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Epidemiology, Prevention and Control of Health Care Acquired Infections in Limited Resource Settings

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Introduction

One of the central premises of healthcare-acquired infection (HAI) prevention and control is that thorough surveillance knowledge of the occurrence of HAIs is essential to effectively address this public health burden. In low and middle income countries (LMIC), such accurate knowledge is many times underestimated, and the actual, critical impact that HAI have on the population of LMIC settings is difficult to assess.[1-3] In this chapter the author analyzed the studies on HAIs in LMIC published since 2002 up to mid 2020.

To determine which countries are referred to as "LMIC", the World Bank categorizes countries worldwide into four economic strata based on 2015 gross national income (GNI) per capita: (1) low-income economies, $1,025 or less; (2) lower middle-income economies, between $1,026 and $4,035; (3) upper middle-income economies, $4,036 and $12,475; and (4) high-income economies, $12,476 or more.[4] Within this categorization, 144 out of 209 (68%) are low-income and lower middle-income economies, which can also be referred to as lower-income countries, low resources countries, developing economies, or developing or emerging countries.[4] Developing economies represent more than 75% of the world population, and it is in these settings where the issue concerning HAI remains many times unresolved and needs to be highlighted and dealt with as a public health priority.[4]

Patient populations vary substantially, so it has become standard to calculate and report risk-adjusted HAI rates. Device associated HAI rates shall be reported adjusted to their most important known confounding factor, which is number of device days.[5] Risk adjustment consists of calculating rates per 1,000 device-days, which shall be central line associated bloodstream infections (CLABSI) per 1,000 central line days, short-term peripheral venous catheters-related bloodstream infections (PVCR-BSI) per 1,000 peripheral venous catheter days, ventilator associated pneumonia (VAP) per 1,000 mechanical ventilator days, and catheter associated urinary tract infections (CAUTI) per 1,000 urinary catheter days. Thus, CLABSI, PVCR-BSI, VAP and CAUTI surveillance by number of device-days is essential and effectively characterizes all device associated HAIs. Unfortunately very few studies from LMICs report device associated HAI per 1,000 device days, and this make impossible to have a benchmark with device associated HAI rates of other countries.

Studies on DA-HAI rates in limited-resource countries had been very limited before 2002, and in most instances, authors had reported percentages (cases over discharges or admissions) of DA-HAIs, or DA-HAI rates as number of infections per 1,000 patient-days, rather than DA-HAIs per 1,000 device-days. In such instances, the denominator of the number of device-days was not known, and thus it was not possible to have a basis of comparison between hospitals.

Thus, in order to identify all scientific researches using device days as a denominator, the author of this chapter conducted a comprehensive and systematic review of the literature from 2002 o 2020 in order to find those publications from LMIC reporting, as recommended, with device days as denominator.
In this review of the literature from 2002 to 2020, the author found a total of 187 scientific researches reporting HAI rates from LMICs.[6-193] Out of those 187 publications, 36 scientific researches published from 2002 to 2020 with data of HAI, reported HAI rates as percentage or per bed days, but not reporting HAI rates per device days.[6-42] Out of those 187 publications, 151 scientific researches published from 2002 to 2020 with data of HAI reported HAI rates per device days.[43-193] Out of these 151 scientific researches showing HAI rates per 1,000 device days, 139 of them, representing 92% were published by the International Nosocomial Infection Control Consortium (INICC) members, and such data was collected and analyzed using INICC software. Meaning that contribution of INICC to the knowledge of HAIs in LMIC was key to understand 92% of that burden of HAIs, and this data will be shown at this chapter.[55-196]

(See table 1)

During last 20 years INICC has been collecting data worldwide in order to contribute to this body of information, and published 7 studies pooling data of different countries from 2002 to 2019.[55-196]

The first INICC Report, conducted from 2002 to 2005, and published in 2006 with data of following 8 countries: Argentina, Brazil, Colombia, India, Mexico, Morocco, Peru, and Turkey.[194]

The second INICC Report, conducted from 2002 to 2007, and published in 2008 with data of following 18 countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Peru, Philippines, El Salvador, Turkey, Uruguay.[195]

The third INICC Report, conducted from 2003 to 2008, and published in 2010 with data of following 25 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Thailand, Tunisia, Turkey, Venezuela, Vietnam.[110]

The fourth INICC Report, conducted from 2004 to 2009, and published in 2012 with data of following 36 countries: Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Puerto Rico, Republic of Singapore, Saudi Arabia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Vietnam.[117]

The fifth INICC Report, conducted from 2007 to 2012, and published in 2014 with data of following 43 countries: Argentina, Bolivia, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Puerto Rico, Republic of Singapore, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.[97]

The sixth INICC Report, conducted from 2010 to 2015, and published in 2016 with data of following 50 countries: Argentina, Bahrain, Bolivia, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Indonesia, Iran, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Puerto Rico, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Uruguay, Venezuela, Vietnam.[196]

And the seventh INICC Report, conducted from 2012 to 2017, and published in 2019 with data of following 45 countries: Argentina, Bahrain, Brazil, Bulgaria, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Palestine, Panama, Papua New Guinea, Peru, Philippines, Poland, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.[99]

INICC also published rates of HAIs per particular country, such as from the following 28 countries: Argentina,[55,56] Brazil,[46,57,101,102] China,[58-62,103] Colombia,[104] Costa Rica,[63,64] Croatia,[65] Cuba,[66] Ecuador,[67] Egypt,[68] El Salvador,[69,70,105] India,[71-73] Iran,[74] Kuwait,[197] Lebanon ,[75] Lithuania,[48] Macedonia,[76] Malaysia,[77] Mexico[78,106] Mongolia,[79] Morocco,[80,81] Peru,[82] Philippines,[83,84] Poland,[85,86] Saudi Arabia,[198] Tunisia,[87] Turkey,[88,89,107] Venezuela,[90] and Vietnam.[91]

In a review on incidence of CLABSI in LMIC by Rosenthal et al., in 2009, it was reported that the CLABSI rate ranged from 1.6 to 44.6 cases per 1,000 central line days in adult intensive care units (ICU) and pediatric intensive care units (PICU) and from 2.6 to 60.0 cases per 1000 central line days in neonatal intensive care units (NICUs), and was associated with significant extra mortality.[199] In that review, a number of structural and behavioral reasons were associated with higher rates of CLABSI, and among their most common observations were overcrowded ICUs, insufficient rooms for isolation, lack of sinks, lack of medical supplies in general, including but not limited to alcohol hand rub, antiseptic soap, and paper towels. In addition, a lack of supplies for the wearing of maximal barriers during catheter insertion, a lack of chlorhexidine (and thus the use of povidone iodine), a lack of needle-free connectors (and the subsequent use of three ways stopcocks), the use of vented IV containers instead of closed IV systems, a lack of ready to use drugs (and the subsequent reliance on manual admixture for all drugs) were noted. [199]

In a study published by INICC in 2010, applying process surveillance a number of measures were found as associated with increased risk of CLABSI, and they are the following: lack of hand hygiene, hand washing with non-antiseptic soup, insufficient skin antisepsis with chlorhexidine, lack of sterile gauze or transparent dressing for catheter care, keep the central line in place beyond the needs, use of three ways stop cock, use of open infusion containers, among others.[156]

The use of outdated technology is a major problem, such as lack of availability of chlorhexidine for skin antisepsis instead of povidone iodine, lack of availability of dressing with chlorhexidine, lack of availability of closed infusion containers instead of open infusion containers, and lack of availability of needles connectors instead of three ways stopcock. On the other hand the commercialization of chlorhexidine is not yet approved in several LMIC.[156]

Moreover, poor performances in infection control practices, such as the case of using cotton balls already impregnated with antiseptic contained in a contaminated container, not covering insertion site with sterile dressing, storing drugs in already open single use vials, reusing single use vials, leaving needles inserted in multiple use vials, taking fluids from a 1,000 cc container for dilution of parenteral solutions, and using tacky mats were paramount.[156]

Similarly, in a systematic review by Arabi et al., on VAP in adults in LMIC, from 1966 to 2007, the rates of VAP were higher overall than NHSN benchmark rates, and ranged from 10 to 41.7 per 1,000 ventilator-days. The review found that the crude mortality attributable to VAP ranged from 16% to 94%.[200]

LMIC are confronted with aspects that transcend clinical findings and good delivery of healthcare practices; the harsher reality suffered by patients hospitalized in the ICUs of LMIC lies outside the scope of the hospital itself, and reflects the country's social and political situation, poor living conditions, difficult or differentiated access to labor market and precarious labor conditions, diversity of cultural values, unequal allocation of assets among population resulting in unsatisfied basic needs, including sanitary infrastructure and limited access to the education and health system. As long as these conditions prevail, healthcare workers from LMIC are urged to focus their best efforts on improving healthcare and clinical practices, and disseminating their successful achievements, so as to be able to counteract the many social factors that cannot be directly controlled by clinical practices alone.[201]

Higher HAI rates may reflect the typical ICU situation in LMICs as a whole,[202,203] and several reasons have been exposed to explain this fact.[204] Among the primary plausible causes, it can be mentioned that, in the majority of LMICs, there are still no legally enforceable rules or regulations concerning the implementation of infection control programs, such as national infection control guidelines; yet, in the few cases in which there is a legal framework, adherence to the rules is most irregular and hospital accreditation is not mandatory.

In most hospitals, this lack of official regulations is strongly correlated to the considerable variability found in the compliance with hand hygiene guidelines. This situation is further emphasized by the fact that administrative and financial support in most hospitals is insufficient to fund infection control programs.[4] Available human resources, and supplies are different in LMIC compared to those of developed countries; and this explains why it is not possible to just use guidelines elaborated in developed countries and apply with no changes to the reality of LMIC. Reduced numbers of nurse to patient ratio is associated with increased HAI rates. Extremely low nurse-to-patient staffing ratios, hospital over-crowding, lack of medical supplies, and in an insufficient number of experienced nurses or trained healthcare workers have proved to be highly connected to high HAI rates in ICUs.[92]

In this respect, a recent study was performed to evaluate the impact of country socioeconomic status and hospital type on HAIs in 30 NICUs, from hospitals members of INICC in 15 LMIC. Its findings revealed that HAIs were significantly lower in private than academic hospitals (10.8 versus 14.3 CLABSI per 1,000 catheter-days [$p<0.03$]), but not different in public and academic hospitals (14.6 versus 14.3 CLABSI per 1,000 catheter-days [p.0.86]).[205] Furthermore, CLABSI rates found in NICUs enrolled from low-income countries were significantly higher than in lower middle-income countries or upper middle-income countries, and VAP rates in patients hospitalized in NICUs from academic hospitals were significantly higher than rates found in private or public hospitals.[205]

These findings are a clear indication of the influence that economics, as a surrogate of available supplies, outdated technology, and scarce human resources availability, have on LMICs, and of the close relation between hospital type and limited access to health care resources. In public and academic hospitals, the limitation to sufficient resources in terms of adequate number of trained and specialized staff, budget, medical supplies, and hospital administrative support is markedly more serious than in private hospitals, as they are more dependent on the socio-economic category of the country concerning the budget allocation.[55-197,206-210]

INICC Report of Device Associated Infections in Intensive Care Units from 2012 to 2017

An INICC surveillance study from January 2012-December 2017 in 523 ICUs in 45 countries from Latin America, Europe, Eastern Mediterranean, Southeast Asia, and Western Pacific was conducted. During the 6-year study period, prospective data from 532,483 ICU patients hospitalized in 242 hospitals, members of INICC, for an aggregate of 2,197,304 patient days, were collected through INICC Surveillance Online System (ISOS). US CDC-NHSN definitions for device-associated healthcare-associated infection (DA-HAI) were applied.

Although device use in INICC ICUs was similar to that reported from CDC-NHSN ICUs, DA-HAI rates were higher in the INICC ICUs: in the medical-surgical ICUs, the pooled CLABSI rate was higher (5.05 vs. 0.8 per 1,000 central line-days); the VAP rate was also higher (14.1 versus 0.9 per 1,000 ventilator-days,) as well as the rate of CAUTI (5.1 versus 1.7 per 1,000 catheter-days). Despite a significant trend toward the reduction in INICC ICUs, DA-HAI rates are still much higher compared to CDC-NHSN's ICUs representing the developed world.

