Resistance in gram-negative bacilli in a cardiac intensive care unit in India: risk factors and outcome. Ann Card Anaesth 2008;11:20-6.
12. Salomao R, Rosenthal VD, Grinberg G, Nouer S, Blecher S, Buchner Ferreira SI, et al. Device-Associated Infections Rates in Critical Patients of Brazilian Hospitals. International Nosocomial Infection Control Consortium (INICC) Findings. Pan American Journal of Public Health 2008;24:195-202.
13. Rosenthal VD, Maki DG, Mehta A, Alvarez-Moreno C, Leblebicioglu H, Higuera F, et al. International Nosocomial Infection Control Consortium report, data summary for 2002-2007, issued January 2008. Am J Infect Control 2008;36:627-37.
14. Cuellar LE, Fernandez-Maldonado E, Rosenthal VD, Castaneda-Sabogal A, Rosales R, Mayorga-Espichan MJ, et al. Device-associated infection rates and mortality in intensive care units of Peruvian hospitals: findings of the International Nosocomial Infection Control Consortium. Pan American Journal of Public Health 2008;24:16-24.
15. Rosenthal VD, Maki DG, Graves N. The International Nosocomial Infection Control Consortium (INICC): Goals and objectives, description of surveillance methods, and operational activities. Am J Infect Control 2008;36:e1-e12.
16. Emori TG, Culver DH, Horan TC, Jarvis WR, White JW, Olson DR, et al. National nosocomial infections surveillance system (NNIS): description of surveillance methods. Am J Infect Control 1991;19:19-35.
17. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. Am J Infect Control 1988;16:128-40.
18. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36:309-32.
19. Edwards JR, Peterson KD, Andrus ML, Tolson JS, Goulding JS, Dudeck MA, et al. National Healthcare Safety Network (NHSN) Report, data summary for 2006, issued June 2007. Am J Infect Control 2007;35:290-301.
20. National Nosocomial Infections Surveillance (NNIS) System Report, data summary from January 1992 through June 2004, issued October 2004. Am J Infect Control 2004;32:470-85.

21. Rosenthal VD, Angelo G, Salomao R, Barahona Guzmán N, Fernández Hidalgo R, Bran de Casares AC, et al. Analysis of 88, 661 Hand Hygiene Opportunities During 11 Years in 77 ICUs of 34 Cities, of 14 Countries. Findings of INICC. In: Proceedings and Abstracts of the 9th Annual Meeting of the International Federation of Infection Control; 2008 October 14-17; Santiago, Chile; 2008.

22. Rosenthal VD, Abouqal R, Medeiros EA, Álvarez-Moreno C, Aragón-Calzada JM, Guanche Garcell H, et al. Impact of Outcome and Process Surveillance in Reducing Device Associated Infections in 78 ICUs of 37 Cities of 13 Limited Resources Countries. Findings of INICC. In: Proceedings and Abstracts of the 9th Annual Meeting of the International Federation of Infection Control; 2008 October 14–17; Santiago, Chile; 2008.