(See Tables 2 to 6)

INICC Report of Short-Term Peripheral Venous Catheters-Related Bloodstream Infections from 2013 to 2019

Short-term peripheral venous catheters-related bloodstream infections (PVCR-BSIs) rates have not been systematically studied in LMIC, and data on their incidence by number of device-days is not available.

A prospective, surveillance study on PVCR-BSI conducted from September 1st, 2013 to 31st May, 2019, in 727 ICUs, members of the INICC, from 268 hospitals in 141 cities of 42 countries of Africa, the Americas, Eastern Mediterranean, Europe, South East Asia, and Western Pacific regions. We applied U.S. CDC-NHSN definition criteria, and reported methods using the INICC Surveillance Online System.

Were followed 149,609 ICU patients for 731,135 bed-days and 743,508 short term peripheral venous catheter (PVC)-days. Were identified 1,789 PVCR-BSIs, amounting to a rate of 2.41/1000 PVC-days. PVCR-BSI rates found in our ICUs were much higher than rates published from industrialized countries.[111,112,114,211]

(See Table 7)

Mortality in patients with PVC but without PVCR-BSI was 6.67%, and 18% in patients with PVC and with PVCR-BSI. The length of stay in patients with PVC but without PVCR-BSI was 4.83 days, and 9.85 days in patients with PVC and PVCR-BSI.

The microorganism profile showed 58% of gram negative bacteria: Escherichia coli (16%), Klebsiella spp (11%), Pseudomonas aeruginosa (6%), Enterobacter spp. (4%), and others (20%), including Serratia marcescens. Staphylococcus aureus were the predominant gram-positive bacteria (12%).

Surgical Site Infections

It is increasingly difficult to ignore the burden posed by surgical site infections (SSIs) on patients' safety in terms of pain, suffering, delayed wound healing, increased use of antibiotics, revision surgery, increased length of hospital stay, mortality, morbidity, which are also reflected in excess health care costs.[212]

Surveillance programs focused on healthcare-associated infections (HAI)—including surgical site infections (SSI)—are essential tools to prevent their incidence and reduce their adverse effects, thereby allowing for the reduction of patients' risk of infection. As widely shown in the literature from high income countries, including the U.S., the incidence of HAI can be reduced by as much as 30%, and by 55% in the case of SSI, through the implementation of an effective surveillance approach.[213]

Within the scope of developing countries, several reports of the International Nosocomial Infection Control Consortium (INICC) have also shown that if surveillance and infection control strategies are applied in limited-resource countries, HAIs can also be reduced significantly.[156,184,214]

The author found reports of surgical site infection (SSI) rates and are summarized at a table.

(See Table 8)

On the other hand, in 2013, the INICC reported the results of a cohort, prospective surveillance study on SSI, conducted on patients undergoing surgical procedures (SPs) from January 2005 to December 2010 in 82 hospitals of 66 cities at following 30 countries: Argentina, Brazil, Colombia, Cuba, Dominican Republic, Egypt, Greece, India, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Salvador, Saudi Arabia, Serbia, Singapore, Slovakia, Sudan, Thailand, Turkey, Uruguay, and Vietnam, from 4 continents such as America, Asia, Africa, and Europe.[215]

Data from 7,523 SSIs were associated with 260,973 surgical procedures. SSI rates were significantly higher for most types of surgical procedures in INICC hospitals compared with US CDC/NHSN data, including the rates of SSI after hip prosthesis (2.6% vs. 1.3%; relative risk [RR], 2.06 [95% confidence interval (CI), 1.8-2.4]; P < .001), coronary bypass with chest and donor incision (4.5% vs. 2.9%; RR, 1.52 [95% CI, 1.4-1.6]; [P < .001); abdominal hysterectomy (2.7% vs. 1.6%; RR, 1.66 [95% CI, 1.4-2.0]; P < .001); exploratory abdominal surgery (4.1% vs. 2.0%; RR, 2.05 [95% CI, 1.6-2.6]; P < .001); ventricular shunt, 12.9% vs. 5.6% (RR, 2.3 [95% CI, 1.9-2.6]; P < .001, and others.[216-222]

(See Tables 9 to 11)

A comparison between this study's findings and the data reported by the CDC NHSN for 2006-2008 showed that in INICC hospitals the SSIs (58%) associated with most of the SPs analyzed were exceedingly higher than those published for the U.S.[223]

The data presented in this report strengthen the fact that HAIs, particularly SSIs, in hospitals internationally pose a grave and many times concealed risk to patient safety, as compared with some countries of the developed world. As reported in the literature, the relation between HAI rates and country socioeconomic level and hospital type indicated a negative correlation. This relationship should be extensively analyzed for SSI. There is, therefore, a definite need for further studies on this subject, particularly, in developing countries. This information can be used as a benchmarking tool to develop targeted interventions aimed at designing SSI prevention programs and evaluating their impact.[215]

Consequences of Health Care Associated Infections: Extra Mortality, Extra Stay, Extra Cost, High Bacterial Resistance

From the available literature, it is highly visible that the adverse consequences of HAI in the developing world, that is, attributable mortality,[61,64,66,70,71,82,92,93,110,115,117,118,120,197,206,224-230] prolonged length of stay (LOS)[64],[66,70,71,82,110,115,117,118,120,197,205,206,224,225,227-231] extra hospital costs,[115,118,120,136] are more far-reaching in terms of severity than in the developed world.

Among the most serious consequences attributable to HAI in LMIC, it has been shown in the mainstream literature that mortality can range from 3 to 75.1%.[55,58,225,226]

Rosenthal et al., have shown mortality due to CLABs has rates that ranged from 4 to 75.1%.[2,71]

Cost, LOS and mortality attributable to DA-HAI have been determined by INICC internationally, through prospective, matched analyses.[115,118,228]

In a review to analyze the incidence of CLABSI in LMIC performed by Rosenthal in 2009, it was demonstrated that the CLABSI rate was associated with significant extra mortality, with an odds ratio ranging from 2.8 to 9.5.[199]

Similarly, mortality attributable to VAP has been found to be as high as 56.7%. With respect to mortality due to CAUTI, reports are scarce and there has been diversity in the interpretation of findings. In some publications, it was stated that CAUTI was not associated to mortality, but other findings specified rates up to 21.3%.

In several studies, researchers have highlighted the extreme vulnerability of neonates hospitalized in NICUs to mortality attributable to DA-HAI, with rates ranging from 24% in the pre-surfactant era to 11% in the post-surfactant era in the developed countries.[232-235]

However, within the context of LMIC, access to knowledge regarding DA-HAI is scarce, and there is an insufficient recognition of the importance of surveillance for measuring the HAI risks, outcomes and processes concerning the neonatal patient hospitalized in the NICU.[70,123,199,236]

The burden of CLABSI in the NICU is not limited to mortality, and newborn sepsis was associated with adverse consequences in the central nervous system, longer duration of mechanical ventilation, and hepatic fibrosis and chronic lung disease higher incidence.[234,237-240]

In a study performed in hospitals member of INICC in 10 LMIC to estimate extra LOS and mortality in an ICU due to a VAP, a cohort of 69,248 admissions were followed for 283,069 days in ICUs. Data were arranged according to a multi-state format. Extra LOS and increased risk of death were estimated independently in each country, and their results were combined using a random effects meta-analysis. The findings of the analysis showed that a VAP prolonged LOS by an average of 2.03 days (95% CI: 1.52, 2.54 days), and increased the risk of death by 14% (95% CI: 2, 27%).[229]

For measuring LOS and mortality attributable to DA-HAI, the INICC applied a new multi-state model, including specific censoring to ensure the estimation of the independent effect of each DA-HAI, and not the combined effects of multiple DA-HAIs.[144,241-243]

To estimate the excess LOS and mortality in the ICU attributable to the CAUTI, a statistical model that accounted for the timing of infection was applied in 29 ICUs of hospitals members of INICC from 10 countries: Argentina, Brazil, Colombia, Greece, India, Lebanon, Mexico, Morocco, Peru, and Turkey. In a cohort of 69,248 admissions followed for 371,452 days in 29 ICUs, a multi-state model was applied to estimate the extra LOS due to HAI. This model included specific censoring to ensure that estimations considered the independent effect of CAUTI, and not the combined effects of multiple infections. The extra LOS and increased risk of death independently for each country, and then combined the results using a random effects meta-analysis. The conclusions showed that a CAUTI prolonged LOS by an average of 1.59 days (95% CI: 0.58, 2.59 days), and increased the risk of death by 15% (95% CI: 3, 28%).[230]

A study to estimate the excess LOS in an ICU due to CLABSI was performed in hospitals members of INICC in three Latin American countries (Argentina, Brazil, and Mexico). An analysis was made by means of a statistical model that accounted for the timing of HAI. A cohort of 3,560 patients hospitalized in 11 ICUs was followed for 36,806 days. The average excess LOS due to a CLABSI increased and varied between –1.23 days to 4.69 days.[242]

(See Tables 12 and 13)

In order to calculate the cost of CLABSI in intensive care units, a 5-year prospective nested case-control study was undertaken in six adult ICUs from three hospitals of Argentina, members of INICC. One hundred and forty-two patients with CLABSI (cases) and 142 patients without CLABSI (controls) were matched for hospital, type of ICU, year of admission, LOS, gender, age, and average severity of illness score. The mean extra LOS for cases (compared to the controls) was 11.90 days, the mean extra antibiotic defined daily doses was 22.6, the mean extra antibiotic cost was $1,913, the mean extra cost was $4,888.42, and the excess mortality was 24.6%.[115]

With a view to calculating the cost of CLABs in ICU, an 18- month prospective nested case-control study was undertaken at three hospitals in Mexico City, members of INICC, in four ICUs. Fifty-five patients with CLABSI (cases) and 55 patients without CLABSI (controls) were compared by analyzing hospital, type of ICU, year of admission, LOS, gender, age, and average severity of illness score. The results indicated that extra LOS of patients with CLABSI was 6.05 days. The mean extra cost of antibiotics amounted to $598, the mean extra cost of other drugs was $25.77, and the mean extra cost of hospitalization was $8,326. The mean extra cost for cases (compared to the controls) amounted to $11,591. Finally, the extra mortality attributable to BSI was 20%.[228]

In order to calculate the cost of VAP in ICU, a 5-year matched cohort study was undertaken at six ICUs of three hospitals in Argentina members of INICC. Three hundred and seven patients with VAP (exposed) and 307 patients without VAP (unexposed) were matched for hospital, ICU, period, LOS more than 7 days, gender, age, and average severity of illness score (ASIS). The mean extra LOS for 307 cases (compared to the controls) was 8.95 days, the mean extra antibiotic defined daily doses (DDD) was 15, the mean extra antibiotic cost was $996, the mean extra total cost was $2,255, and the extra mortality was 30.3%. [118]

Another study from northern India, patients with VAP experienced significantly longer hospital stay [21 (IQ=14-33) days versus 11 (IQ=6-18) days, P<0.0001)] and incurred greater hospital costs [USD $6250.92 (IQ=3525.39-9667.57) versus $2598.84 (IQ=1644.33-4477.65), P<0.0001]. Multiple regression analysis revealed that the cost-driving factors in this study population were the occurrence of VAP infections (P<0.0001) and the duration of hospital stay (P<0.0001). The attributable cost of VAP infection was calculated to be USD $5200 (95% CI=3245-7152). [244]

(See Table 14)

The above-referred findings of studies performed in LMIC stress on the adverse consequences caused by HAIs in terms of increased LOS and extra hospital costs.[66,70,71,82,110,115,118,120,171,205,224,225,227-231]

They emphasize how important continued surveillance is to understand all the aspects, medical and social, involved within the implementation of sound infection control programs. This knowledge is essential to lead to decreased HAI rates, but it also aids the prioritization of resources and other efforts to improve patient safety.

It is known that eventually bacteria react to antibiotics treatment and become resistant to them. This means that the effectiveness of the antibiotic life span is limited. Antimicrobial resistance (AMR) is influenced by the unnecessary or inappropriate administration of antimicrobials. The increase in antimicrobial treatments and generalized overuse of antimicrobials during the last decades has turned some once-common infections that were easy to treat into a serious and, many times, life-threatening infection.[245]

Patient safety is at high risk because of AMR, including multidrug resistance, because increasingly different bacteria, viruses, fungi, protozoa, or helminths are no longer sensitive to the agents commonly administered to control the infections they cause. AMR threatens most clinical and public health practices both in limited-resource countries and high-income countries—from complex therapies to those routinely used for common infectious diseases.

AMR imposes an extra financial burden upon healthcare facilities, affecting limited-resource countries severely. Acting against AMR not only has an effect at public health level, but it also affects different economic sectors, such as those involved in international trade and travel, because of the cross-border spread of resistant infections.[245] AMR is related to loss of productivity (loss of income and reduced worker productivity) and increased cost of diagnostics, testing, and treatment (costs related to infrastructure, screening, equipment, consultation, and drugs).

In studies from Europe, it has been shown that extra mortality caused by AMR exceeds $25,000 annually, and the extra healthcare costs and loss in productivity have been estimated to be €1.5 billion each year.[245] Because the data available on the health and financial burden of AMR is scarce in many countries, it is difficult to make an accurate estimate on the actual magnitude of the problem. In addition, the stress and suffering caused at patient level is even more difficult to measure. Furthermore, it is a fact that antimicrobials are extensively used in the animal food industry, which together with the use of inadequate measures to control the spread of infection, increases the difficulties to convey the sheer complexity of the situation. AMR, thus, affects entities from several sectors, public and private, whose commitment is necessary to confront this evolving threat at different levels.

Usually, reports on AMR are generated by laboratory results. These data are used as evidence for policy makers' decisions and for decisions on individual patient's treatment. Such reports document that AMR is increasingly affecting the prevention and control of infections not only at healthcare facilities but also in the community. Moreover, anti-infective agents are fundamental for many of the medical advances in recent years, such as chemotherapy for cancer treatment and organ transplantation, which are dependent on their availability to control infections.

Healthcare facilities worldwide experience a wide variety of patterns and diverse prevalence of AMR, which contributes to failures in antibiotic therapies and increased cost, morbidity, and mortality.[246] There are different options available to counteract the evolving nature of AMR, which can be implemented to effectively maximize the limited life span of antibiotics. The available strategies and interventions, however, should be applied globally to optimize their beneficial effects. Over the last two decades, AMR has been recognized as part of a public health crisis, and international agencies and different organizations worldwide have been implementing strategies in different sectors.[247]

The evolving public health threat of AMR is driven by both appropriate and inappropriate use of anti-infective agents for human and animal health and food production, together with inadequate measures to control the spread of infections.[247]

The burden of AMR is difficult to assess for bacteria that cause community-acquired infections. In laboratory reports, it has been shown that resistance is increasing in bacteria causing pneumonia, which is responsible for the death of approximately 1.8 million children annually.[245]

Around 90% of antibiotic treatments for humans are prescribed as part of the general medical practice. This has led to a generalized use of antibiotics, which is based on national treatment guidelines, and not considered from a global

perspective. The use of second- and third-line agents adds higher costs to treatment, and development of treatment guidelines has become extremely difficult for many common infections.[245]

Resistant bacteria spread both in hospitals and community-wide. Several bacteria can inactivate carbapenems and resist third-generation cephalosporins, causing significant numbers of HAIs and community-acquired infections.[245] Recently, there has been a development in apparent shift in AMR, which might be occurring between the main classes of pathogenic bacteria (from gram-positive to gram-negative pathogens). It is likely that recent achievements to control gram-positive organisms are outweighed by the emergence of highly resistant gram-negative bacteria.[245] It has been considered that the lack of new antibiotics render some multidrug-resistant (MDR) infections untreatable. In spite of the implementation of AMR containment and antibiotic stewardship programs, AMR is very slow to reverse or even irreversible.[245] That is why the introduction of interventions to avoid the initial spread of AMR should be considered a priority in public health.

Addressing AMR from a comprehensive perspective requires that environmental aspects are also considered.[245] Water, air, and soil are being examined for the presence and possible spread of resistant bacteria. [245] Contaminated effluent and manure have been shown to contain significant amounts of antibiotic. It is therefore essential that sanitation and water supply services be appropriately rendered to halt or reduce the spread of bacteria, including AMR.

The general interventions to reduce AMR include surveillance of antimicrobial resistance and use, although resistant-bacteria proportions may vary from one area to another, and in many hospitals and medical centers there are no local data on resistance patterns. It has been reported that data on antimicrobial use and AMR are useful in serving as guides for treatment options, knowing and understanding AMR trends, making information known for public health policy, and identifying areas in need of priority, and monitoring the impact of interventions to contain AMR.

Another important aspect for AMR control is using antimicrobial rationally and imposing antibiotic regulation. It is known that the development of resistance is the natural response of any bacteria when they are under threat. Individual use, overuse, and inappropriate use have a considerable effect in the evolution of AMR. For this reason, containment strategies are to include regulations for the appropriate use of antibiotics. In limited-resource countries, there are socioeconomic and behavioral factors that can lead to increased AMR. Particularly in rural areas, lack of adequate laboratory support and insufficient knowledge on the epidemiology of antibiotic resistance patterns may force prescribers to empirically administer broad-spectrum antibiotic combinations. LMIC are confronted with major difficulties arising from substandard or counterfeit antibiotics.

Unfortunately, it has been reported that the WHO Essential Drug Program has not obtained satisfactory results in most countries, because of the continued existence of a black market, and individual financial interests at local, national, regional, and international levels.

However, as described in recent studies, high-income countries are also affected by counterfeit antibiotics, where the World Wide Web has played a fundamental role through Internet pharmacies, which even licensed, are increasingly buying counterfeit drugs themselves from foreign sources to meet demand.

Infection prevention and control activities also are essential to limit the spread of AMR, as they spread from individuals to other individuals or to the environment and then again to individuals. Effective control of HAIs helps reduce the impact of AMR.

In 1992, the Alexander Project was launched in seven countries to fight against the evolving threat of antibiotic resistance in Europe.[246] The WHO has also called upon member states and the international community to take measures to counteract the spread of AMR by means of a global strategy for containment of AMR published in 2001, which set out a collection of recommendations for AMR control.

Several world health assembly resolutions have called for action on specific health aspects related to AMR, and the WHO published its global strategy to contain AMR in 2001. Ten years later, in 2011, the WHO on world health day (WHD) published a six-point policy package addressed to countries worldwide to (a) commit to a comprehensive, financed national plan with accountability and civil society engagement; (b) strengthen surveillance and laboratory capacity; (c) ensure uninterrupted access to essential medicines of assured quality; (d) regulate and promote rational use of medicines in animal husbandry and to ensure proper patient care; (e) enhance infection prevention and control, and (f) foster innovations and research and development of new tools.[245]

Political commitment and stimulating innovation in antibiotic development are key interventions to be applied to control AMR. Developments in effective drugs have declined during the last decades, especially for MDR infections. Pharmaceutical companies are not financially incentivized by this type of development. Furthermore, new technologies and innovations are needed for other areas such as rapid diagnostic tests and infection control, which are essential for controlling AMR effectively. Consequently, the role played at governmental level is crucial, as it comes to policy makers to take the necessary steps toward the implementation of effective actions.

The increased bacterial resistance[61,64,71,82,93,110,197,206,210,225-227,231,248-250] is more far-reaching in terms of severity than in the developed world. The prevalence of HAI in LMIC was found by INICC to at least double the rates published by the European Centre for Disease Prevention and Control,[251] and triple those found in the USA.[252] The relationship of antibiotic use and the emergence of antibiotic-resistant HAI is an issue that epidemiologists and hospital authorities in LMIC must be aware of.[226,248,253]

In the last INICC Report, which contain a data summary of the device-associated HAIs of 45 countries for 2012-2017, antimicrobial resistance rates found of S aureus to Oxacillin was 64.7%, of *Enterococcus faecalis to vancomycin was 18.5%, and of* E Coli to fluoroquinolones was 49.38%, all them were far higher than US CDC-NHSN ICUs' rates.[99]

(See Table 6)

Hand Hygiene Compliance

The impact of hand hygiene (HH) before each patient contact for infection prevention was demonstrated 160 years ago when Semmelweis studied the relation between improved hand antisepsis and reduced mortality from puerperal sepsis.[254] Since then it has been proven in many studies that improved HH practice reduces HAI rates and antimicrobial resistance.[255-258] Health care workers (HCW) commonly carry nosocomial pathogens on their hands.[259,260] Most pathogens responsible for HAIs are transmitted from patient to patient through the HCW's hands.[259,260] Although invasive devices and other infection control practices that aid in the prevention of HAIs have improved, HH remains the cornerstone in the prevention of cross infection among patients.

Achieving higher adherence to HH guidelines has been a complex issue, which remains unresolved in many healthcare facilities worldwide.[261] Factors predicting poor HH adherence level have been identified in publications dating from the eighties.[262] The main factors include male gender,[201] type of healthcare worker, [201,263] type of ICU,[264,265] and type of procedure.[263,264]

The effectiveness of different interventions had been previously analyzed, and published from the early eighties by several investigators, such as contribution of supplies availability, published by Preston in 1981,[266] by Mayer in 1986,[267] and by Doebbeling in 1992;[255] use of reminders and posters published by Conly in 1989,[268] by Graham and by Simmons in 1990,[257,269] and by Lohr in 1991,[270] by Dorsey in 1996,[271] and by Avila-Aguero in 1998;[272] use of monitoring and performance feedback published by Mayer in 1986,[273] by Conly in 1989, [274] by Graham and by Dubbert in 1990,[269,275] by Lohr in 1991,[270] by Raju in 1991,[276] by Berg in 1995,[277] by Tibballs in 1996, [278] by Larson in 1997,[279] by Avila-Aguero in 1998,[272] and by Rosenthal in 2003 and 2005;[280,281] administrative support, published by Larson et al in 1997 and 2000,[256,279] and by Rosenthal in 2003 and 2005;[280,281] introduction of alcohol-based handrub published by Graham in 1990; [282] effectiveness of education as published by Dubbert,[283] and by Tibballs, and by Dorsey in 1996,[271,278], by Larson in1997,[279] and by Rosenthal 2003 and 2005.[280,281]

Combining these several interventions, multidimensional approaches have been designed and implemented with successful results since late eighties. In 1989, Conly [268] concluded that an educational and enforcement program was an efficient tool to gain higher HH compliance. In 1990, Dubbert et al reached the same conclusions combining education, monitoring and performance feedback, [283] but it was in 1997 that Larson et al explicitly referred to a multidimensional strategy that considered several interventions in a study conducted in the US.[284] Similarly, in 1998 Won et al. launched a multimodal campaign for hand hygiene promotion in a university hospital in Taiwan, which included lectures, written instructions, reminding posters on adequate HH techniques, monitoring, financial incentives, and performance feedback.[285] Likewise, in 2003 and 2005, Rosenthal et al. implemented programs in Argentina since 1993 combining administrative support,[201] supplies availability,[201] education and training,[201] process surveillance and performance feedback.[201], which produced a sustained improvement in HH compliance, coinciding with a reduction in HAI rates.[201,258]

The CDC of USA published their HH guideline in 2002 including a recommendation to apply all these previously published strategies.[286 287]

The author also conducted a literature research and found studies analyzing hand hygiene compliance, and are listed below.

(See Table 15)

Impact of the International Nosocomial Infection Control Consortium Multidimensional Hand Hygiene Approach over 13 years in 51 cities of 19 Limited Resource Countries from Latin America, Asia, the Middle East, and Europe

Monitoring HH compliance and providing HCWs with feedback regarding their performance are considered integral parts of multidisciplinary HH improvement programs. Observational surveys conducted by trained personnel are currently considered the "gold standard" method for establishing compliance rates. The objective of this study was to evaluate the impact of a multidimensional intervention to increase rates of adherence to HH among HCWs and identify variables associated with non-adherence to HH by HCWs.

A multi-center, prospective, cohort, interventional study. Ninety nine ICUs in 19 LMIC countries of Latin America, Asia and Europe (Argentina, Brazil, China, Colombia, Costa Rica, Cuba, Greece, El Salvador, India, Lebanon, Lithuania, Macedonia, Mexico, Pakistan, Panama, Peru, Philippines, Poland and Turkey): members of the INICC.[288]

HH was observed during randomly selected 30-minute periods in each unit from April 1999 to December 2011. After a 3-month baseline period, intervention consisted of a multidimensional approach including: 1- Administrative support; 2- Supplies availability; 3- Education and training; 4- Reminders in the workplace; 5- Process surveillance and performance feedback.

During 13 years, a total of 151,758 opportunities for HH were observed. Overall HH compliance increased from 48.3% to 71.2% (RR, 1.47; 95% CI, 1.44-1.50; P <0.01) during the study.

Considering HH compliance over time and adjusting for ICU, we found a higher improvement in the second and third year of participation (OR: 3.07 and 3.03 respectively) the follow up was during 9 years, and there was not a regression to the mean during the study period.

Logistic regression multivariate analysis showed that the following independent variables were significantly associated with poor HH: males (OR: 0.91, P value < 0.001); physicians (OR: 0.68, P value < 0.001), non-invasive contact (OR 0.95, P value < 0.001), adult ICU (OR 0.49, P < 0.001), and others.

Among HCWs, the rate of adherence to HH had a statistically significant rise with INICC multidimensional intervention. Male gender, physicians, adult ICUs, non-invasive contact and others are predictors of poor HH compliance. Specific programs directed to increase HH compliance among these variables should be implemented.[288]

(See Tables 16 to 20)

International Nosocomial Infection Control Consortium Resources: INICC Multidimensional Approach (IMA), and INICC Surveillance Online System (ISOS)

Founded in Argentina in 1998, and internationally in 2002, the INICC is an international, altruistic, non-profit, open, HAI surveillance network with an international board of 30 members from high-income and also from LMIC, leading this international organization, comprised of more than 2,000 affiliated infection control professionals (ICP), from hundreds of hospitals in more than 50 countries in Latin America, Asia, Africa, Middle East, and Europe, which since its first publication by one hospital member in 2003,[120] and its first pooled publication in 2006,[160] has become the only source of aggregate standardized international data on the epidemiology of HAIs internationally.[289] With a methodology based on the methods and definitions of the U.S. CDC-NHSN,[290] INICC has promoted evidence-based infection control by providing free training, and free access to online outcome and process surveillance tools to hospitals worldwide.[291]

The INICC is focused on the surveillance and prevention of DA-HAI --CLABSI, pneumonia (PNEU) and CAUTI in adult ICUs, PICUs, NICUs, step down units, and inpatient wards, and of SSI, as well as improving antimicrobial consumption and many other interventions to improve patient safety, such as reducing needle stick injuries, among others.[291]

Since 1998 the INICC has been conducting surveillance of HAIs in LMIC, and has shown through the publication of 7 multinational reports,[99,160,194,195,289,292,293] published for first time in 2006,[160] and in studies conducted in 28 countries separately, published for first time in a study from Argentina in 2003,[120] and later from Brazil,[46,57,101,102,225] China, [58-62,103,294] Colombia,[61,104] Costa Rica,[63,64] Croatia,[65] Cuba,[66] Ecuador,[67] Egypt,[68] El Salvador,[69,70,105] India,[71-73] Iran,[210] Kuwait,[197] Lebanon,[75] Lithuania,[48] Macedonia,[76] Malaysia,[77] Mexico,[78] Mongolia,[79,295] Morocco,[80,81,226] Peru, [82] Philippines,[227] Poland,[85,86,121,208] Saudi Arabia,[198] Tunisia,[87] Turkey,[88,89,107,122] Venezuela,[90] and Vietnam.[296]

DA-HAI rates in ICUs from LMICs are 3-5 times higher than rates reported in hospitals from high-income countries, and also have shown device utilization, crude extra LOS and crude extra mortality.[46,48,57-73,75-82,85-90,99,101-105,107,120-122,160,194,195,197,198,208,210,225-227,289,292-296]

Similarly, the burden posed by SSIs on patients' safety in LMIC is higher than in industrialized countries.[212] The incidence of SSI has been recently studied by the INICC multinational data of 30 countries,[297] and at national levels in Brazil,[298] Colombia,[221] India,[299] Mexico,[220] Peru,[218] Turkey[219], and Vietnam.[300]

The attributable cost, LOS, and mortality of DA-HAI have also been determined by INICC for the first time in LMICs through prospective, matched analyses of CLABSI and PNEU in Argentina,[115,118] and CLABSI in Mexico.[228]

For LOS, also for the first time in LMICs, the INICC applied a new multi-state model, including specific censoring to ensure the estimation of the independent effect of each DA-HAI, and not the combined effects of multiple infections.[241] With this method, INICC conducted time-dependent analyses of LOS and mortality due to CLABs in Argentina, Brazil and Mexico[242] due to PNEU in Argentina, Brazil, Colombia, Greece, India, Lebanon, Mexico, Morocco, Peru and Turkey,[301] and due to CAUTI in Argentina, Brazil, Colombia, Greece, India, Lebanon, Mexico, Morocco, Peru, and Turkey.[292]

The INICC has published several studies, including randomized clinical trials,[302] which compared new devices with outdated technologies[303] in Argentina,[144,301] Brazil,[301,304,305] India,[302] Italy [301,306,307]and Mexico.[144,301,305]

To counteract this adverse situation, the INICC implemented the INICC Multidimensional Approach (IMA) to prevent and control DA-HAIs.

The improvement of adherence to HH has been long considered the cornerstone of HAI prevention and control, and since 1998, INICC has been applying the INICC Multidimensional Hand Hygiene Approach (IMHHA), published for the first time in 2003 in a study from Argentina,[201] which includes the following 6 components: (1) Administrative support, (2) Supplies availability, (3) Training and Education, (4) Reminders in the workplace (5) Process surveillance and (6) Performance feedback. The results of implementing the IMHHA were published in an multinational study conducted in 19 LMIC,[308] and at a national level in Argentina,[201,309,310] Brazil,[311] China,[312] Colombia,[313] India,[314] Mexico,[315] and Turkey.[316]

With regard to specific DA-HAIs, the INICC has implemented an specific IMA, since 1998, published for the first time in 2003 in Argentina,[123,125] whose successful application resulted in significant reductions in the rates of CLABSI in multinational studies in adult ICUs,[156] pediatric ICUs[159] and NICUs[157] of LMIC, and at national level in Argentina,[123] Bahrain, [317] Colombia,[192] India,[135] Mexico,[141] Saudi Arabia,[318] and Turkey.[319]

Likewise, the implementation of the IMA for the prevention of PNEU proved successful in multinational studies in adult ICUs,[171] pediatric ICUs,[172] and NICUs,[170] and at national level in Argentina,[160,161] China,[320] Cuba,[167] India,[169] Kuwait,[321] Malaysia,[193] Turkey,[177] and Saudi Arabia[322]

Finally, the impact of the IMA for the prevention of UTI also achieved significant rates reductions in multinational studies in adult[186] and pediatric ICUs,[185] and at national level in Argentina,[180] Lebanon,[187] Philippines,[189] Saudi Arabia,[190] and Turkey.[191]

Advancing our understanding of the epidemiology, prevention and control of HAI is a continuing concern within the many thousands of hospitals and billions of patients of LMIC, and at hospitals in *high-income countries without enough experience in HAI surveillance and control*.

The lack of enough knowledge regarding HAI, especially in LMICs, translated into the need for more precise measurements of HAI risks and outcomes in specific patient groups through the adoption of surveillance and infection control programs that can successfully reduce the risk of HAI, led INICC to the concept, development and implementation of the INICC components of the IMA. The IMA proposes a new methodology for HAI prevention, and the importance of this report lies in the presentation of a clear and comprehensive description of the INICC resources and methods to facilitate its implementation and reduce and control HAIs, and their adverse effects, worldwide.

INICC's goals, mechanisms of membership, basic structure, remain the same as were described in our previous manuscript published in 2008.[249]

Active membership of participating hospitals provides the following benefits in relation to hospital safety and improved health care:

- Training of hospital epidemiologists and ICPs in basic hospital epidemiology, surveillance methods and data analysis;
- Training to detect relevant trends in HAIs and make intra- and inter-hospital comparisons with risk-adjusted data that can be used for local, regional and nation-wide quality improvement activities;
- Training of hospital epidemiologist and ICPs to design and undertake simple hypothesis-driven applied research;
- Ongoing support and advice on surveillance activities and control programs;
- Availability of a Surveillance online tool, called INICC Surveillance Online System (ISOS), to conduct outcome and process surveillance that allows timely recognition of patient safety problems and intervention with appropriate control measures, to be able to assess the clinical and economic impact of HAIs in their hospital, and to assess the impact of specific infection control practices;
- Reports generated automatically by the ISOS, including key tables and graphs;
- Reduced HAI rates, LOS, extra costs, and mortality due HAIs;
- Improved safety and quality of healthcare through implementation of systematized programs to reduce HAI rates, associated mortality, excess lengths of stay, excess costs and bacterial resistance;
- Improved use of anti-infective for prophylaxis and therapeutic use, with the goal of helping to control antimicrobial resistance;
- Certificate health care organizations determining that they meet a set of standard requirements designed to improve quality of care related to surveillance, prevention and control of HAIs, showing a commitment by an organization to ensure a safe environment for its patients and staff.
- Immediate access to current scientific knowledge relevant to the diagnosis, surveillance, prevention and control of HAIs;
- Advice regarding clinical cost effectiveness of new technologies relevant to infection control;
- Opportunity to coauthor researches to be published in peer review journals.

Characteristics Of Participating Hospitals

The hospitals participating in INICC provide general in-patient services to adult, children and newborns requiring acute care, and also patients admitted to inpatient wards and step down units, and patients undergoing surgical procedures of any type. They may be of any size and ownership, affiliated or unaffiliated with a medical school, and located anywhere worldwide. Although participation is voluntary and free, hospitals must apply for membership in INICC and have adequate personnel and support for infection control, and approval from hospital administration to participate in the INICC. More than 2,000 affiliated ICPs, from hundreds of hospitals from more than 50 countries in Latin America, Asia, Africa, Middle East, and Europe currently participate in INICC.[289] INICC achieved a

membership of more than 5 countries per continent, more than 5 cities per country, and more than 1 hospital per city, which constitute a representative sample of the limited-resources countries and hospitals of the world.[291]

Methodology, Approach, And Resources

INICC has an IMA with 6 components to reduce HAI rates, mortality rates, LOS, costs, bacterial resistance and antibiotic consumption.[249]

INICC applies two kinds of surveillance: INICC Outcome Surveillance and INICC Process Surveillance.

For surveillance, the INICC uses an Online Platform, called ISOS, with 27 modules.[291]

INICC Multidimensional Approach (IMA)

The INICC program developed an IMA, which consists of the simultaneous implementation of 6 components for HAI control and prevention:

1. Bundles
2. Education and training
3. Outcome surveillance of HAI rates and adverse consequences
4. Process Surveillance of compliance with bundles
5. Feedback of HAI rates and adverse consequences.
6. Performance Feedback

As part of the above-described IMA, the INICC uses an online platform called ISOS, which includes 4 out of the 6 components of the IMA: 1- Outcome surveillance; 2- Process Surveillance; 3- Feedback of HAI rates and adverse consequences; and 4- Performance Feedback (Figure 1.)

The INICC bundles of interventions for HAI prevention were designed as adaptation of the bundles and recommendations and guidelines published by the Institute for Healthcare Improvement (IHI),[323] CDC,[324] Society for Health Care Epidemiology of America, Infectious Diseases Society of America,[325] Association for Professionals of Infection Control,[326] and Joint Commission International.[327] These guidelines describe different groups of recommendations for HAI prevention.

Education And Training

For an effective implementation of an infection control program, education of health care workers (HCWs) is a crucial tool. It is essential that prevention education practices be deeply rooted in hospitals' customs and culture. Education to HCWs includes information about surveillance and infection control measures based on the mentioned guidelines and recommendations.

The INICC Founder and Chairman, Dr Rosenthal, personally train the hospital epidemiologists and ICPs in many member hospitals. In other cases, webinars were carried out, or movies, or printed tutorials with screen shots of the ISOS were provided as tools for training on how to conduct surveillance and upload surveillance data.

Hospital epidemiologists and ICPs have continuous telephone and email access to a support team in the INICC Central Office in Buenos Aires, which responds to all inquiries within 24 hours; the INICC Chairman reviews queries and responses.[291]

INICC Surveillance Online System (ISOS) Modules

The ISOS has 27 modules. Ten modules are for outcome surveillance, 4 modules are for process surveillance, and 13 modules are for improvement of health care quality.

The time needed to generate reports of each one of these 27 modules has a range of 1- 5 seconds. Available types of reports for all described 27 modules are online, printed; PDF file, row data as an Excel files.[291]

Outcome Surveillance

Outcome surveillance is the measurement of the rates and consequences of HAIs, including but not limited to, the following variables: HAI rates, extra mortality, extra LOS, extra cost, microorganism profile, and bacterial resistance.

Outcome surveillance data also identify HAI risk factors through case-control studies.. The results of HAI outcome surveillance allow infection control professionals to define the magnitude of the problem, identify devices with the highest risk, and provide the framework for plans to reduce infection risk, including the evaluation of the cost-effectiveness of specific infection control interventions.[302]

By applying INICC resources in which DA-HAI rates are reported per 1,000 device days, it is possible to benchmark HAI rates in LMIC against high-income countries.

INICC Outcome Surveillance Online System has modules for Surveillance of HAIs, stay, mortality and cost in adult ICUs, pediatric ICUs, NICUs, inpatient wards, step down units, surgical site infections, Microorganism profile and bacterial resistance, laboratory based surveillance of multi drug resistant organisms and clostridium dificcile Infections, antimicrobial consumption, and several other modules.

INICC applies CDC NSHN methodology, and also collects other extra data as well. Using standard CDC NSHN methods, numerator are the number of HAIs of each type, and denominators are device days collected from all patients, as pooled data, without identifying how many device days belong to ach particular patient, and without collecting features per specific patient, such as age, gender, underlying diseases, severity illness score, vital signs, use of antibiotics, LOS, mortality and others.

Since 1998, INICC has also conducted a cohort study, designed to collect specific data per patient from all patients, both those with and those without HAI, such as such as age, gender, underlying diseases, severity illness score, vital signs, antibiotic use, length of stay, mortality, and others. Using ISOS data are prospectively gathered during the study period from all patients whose stay in the hospital exceeds 24 hours. The ICP at each INICC hospital is responsible for extracting patients' data prospectively from medical records, charts, patient inspection, laboratory results, including radiographs and all cultures done.

INICC is specifically designed to continuously prompt the ICPs to suspect HAI because it provides a panoramic view of what is happening each day to every patient in the ICU in terms of their risk factors such as exposure to invasive devices, and also key surrogates of HAIs, such as high temperature, low blood pressure, results of cultures, antibiotic therapy, LOS, and mortality. 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 clinical pneumonia, and that may not be otherwise recognized as a HAI, or when ICPs has no enough experience and then not enough sensitivity to detect HAIs.[328] We found that the INICC cohort methodology further improves sensitivity of surveillance because each reported infection is validated through above described rigorous and comprehensive process.

Furthermore, by collecting data on all patients in the ICU, it is possible to easily match patients with and without HAI by characteristics such as age, gender, underlying diseases, service, admission diagnosis, severity-of-illness score, time of year or exposure to specific invasive devices and several others in order to calculate attributable extra LOS, costs, and mortality, as well as risk factors for infection.[61,82,115]

Infections are categorized by HAI sites, using standard CDC-NHSN definitions, that include clinical, and laboratory and other tests criteria.[290] Validation of each case is checked and the recorded signs and symptoms of infection and the results of laboratory studies, radiographic studies, and cultures are scrutinized to assure that the U.S. NHSN criteria for HAIs are met.[290] All patients are followed over time to determine the occurrence of HAI, dead, and LOS from the day of admission to 2 days after discharge from a specific location.

Denominator data include the number of patients, total patient-days in the unit, and number of days of exposure to invasive devices --central line (CL), urinary catheter (UC), and mechanical ventilator (MV)-- for ICUs, and the number of surgical procedures for surgical components. Calculation of site-specific infection rates is based on the appropriate denominator (e.g., number of CAUTIs divided by the total number of indwelling urinary catheter-days).[290]

Hospitals with more than one location may carry out surveillance in any or all locations, but in the selected location, every patient is monitored for HAI, including the following groups of HAIs: BSI, PNEU, UTI, ventilator-associated event (VAE) (including all their types of infection); mucosal barrier injury laboratory-confirmed BSI; bone and joint infection; central nervous system; eye, ear, nose, throat and mouth infection; lower respiratory system infection; reproductive tract infection; and skin and soft tissue infection (including all their types of infection.)

For patients hospitalized in NICUs, denominator data are stratified for each of the following five birth weight categories— ≤ 1000 gm, 1001-1500 gm, 1501 to 2500 gm and >2500 gm—and include the total number of patients in the NICU during the month, total number of patient-days, umbilical catheter/CL-days, and MV-days.)[290]

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, gender, severity illness score, and other variables. Differences in LOS have been attributed to the HAI.[118,228] This method is used widely, but has some weaknesses. There are many factors associated with LOS in ICU/hospital. Matching on more than seven factors excludes infected patients for whom no match can be found, and this will induce a selection bias. Matching on six factors, or even fewer, is unlikely to control much of the variation among LOS outcomes, inducing another source of bias.[241] The INICC developed statistical models of LOS that mitigate these problems and provide better estimates. Timing of events is important -defining HAI as a time-dependent covariate is important for models that predict LOS in hospital.[241] 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. INICC is using rigorous economic methods to estimate the changes to costs from preventing HAIs.[302]

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.[301,305]

Antimicrobial-resistant pathogens are those, which have the ability to develop resistance to the drugs developed for their elimination. These pathogens pose an increasing challenge to the hospital setting, because they cause HAIs, which threatens clinical treatments.[329]

The fact that antibiotics have been used so widely, and for so long, contributed to pathogenic adaptation to them, allowing for bacterial resistance.[330]

These pathogens include methicillin-resistant Staphylococcus aureus (MRSA), vancomycin-resistant Enterococcus species, extended-spectrum b-lactamase– producers, Escherichia coli and Klebsiella species, and fluoroquinolone- or carbapenem-resistant Enterobacteriaceae or Pseudomonas aeruginosa.

Updated data on microorganism profile and resistance are crucial to describe the magnitude of the problem and show trends in the bacterial resistance patterns related to specific HAIs.

ISOS includes surveillance of the microorganism profile and antimicrobial susceptibilities of HAIs that are confirmed microbiologically in CLABs, UTIs, and PNEUs.[330]

Process Surveillance

HCWs are aware that bundle elements are the most adequate practices for effective infection control; however, their actual application may not be consistent in routine patient care. Process surveillance serves as a means to ensure that all bundle interventions are carried out consistently for all patients and at all times.

Process surveillance consists of a standardized collection of data on the regular supervision of a series of routine infection control practices and use of supplies P in the healthcare facility. These practices include the monitoring of compliance with HH recommendations, CL care, UC care, measures to prevent PNEUs and measures to prevent SSIs.

Accompanying the other 5 components of the IMA to reduce DA-HAIs and SSIs, process surveillance is crucial to provide a basis to focus on the areas needing more attention: first, it measures the actual situation of compliance with infection control practices, providing a general overview of HCW's perception and knowledge of the burden of HAIs. Second, this evaluation and measurement permits the identification of problem areas in healthcare delivery, which is essential to implement localized interventions.[291]

Process surveillance is conducted by an ICP, who directly monitors HCWs' practices and supplies utilization, by following a standardized protocol, and conducting specific surveillance at regular intervals. HCWs are not aware of the actual schedule of the monitoring, so to avoid or minimize the observer effect.[249]

Process surveillance data include key interventions to control and reduce the incidence of HAI, such as HH compliance,[201,309,310] and specific measures to prevent PNEU,[160] CLABSI,[123,141] UTI,[180] and SSI.

INICC Process Surveillance Online System following modules: Monitoring of compliance with HH, Monitoring of compliance with bundle to prevent BSIs, Monitoring of compliance with bundle to prevent PNEUs, Monitoring of compliance with bundle to prevent UTIs, Monitoring of compliance with bundle to prevent SSIs, among others.

Feedback of HAI Rates And Adverse Consequences

The goal of measuring HAIs through outcome surveillance is directly related to the need of communicating those rates to HCWs, who are expected to cause meaningful changes. This communication process entails providing HCWs with feedback of the incidence of HAI rates and their adverse consequences. The concept of using feedback of outcome surveillance is a powerful control measure in hospitals with limited resources, whose effectiveness has been analyzed by INICC since 1998 and reported since 2003.[123]

HCWs receive feedback on HAI rates and their consequences at monthly meetings, by means of the review of reports generated through the ISOS,[249] which contains charts and tables with a running record of the monthly data of cohort surveillance.[291]

Performance Feedback

Providing feedback to HCWs in order to assess performance levels is an important motivating aspect of the IMA from the perspective of HCWs. Knowing the outcome of their efforts reflected by the measurement of their practices and the incidence of HAIs can be a most rewarding or conscious-raising factor, which is crucial to ensure the effectiveness of the IMA.

The ICPs retrieve those tables and charts from ISOS, with monthly reports, showing bar charts with HH compliance; CL, urinary catheter care compliance, measures to prevent pneumonia, and SSIs. The data are reviewed at monthly meetings of ICU staff, and also to posted them in the hospital in a prominent location, in order to provide feedback to the HCWs. [201,309]

Definitions

The ISOS uses the CDC/NHSN surveillance definitions and criteria for all specific types of HAIs published in 2015, [290], and all following updates.

The site-specific criteria include reporting instructions and provide full explanations integral to their adequate application.[290]

Proactive Prospective Validation of Health Care-Acquired Infections

There was a strong linear trend relating increasing sensitivity to numbers of years of ICP surveillance experience ($P < .001$). For ICPs with < 4 years of experience, satisfactory sensitivity (> or = 80%) was reached in only one of 10 ICP-years of observation. For ICPs with > or = 4 years' experience, satisfactory sensitivity was achieved for 14 of 18 person-years ($P = .001$). Ehrenkranz described these findings in 1995, in a study conducted at US hospitals, showing that sensitivity of ICPs to detect HAI during the first 3 years is very low, and after 4 years it rose significantly to

80%. For that reason is necessary to apply methods to increase sensitivity, especially during the first 3 years.[328]

Validation of HAIs is a unique feature of INICC outcome surveillance component and is considered essential for maximizing the sensitivity and accuracy of surveillance data. Each HAI reported by an ICP is validated, i.e., scrutinized to be certain that criteria are fulfilled to justify its recording as a HAI; the validation process also includes the scrutiny of data reported for putatively uninfected patients to permit detection of unreported but true HAIs. To do that, the INICC robot shows an online message the ICP asking to check CDC NHSN criteria for that putative HAI.

Informatics' System to Avoid Mistakes During Data Entry Process: The Robot of INICC Surveillance Online System

The ISOS has a robot to optimize performance and accuracy of surveillance and collaborate with researchers so as to identify under-reporting and avoid wrong and inconsistent selections, oversights, typos --such as when selecting a date of discharge which is prior to the date of admission, and forgetting to load the discharge date, or uploading a used invasive device, or reporting a HAI.

All necessary corrections and additions are alerted with a clear sign on the screen, and may be modified and removed by ICPs, as applicable. This robot is an essential tool for the validation of the data uploaded on the ISOS, because entails a process of determining if the information uploaded during data collection is complete and accurate, checking the data against the set of validation rules with the aim of reducing the number of errors in the data being entered into the system. The validation is performed by the INICC robot while data is being uploaded.

Cost-Effectiveness Analysis

The cost-effectiveness of IMA and use of ISOS for HAI prevention has been demonstrated in different studies in the mainstream scientific literature.[157,170,172,302] Recently, studies have shown that although these programs require ongoing investments in HAI prevention, reductions in costs were significant.[331]

The methods of the INICC cost-effectiveness analysis includes the estimation of effectiveness by modeling Life-years (LYs), quality-adjusted LYs (QALYs), health care expenditures with and without HAIs, and incremental cost-effectiveness ratios (ICERs) of the IMA and ISOS for HAI prevention.[331] In a cost-effectiveness analysis considering a health care payer perspective, for each alternative, CL-days are multiplied by US$, which is the daily cost of hospitalization. Extra decrements of QALYs are estimated for patients at age 65, and an annual decrement of 0.005 for each year over 65 is also considered. Both costs and QALYs are estimated for each patient of this trial using the parameters mentioned above, and the mean calculated for each group (standard and test cares.)

Conclusion of INICC Methods

HAIs are a major cause of patient morbidity and mortality, and DA-HAIs pose the greatest threat to hospital safety in the ICU, particularly in LMIC, as communicated for first time in a multinational report published by INICC in Annals of Internal Medicine in 2006.[116] Surveillance of HAIs has been standardized by the US CDC's NHSN by providing simple unambiguous definitions.[290] Targeted surveillance and calculation of DA-HAI rates per 1000 device-days allows benchmarking with other similar hospitals and detection of unique institutional problems in need of redress.

The methods applied by the INICC are based on those of the CDC's NHSN, in terms of definitions and criteria, but also adds a IMA, which includes the simultaneous implementation of six components: (1) bundles, (2) education and training, (3) Outcome surveillance, (4) Process Surveillance, (5) Feedback of HAI rates and adverse consequences, and (6) Performance Feedback. It should be noted that process surveillance was proposed and used for first time by INICC hospitals since 1998, and published for first time in AJIC in 2003.[123]

INICC implements CDC NSHN methodology, and also collect additional extra data as well. According to standard CDC NSHN methods, numerators are the number of HAIs of each type, and denominators are device days collected from all patients, as a pooled data, without determining the number of device days related to a particular patient, and

without collecting characteristics per specific patient. INICC, is also a cohort study, designed to collect specific data per patient from all patients, both those with and those without HAI, collecting risk factors of HAIs, such as invasive devices, and surrogates of HAIs, which include, but are not limited to, high temperature, low blood pressure, results of cultures, antibiotic therapy, LOS and mortality. This approach is useful to increase sensitivity of ICPS to detect HAIs. Furthermore, by collecting data on all patients in the ICU, it is possible to match patients with and without HAI by several characteristics to estimate extra LOS, mortality and cost.

The ISOS and the IMA, have been successfully applied in hospital settings worldwide, and significant reductions in DA-HAI rates have been achieved since its inception in 2002. We are confident that knowledge of the magnitude of the problem of DA-HAIs in the INICC member hospitals provides a powerful impetus for instituting needed changes, and we have already seen ample evidence of improvement: process surveillance, targeted performance feedback programs for HH and CL, MV and UC care have already translated to documentation of major reductions in the incidence of ICU-acquired infections in individual member hospitals.[123,135,141,160,167,169,177,180,187,189,191,319,320] INICC data are used by national health care planners in the member countries to develop strategies and target resources for control of HAI.[291]

Recommendations to Reduce HAI rates

There are several measures to be considered as basic recommendations for the implementation of an infection control program, which should be consistent with the actual capabilities of the healthcare facility and personnel. In this respect, the recommendations described in the guidelines published by published by the Institute for Healthcare Improvement (IHI),[323] CDC,[324] Society for Health Care Epidemiology of America, Infectious Diseases Society of America,[325] Association for Professionals of Infection Control,[326] Joint Commission International,[327] and INICC,[332] provide cost-effective preventative measures, feasibly applicable to infection control programs in LMIC.

The logical initial step is the organization of a surveillance system, as it permits the identification of local problems, distinctively specific to a particular institution, and will thus serve as guide for subsequent changes. Targeted surveillance and calculation of device-associated infection rates per 1000 device-days also allows benchmarking with other similar institutions. In this respect, "Outcome Surveillance" developed by INICC includes the systematic standardized measurement of DA-HAI rates and their associated effects: mortality, morbidity, extra length of stay, extra hospital costs, and bacterial resistance.[291]

Surveillance data are essential to have an accurate knowledge of the burden of HAI and focus efforts on the areas that need more attention. Hospitals with limited resources need to start surveillance of critical areas, such as intensive care units, where DA-HAI pose the most threatening risks for patient safety. This first approach needs to be followed by the surveillance and monitoring of processes. Process surveillance is necessary to monitor compliance with infection control prevention guidelines and basic measures, such as hand hygiene, vascular catheter care, urinary catheter care, and measures to prevent VAP. Thirdly, a continuing education program on HAI control and prevention must be addressed to healthcare-workers, particularly nurses, who have the greatest risk of transmission of organisms, and are essential to interrupt the transmission of HAI.[291]

To reduce the incidence of these higher rates internationally, and particularly, in LMIC, INICC adopted the "INICC Multidimensional Approach" (IMA).[291] and as part of the IMA, the INICC uses an online platform called INICC Surveillance Online System (ISOS).[291]

The successful application of the IMA and ISOS resulted in significant reductions in the rates of CLABSI, VAP and CAUTI in pooled multinational studies in ICUs[156,157,159,170,171,185,186,333] of many countries, and also at national level.[123,135,141,160,167,169,177,180,187,189,191,319,320]

Finally, it is to be noted that a reduction in DA-HAI rates cannot be expected to derive from surveillance by itself, and such educational efforts may be short-lived if regular reinforcement is absent. For this reason, in a context where there is lack of financial resources, it is compelling to find and show the information on the incidence and magnitude of the burden of HAI at the hospital level. The collection of this data must be used for improvement of patient care practices, higher adherence to published infection control guidelines, and performance feedback.

As reported in different studies from LMIC, disseminating data on morbidity and mortality due to HAI, and avoidable patient suffering and economic impact, is a necessary approach to move the hospital administration and healthcare workers into supporting the infection control program.[123,135,141,160,167,169,177,180,187,189,191,319,320]

At country level, different successful interventions of clinical trials from INICC hospital members in Argentina, Mexico, and Brazil have been published in order to reduce rates of CLABSI, VAP, CAUTI, pooled DA-HAI, and increase hand hygiene compliance.[308,311,313-315,334-336]

Central Line-Associated Bloodstream Infection Reduction

In a time-sequence analysis of the effectiveness of this multi-faceted approach in reducing rates of CLABSI in 15 LMIC from INICC, it was concluded that after implementing the infection control program, adherence to infection control compliance significantly improved, the CLABSI incidence was reduced by 54% (16.0 to 7.4 CLABs per 1,000 CL-days; RR 0.46, 95% CI 0.33 - 0.63, P< 0.001) and the number of CLABSI-associated deaths decreased by 58%.[156]

A recent study was performed by INICC on pediatric intensive care units (PICUs) of five LMIC to analyze the impact of a multidimensional infection control approach on CLABSI rates. The approach included (1) a bundle of infection control interventions, (2) education, (3) outcome surveillance, (4) process surveillance, (5) feedback of CLABSI rates, and (6) performance feedback of infection control practices. After intervention, the CLABSI was reduced from baseline by 52% (10.7 to 5.2 CLABs per 1000 CL-days; RR 0.48, 95% CI 0.29 – 0.94, P 0.02).[337]

A similar multidimensional approach for CLABSI reduction was adopted in another study conducted by INICC in NICUs of 4 LMIC. During baseline, the CLABSI rate was 21.4 per 1,000 CL days, and after intervention, the CLABSI rate decreased to 9.7 per 1000 CL days [RR 0.45 (95% CI 0.33 – 0.63)], showing a 55% CLABSI rate reduction.[338]

With regard to the reduction of CLABSI, in a prospective before/after trial performed in Argentina, at hospitals members of INICC, the rates of CLABSI determined during a period of active surveillance without education or performance feedback (phase 1) were compared to rates of CLABSI after sequential implementation of an infection control program that included education (phase 2) and performance feedback (phase 3). Overall rates of CLABSI were reduced by 75%, from 46.63 to 11.10 BSIs per 1,000 IVD-days (RR = 0.25, 95% CI = 0.17-0.36, P-value = <0.0001).[123]

In Mexico, a prospective before/after trial was performed at level III adults ICUs in one public university hospital member of INICC. During a period of active surveillance without process control, rates of CLABSI were determined (phase 1) and were then compared to rates of CLABSI after implementing an infection control program that applied process surveillance and performance feedback (phase 2). Compliance with CL site care and hand hygiene improved significantly from baseline during the study period: placing a gauze dressing over the catheter insertion site improved from 86.69% to 99.24% (RR:1.14, 95% CI:1.07-1.22, P-value: 0.0000.), proper use of gauze central line insertion site improved from 84.21% to 97.87% (RR: 1.16, 95% CI:1.09-1.24, P-value: 0.0000.), documentation of date of placement of administration set of vascular catheter improved from 40.69% to 93.85% (RR: 2.34, 95% CI:2.14-2.56, P-value: 0.0000), hand hygiene prior to contact with the patient improved from 62% to 84.9% (RR:1.37, 95% CI:1.21-1.51, P-value: 0.0000). Overall rates of CLABSI were significantly reduced by 58% after implementing a process control program, from 46.3 to 19.5 CLABs per 1000 CL-days (RR = 0.42, 95% CI = 0.27-0.66, P-value = 0.0001). Finally, overall rates of crude unadjusted mortality were lowered significantly from baseline rates, from 48.5% per 100 discharges to 32.8% (RR: 0.68, 95% CI: 0.50-0.31, P-value: 0.01). [141]

In India, a study was conducted to evaluate the impact of the INICC multidimensional infection control approach on CLABSI rates in 16 adult ICUs of 11 hospitals, members of INICC. During the baseline period, outcome surveillance of CLABSI was performed, applying the definitions of the CDC/NHSN (US Centers for Disease Control and Prevention/National Healthcare Safety Network). During the intervention, the INICC approach was implemented, which included a bundle of interventions, education, outcome surveillance, process surveillance, feedback on CLABSI rates and consequences, and performance feedback. Random effects Poisson regression was used for clustering of CLABSI rates across time periods. The baseline rate was 6.4 CLABs per 1000 CL-days, which was reduced to 3.9 CLABs per 1000 CL-days in the second year and maintained for 36 months of follow-up, accounting for a 53% CLABSI rate reduction (incidence rate ratio 0.47, 95% confidence interval 0.31-0.70; p=0.0001). [135]

In Brazil, an educational program was developed by a multidisciplinary task force to highlight correct practices for central line (CL) care. Before intervention, the CLABSI rate was 20 per 1000 CL days, and after the educational intervention and policy change, such as standardized use of povidone-iodine during dressing care, the number of CLABSI dropped to 11 per 1,000 CL-days.[127]

In Tunisia, a randomized, controlled trial was conducted in which 246 patients with non-tunneled CL were randomly assigned to receive a heparin-coated line with 50 mL/d of normal saline solution as a continuous infusion (heparin-coated group) or a non-coated catheter with a continuous infusion of low-dose unfractionated heparin (control group: continuous infusion of 100 U/kg/d). CLABSI occurred in 0.9 events per 1,000 days in the heparin-coated group and in 3.5 events per 1,000 days in the control group (3.5 events per 1,000 days; P = 0.027). The conclusion of this study stated that the use of heparin-coated lines could be a safe and effective approach to the prevention of CLABSI in patients with haemato-oncologic disease.[339]

In Turkey, a study was conducted to analyze the effect of education on the rate of CLAB. During the pre-education period, the CLABSI rate was 8.3 infections per 1,000 CL-days, and during the post-education period, the CLABSI rate was 4.7 infections per 1,000 CL-days.[340] In another study conducted in Turkey, 133 patients requiring CL were chosen at random to receive either an antiseptic-impregnated triple-lumen line (N=64) or a standard triple-lumen line (N=69). The CLABSI rates were 5.3/1,000 CL-days for the antiseptic line group and 1.6/1,000 CL-days for the standard line group (P=0.452). The results of this study indicated that the use of antiseptic-impregnated central lines had no effect on the incidence of either line colonization or CLABSI in critically ill patients.[148]

An open-label, prospective cohort, active healthcare-associated infection surveillance, sequential study was conducted in three intensive care units in Brazil at hospitals members of INICC, to determine the rate and time to develop first CLABSI when comparing open and closed infusion containers. The probability of acquiring CLABSI was assessed over time and compared between open and closed infusion container periods; 3-day intervals were examined. CLABSI rate was significantly higher during the open compared with the closed infusion container period (6.5 versus 3.2 CLAB/1000 CL days; RR=0.49, 95%CI=0.26- 0.95, p=0.031). During the closed infusion container period, the probability of acquiring a CLABSI remained relatively constant along the time of central line use (0.8% Days 2-4 to 0.7% Days 11-13) but increased in the open infusion container period (1.5% days 2-4 to 2.3% days 11-13). Combined across all time intervals, the chance of a patient acquiring a CLABSI was significantly lower (55%) in the closed infusion container period (Cox proportional hazard ratio 0.45, p= 0.019).[304]

There is only one meta-analysis with data from LMIC that compared the use of open infusion containers (glass bottle, burette, or semi-rigid plastic bottle) or closed infusion containers (fully collapsible plastic containers) on CLABSI rates and mortality in Argentina, Brazil, Italy, and Mexico. CLABSI incidence dropped markedly in all four countries after switching from an open to a closed infusion container (pooled results, from 10.1 to 3.3 CLABs per 1,000 central line-days; relative risk [RR], 0.33 [95% confidence interval, 0.24-0.46]; P < .001), and also mortality also decreased significantly, from 22.0 to 16.9 deaths per 100 patients (RR, 0.77 [95% CI, 0.68-0.87]; P < .001). Switching from an open to a closed infusion container resulted in a striking reduction in the overall CLABSI incidence and all-cause ICU mortality. Its findings suggested that open infusion containers are associated with a greatly increased risk of infusion-related bloodstream infection and increased ICU mortality that have been unrecognized.[341]

According to the first randomized controlled trial (RCT) conducted to compare rates of CLABSI between patients using a closed system with a pre-pierced septum (Split Septum) and single-use prefilled flushing devices (SUF) and those using an open system (three-way stopcocks) and manual admixture (MA), which was conducted by the INICC in India, a significantly lower incidence of CLABs and higher cost-effectiveness were observed in the Split Septum +SUF group compared with the three-way stopcocks +MA group.[302] Coincidentally, the use of the Split Septum +SUF significantly improved the cumulative infection-free catheter survival compared with the three-way stopcocks +MA (hazard ration, 0.33; 95% CI, 0.15-0.73; P = .006). Using a Split Septum + SUF represented savings of $402.88 and an increase in quality-adjusted life years of 0.0008 per patient. For each extra dollar invested in a Split Septum + SUF, $124 was saved. In conclusion, the use of Split Septum + SUF is cost-effective and associated with a significantly lower CLABSI rate compared with the use of three-way stopcocks.[302] Nevertheless, the extended suffering of patients and their relatives cannot be estimated in terms of economic costs only.

(See Table 21)

Health Care Associated Pneumonia Reduction

As regards the reduction of VAPs, in another multi-center study conducted by INICC in adult ICUs of 14 LMIC, a multi-dimensional approach was applied by with the aim of reducing the rates of VAP. The VAP rate at baseline was 22.0, and after intervention, it decreased to 17.2 per 1,000 MV days (RR; 0.78; 95% CI 0.68-0.90; P 0.0004), showing a 55.83% VAP rate reduction.[342]

With the same approach, in a study conducted in PICUs of five LMIC it was shown that the rate of VAP at baseline was 11.7, and after intervention, it had decreased to 8.1 per 1,000 MV days (RR; 0.69; 95% CI 0.5-0.96; P 0.02), showing a 31% VAP rate reduction.[114]

Another similar study to assess the effectiveness of a multidimensional approach on VAP rates was recently performed by INICC in NICUs of 10 LMIC. The VAP rate during Phase 1 period was 17.8, and during Phase 2 period was 12.0 per 1000 MV days (RR; 0.67; 95% CI 0.50-0.91; P 0.001), showing a reduction in the VAP rate of 33%.[343]

In a before-after study performed in four level III adult ICUs in two Argentinean hospitals, members of INICC, it was reported that after the implementation of a multi-faceted infection control program, the rate of VAP was successfully reduced by 31%, from 51.28 to 35.50 episodes of VAP per 1,000 MV-days (RR = 0.69, 95% CI: 0.49-0.98, P <or= .003).[160]

In China, a before-after study was conducted by INICC members from January 2005 to July 2009, to evaluate the implementation of a multidimensional approach for VAP reduction. The VAP baseline rate was 24.1 per 1000 ventilator-days, which was significantly decreased to 5.7 per 1000 ventilator-days in 2009 (2009 vs 2005: relative risk, 0.31; 95% confidence interval, 0.16-0.36; P = .0001), amounting to a 79% cumulative VAP rate reduction. [163]

In India, the INICC multidimensional approach for the reduction of VAP was assessed in adult patients hospitalized in 21 ICUs from 14 INICC member hospitals in 10 Indian cities. The VAP rate was 17.43/1000 mechanical ventilator days during baseline, and 10.81 for intervention, showing a 38% VAP rate reduction (relative risk 0.62, 95% confidence interval 0.5-0.78, P = 0.0001). [169]

In Cuba, a pre-post study in AICU patients in an INICC member hospital assessed the effect of the multidimensional approach on the reduction of VAP rates. The baseline rate of VAP was 52.63 per 1000MV days and 15.32 per 1000MV days during the intervention, showing a 70% VAP rate reduction at the end of the study period.[167]

In Turkey, a prospective before-after study evaluated the impact of the INICC multidimensional approach on the reduction of VAP in adult patients hospitalized in 11 ICUs, from 10 hospitals, members of the INICC, in 10 cities of Turkey. The baseline rate of VAP was 31.14 per 1,000 MV-days, and was reduced to 16.82 per 1,000 MV-days during intervention, amounting to a 46 % VAP rate reduction (RR, 0.54; 95 % CI, 0.42-0.7; P value, 0.0001.) [177]

In Pakistan, an observational pre and post-intervention study was conducted to assess whether an educational program focusing on preventive practices for VAP could reduce its incidence. An evidence-based guideline for preventive practices at the bedside was developed and disseminated to the intensive care unit staff. VAP infection rates were reduced by 51%, from a mean of 13.2 VAP in the pre-intervention period to 6.5 VAP per 1,000 device days in the post-intervention period (mean difference 6.7; 95% CI: 2.9-10.4, P =0.02). [174]

In Thailand, a study was performed to determine the long-term effect of an educational program to prevent VAP in a medical ICU (MICU). The educational program involved respiratory therapists and nurses, and included a self-study module with pre-intervention and post-intervention assessments, lectures, fact sheets, and posters. Before the intervention, there were 20.6 cases per 1,000 ventilator-days in the MICU, and after intervention the rate of VAP decreased by 59% to 8.5 cases per 1000 ventilator-days; P=. 001. [344]

In a before-after study performed in four level III adult ICUs in two Argentinean hospitals, members of INICC, it was reported that after the implementation of a multi-faceted infection control program, the rate of VAP was successfully reduced by 31%, from 51.28 to 35.50 episodes of VAP per 1,000 MV-days (RR = 0.69, 95% CI: 0.49-0.98, P <or= .003).[118]

(See Table 21)

Catheter Associated Urinary Tract Infection Reduction

In relation to CAUTI, a before-after study conducted in 15 countries, at INICC member hospitals, evaluated the impact of a multidimensional infection control strategy for the reduction of the incidence of CAUTI in patients hospitalized in adult ICUs. Before the intervention, the CAUTI rate was 7.86 per 1,000 UC-days, and after intervention, the rate of CAUTI decreased to 4.95 per 1,000 UC-days [relative risk (RR) 0.63 (95% confidence interval [CI] 0.55-0.72)], showing a 37% rate reduction. [186]

Likewise, a study was conducted by INICC in PICUs from six LMIC; the study analyzed the impact of a multi-dimensional approach developed by INICC to reduce CAUTI rates. In Phase 1, the CAUTI rate was 5.9 per 1,000 UC days, and in Phase 2, after implementing the multidimensional infection control approach for CAUTI prevention, there rate of CAUTI decreased to 2.6 per 1,000 UC days [RR 0.43 (95% CI 0.21–1.0)], showing a rate reduction of 57%.[345]

In an open trial in an Argentinean hospital members of INICC, performed by Rosenthal et al., rates of CAUTI were determined during a baseline period of active surveillance without education and performance feedback, and were then compared with rates of CAUTI after implementing education, process surveillance, and performance feedback regarding catheter care measures and hand hygiene compliance. The findings showed that the CAUTI rate decreased significantly by 42%, from 21.3 to 12.39 CAUTIs per 1,000 catheter-days (RR, 0.58; CI%, 0.39 to 0.86; P = .006).[116]With regard to hand hygiene compliance, three Argentinean hospitals members of INICC were studied for adherence to a hand hygiene protocol, and 15,531 patient contacts were observed. The baseline rate of hand hygiene before contact with patients was 17%. The implementation of a program consisting in education, hand hygiene before contact with patients increased to 44% (RR 2.65; 95% CI 2.33-3.02, P-value: <0.001), and with education and performance feedback, hand hygiene further increased to 58% (RR 1.86; 95% CI 1.38-2.51; P value: <0.001).[201]

In Turkey, a before-after prospective active surveillance study evaluated the effectiveness of the INICC multidimensional infection control approach for the reduction of CAUTI in 13 ICUs in 10 hospital members of the INICC During phase 1, the rate of CAUTI was 10.63 per 1,000 UC-days and was significantly decreased by 47% in phase 2 to 5.65 per 1,000 UC-days (relative risk, 0.53; 95% confidence interval: 0.4-0.7; P value = .0001).[191]

In Lebanon, a study assessed the impact of a multidimensional infection control approach for the reduction of CAUTI adult ICU patients of a hospital member of the INICC. The baseline rate of CAUTI was 13.07 per 1000 urinary catheter-days, and was decreased by 83% to 2.21 per 1000 urinary catheter-days (risk ratio 0.17; 95% confidence interval 0.06-0.5; p=0.0002). [187]

In the Philippines, a before-after prospective active surveillance study was conducted to assess the impact of the INICC multidimensional infection control approach on the reduction of CAUTI rates in adult ICUs in two hospitals in the Philippines, members of the INICC. The rate of CAUTI was 11.0 per 1000 UC-days at baseline and was decreased by 76% to 2.66 per 1000 UC-days during intervention [rate ratio [RR], 0.24; 95% confidence interval [CI], 0.11-0.53; P-value, 0.0001]. [189]

The extracted findings from the available clinical trials are representative and consistent evidence of the effectiveness that multi-faceted infection control strategies can have in LMIC. Within the broad spectrum of infection control, to successfully address the burden of HAI in limited-resource healthcare facilities, it has been key to implement surveillance of DA-HAI rates and of processes related to appropriate use and care of devices, educate healthcare workers, assesses their practices, and provide them with feedback of observed processes, and ensure adequate observations of the recommendations set forth in published guidelines. These findings reveal that the reduction of DA-HAIs is feasible and cost-effective in LMIC; therefore, this valid evidence should lead to the mandatory organization of multi-dimensional infection control programs at every hospital.

To conclude, it is necessary to highlight that in order to reduce the hospitalized patients' risk of infection in LMIC, a multidimensional approach is primary and essential. As a first step it is necessary to include the implementation of DA-HAI surveillance, because it effectively describes and addresses the importance and characteristics of the threatening situation created by HAIs. Additionally, surveillance of DA-HAI has played a fundamental role, not only in increasing the awareness of DAI risks, but also providing an exemplary basis for the institution of infection control practices. It is key that surveillance is implemented along with the monitoring of practices of infection control (process surveillance), education, presence of practice bundles, performance feedback, and feedback of DA-HAI rates and consequences.

The high incidence of DA-HAI and mortality has been reduced by carrying out a multidimensional approach, with targeted performance feedback programs for hand hygiene and central line, ventilator, and urinary catheter care. Finally, it is of utmost importance to restrict the administration of anti-infective in order to effectively control of antibiotic resistance; however, this subject exceeds the scope of this chapter.

(See Table 21)

It is clear that HAIs are a huge and largely underestimated threat to patient safety, particularly in hospitals of the developing countries, a far greater threat than in high-income ones –we believe, rivaling the huge burden of diarrhea of childhood, tuberculosis and malaria. It is our hope that the successes of the INICC, combined with our on-going efforts to more consistently implement simple and inexpensive measures for prevention, will lead to wider acceptance of infection control practices and continued reductions in HAI rates and their adverse effects, not only in the hospitals of the INICC, but in hospitals worldwide as well.

Table 1.
Device Associated Health-Care Associated Infections Rate per 1000 Device Days at Adult, Pediatric and Neonatal Intensive Care Units. Reported by Hospitals from Economies Defined as Low-, or Lower-Middle, or Upper-Middle Income by the World Bank.

Country	ICU Type	CLABSI per 1000 CL days	VAP per 1000 MV days	CAUTI per 1000 UC days	Year of publication	Reference
Albania	Adult	—	40.0	41.0	2008	[43]
Argentina	Adult	11.4	—	—	2002	[44]
Argentina *	Adult	30.3	46.3	18.5	2004	[55]
Argentina *	Adult	2.7	—	—	2004	[56]
Brazil	Adult	10.2	18.7	1.8	2003	[46]
Brazil*	NICU	17.3	3.2	-	2010	[101]
Brazil *	Adult	9.1	20.9	9.6	2008	[57]
Brazil *	Adult	9.1	20.9	9.6	2008	[57]
Brazil *	NICU	3.1	4.3	-	2007	[102]
China*	NICU	18	63.3	-	2007	[103]
China *	Adult	3.1	20.8	6.4	2012	[58]
China *	Adult	7.66	10.46	1.3	2012	[59]
China *	Adult	-	19.56	-	2015	[60]
Colombia *	Adult	11.3	10.1	4.3	2006	[61]
Colombia *	Adult	12.9	-	-	2016	[62]
Colombia *	NICU	50.6	13.2	-	2004	[104]
Costa Rica *	Adult	4.65	29.9	0.0	2009	[63]
Costa Rica *	Adult	2.9	30.7	1.5	2015	[64]
Costa Rica *	Adult	4.65	29.9	—	2009	[63]
Croatia *	Adult	8.3	47.8	6.0	2006	[65]
Cuba *	Adult	2.0	52.5	8.1	2011	[66]
Ecuador *	Adult	6.5	44.3	5.7	2017	[67]
Egypt *	Adult	22.5	73.4	34.2	2013	[68]
Egypt *	Adult	18.8	31.8	—	2011	[68]
El Salvador *	Adult	8.16	11.1	7.53	2007	[69]
El Salvador *	Adult	10.1	12.1	5.8	2011	[70]
El Salvador *	NICU	16.1	9.9	-	2011	[105]
India *	Adult	7.9	10.4	1.4	2007	[71]
India *	Adult	0.48	21.9	0.6	2010	[72]
India *	Adult	5.1	9.4	2.1	2015	[73]
India *	Adult	7.9	10.4	1.4	2007	[71]
Iran	Adult	147.3	275	137.5	2004	[47]
Iran *	Adult	5.84	7.88	8.99	2015	[74]
Lebanon *	Adult	5.2	8.1	4.1	2012	[75]
Lithuania	Adult	7.7	28.8	3.4	2009	[48]
Macedonia *	Adult	1.47	6.58	0.45	2010	[76]
Malaysia *	Adult	9.4	21.2	5.0	2016	[77]
Mexico *	Adult	23.1	21.8	13.4	2006	[78]
Mexico *	Adult	23.1	21.8	13.4	2006	[78]

Mexico *	NICU	24.6	25.9	-	2004	[106]
Mongolia *	Adult	19.7	43.7	15.7	2015	[79]
Morocco *	Adult	12.1	45.3	9.7	2007	[80]
Morocco *	Adult	15.7	43.2	11.7	2009	[81]
Peru	Adult	18.1	7.9	5.1	2010	[49]
Peru *	Adult	7.7	31.3	5.1	2008	[82]
Philippines *	Adult	14.0	27.4	16.2	2007	[83]
Philippines *	Adult	4.6	16.7	4.2	2011	[84]
Philippines *	Adult	8.23	12.8	0.0	2011	[84]
Poland *	Adult	4.01	18.2	4.8	2011	[85]
Poland *	Adult	-	11.15	-	2015	[86]
Tunisia	Adult	15.3	4.4	—	2006	[50]
Tunisia	Adult	14.8	—	—	2007	[54]
Tunisia *	Adult	8.65	5.56	0.0	2010	[87]
Turkey	Adult	11.8	27.1	9.6	2010	[51]
Turkey	Adult	2.8	21.2	11.9	2011	[52]
Turkey	Adult	—	—	19.02	2012	[53]
Turkey	Adult	6.4	14.3	4.3	2014	[45]
Turkey *	Adult	17.6	26.5	8.3	2007	[88]
Turkey *	Adult	11.1	21.4	7.5	2014	[89]
Turkey *	NICU	9.8	53.6	-	2004	[107]
Turkey *	NICU	21	8.1	-	2014	[89]
Venezuela *	Adult	5.1	7.2	3.9	2017	[90]
Vietnam *	Adult	9.8	13.4	5.3	2018	[91]
INICC Report 2006- with pooled data of 8 countries.*	Adult	18.5	24.1	8.9	2006	[92]
INICC Report 2008- with pooled data of 18 countries.*	Adult	9.2	19.5	6.5	2008	[93]
INICC Report 2010- with pooled data of 25 countries.*	Adult	7.6	13.6	6.3	2009	[95]
INICC Report 2010- with pooled data of 25 countries.*	NICU	13.9	9.5	-	2010	[110]
INICC Report 2012- with pooled data of 36 countries.*	Adult	6.8	15.8	6.3	2012	[96]
INICC Report 2012- with pooled data of 36 countries.*	NICU	12.2	9.0	-	2012	[96]
INICC Report 2014- with pooled data of 43 countries.*	Adult	4.9	16.8	5.05	2014	[97]
INICC Report 2014- with pooled data of 43 countries.*	NICU	5.17	9.54	-	2014	[97]
INICC Report 2016- with pooled data of 50 countries.*	Adult	4.1	13.1	5.07	2016	[98]
INICC Report 2016- with pooled data of 50 countries.*	NICU	16.37	9.02	-	2016	[98]
INICC Report 2019- with pooled data of 45 countries.*	Adult	5.05	14.1	5.1	2019	[99]
INICC Report 2019- with pooled data of 45 countries.*	NICU	12.7	7.5	-	2019	[99]

*Scientific research conducted by INICC members, using INICC software, and published by INICC Team.

ICU, Intensive care unit; PICU, Pediatric intensive care unit; NICU, neonatal intensive care unit; CLABSI, Central-Line Associated Bloodstream Infection; VAP, Ventilator-Associated Pneumonia; CAUTI, Catheter-Associated Urinary Tract Infection; CL, central line; MV,

mechanical ventilator; UC, urinary catheter; INICC, International Nosocomial Infection Control Consortium.

- INICC Report 2006- with pooled data of 8 countries: Argentina, Brazil, Colombia, India, Mexico, Morocco, Peru, and Turkey.
- INICC Report 2008- with pooled data of 18 countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Peru, Philippines, El Salvador, Turkey, Uruguay.
- INICC Report 2010- with pooled data of 25 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Thailand, Tunisia, Turkey, Venezuela, Vietnam.
- INICC Report 2012- with pooled data of 36 countries: Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Puerto Rico, Republic of Singapore, Saudi Arabia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Vietnam.
- INICC Report 2014- with pooled data of 43 countries: Argentina, Bolivia, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Puerto Rico, Republic of Singapore, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.
- INICC Report 2016- with pooled data of 50 countries: Argentina, Bahrain, Bolivia, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Indonesia, Iran, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Puerto Rico, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Uruguay, Venezuela, Vietnam.
- INICC Report 2019- with pooled data of 45 countries: Argentina, Bahrain, Brazil, Bulgaria, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Palestine, Panama, Papua New Guinea, Peru, Philippines, Poland, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.

Table 2.
International Nosocomial Infection Control Consortium report, data summary of 45 countries for 2012-2017.
International Nosocomial Infection Control Consortium facilities contributing data used in this report per region

	Africa	Latin America	Eastern Mediterranean	Europe	South East Asia	Western Pacific	Pooled
ICUs, type							
Surgical Cardiothoracic	1	4	1	6	9	0	21
Medical Cardiac	0	14	10	2	12	2	40
Medical	5	11	17	7	29	3	72
Medical/Surgical	2	61	35	30	44	11	183
Neonatal	3	22	20	6	17	2	70
Neuro Surgical	0	3	2	4	8	3	20
Neurologic	0	1	0	1	5	0	7
Oncology	0	1	2	0	0	0	3
Pediatric	2	19	11	9	11	5	57
Respiratory	0	2	0	3	1	0	6
Surgical	3	3	4	10	15	2	37
Trauma	0	2	2	0	3	0	7
Total ICUs, n (%)	16(3%)	143(27%)	104(20%)	78(15%)	154(30%)	28(5%)	523 (100%)
Hospitals							
Academic teaching, n (%)	3 (75%)	12 (17%)	11 (20%)	35 (85.4%)	6 (10%)	5 (33%)	72 (30%)
Public, n (%)	0 (0%)	19 (27%)	37 (66%)	2 (4.8%)	4 (7%)	4 (33%)	66 (27%)
Private community, n (%)	1 (25%)	39 (56%)	8 (14%)	4 (9.8%)	48 (83%)	4 (33%)	104 (43%)
Total Hospitals, n	4	70	56	41	58	13	242

ICU, intensive care unit

Table 3.
International Nosocomial Infection Control Consortium report, data summary of 45 countries for 2012-2017.
Pooled means, 95% confidence intervals and key percentiles of the distribution of central line-associated bloodstream infection rates and ventilator-associated pneumonia rates by type of location, in adult, pediatric, and neonatal intensive care units, and of urinary catheter-associated urinary tract infection rates, by type of location, in adult and pediatric intensive care units, DA module, 2012-2017

Central line-associated BSI rate								***Percentile****				
Type of ICU	**Nº of ICUs**	**No of patients**	**No of CLABs**	**Central line days**	**Pooled mean**	**95% CI**		**10%**	**25%**	**50% (median)**	**75%**	**90%**
Surgical cardiothoracic	21	22,979	169	76,729	2.20	1.8	2.6	0.0	0.0	0.9	2.5	5.2
Medical Cardiac	40	44,526	439	86,395	5.08	4.6	5.6	0.0	0.0	0.6	4.3	18.0
Medical	72	38,313	642	143,716	4.47	4.1	4.8	0.0	0.0	3.8	9.3	30.6
Medical/Surgical	185	304,958	6,140	1,216,897	5.05	4.9	5.2	0.0	0.7	3.6	9.4	24.8
Neuro Surgical	20	15,949	197	44,466	4.43	3.8	5.1	0.0	1.1	3.9	7.9	11.4
Neurologic	7	1,901	15	5,883	2.55	1.4	4.2	0.0	0.0	0.0	6.1	-
Oncology	3	832	44	2,998	14.68	10.7	19.7	1.6	1.6	15.6	-	-
Pediatric	57	27,486	975	135,543	7.19	6.7	7.7	0.0	0.0	3.5	7.5	23.5
Respiratory	6	2,139	54	21,843	2.47	1.9	3.2	0.0	0.9	4.4	13.5	-
Surgical	37	29,654	424	81,013	5.23	4.7	5.6	0.0	0.0	2.5	10.9	35.2
Trauma	7	10,260	151	27,614	5.47	4.6	6.4	0.0	0.0	10.1	12.6	-
Pooled (Adult and Pediatric ICUs)	455	498,997	9,250	1,843,097	5.02	4.9	5.1	0.0	0.0	3.1	8.7	21.1
NICU. Birth-weight category, Kg						**95% CI**		***Percentile***				
< 750gr	70	1,739	137	7,468	18.3	15.4	21.7	0.0	0.0	3.6	36.5	71.4
751 - 1000gr	70	2,442	255	17,553	14.5	12.8	16.4	0.0	0.0	0.0	24.7	70.2
1001 - 1500gr	70	10,223	566	36,978	15.3	14.1	16.6	0.0	0.0	0.0	21.3	47.4
1501 - 2500gr	70	9,492	156	20,310	7.7	6.5	9.0	0.0	0.0	0.0	4.6	46.5
> 2500gr	70	9,981	180	19,376	9.3	8.0	10.8	0.0	0.0	0.0	0.0	36.6
Pooled (NICUs)	70	33,877	1,294	101,685	12.7	12.0	13.4	0.0	0.0	0.0	15.9	52.6
Ventilator-associated PNEU rate								***Percentile***				
Type of ICU	**Nº of ICUs**	**No of patients**	**No. of VAPs**	**Ventilator days**	**Pooled mean**	**95% CI**		**10%**	**25%**	**50% (median)**	**75%**	**90%**
Surgical cardiothoracic	21	22,979	288	39,073	7.4	6.5	8.3	0.0	0.0	1.6	10.8	14.7
Medical Cardiac	40	44,526	735	41,409	17.7	16.5	19.1	0.0	0.0	10.1	20.7	37.5
Medical	72	38,313	1,192	93,867	12.7	12.0	13.4	0.0	0.0	6.6	20.9	42.2
Medical/Surgical	185	304,958	10,882	771,025	14.1	13.8	14.4	0.0	3.2	11.7	24.2	41.8
Neuro Surgical	20	15,949	450	32,987	13.6	12.4	15.0	0.0	2.3	13.4	33.0	51.2
Neurologic	7	1,901	31	2,243	13.8	9.4	19.6	0.0	0.0	0.0	17.6	-
Oncology	3	832	13	1,574	8.3	4.4	14.1	0.0	0.0	0.0	-	-
Pediatric	57	27,486	1,356	114,845	11.8	11.2	12.5	0.0	0.0	4.6	11.9	29.4
Respiratory	6	2,139	207	19,356	10.7	9.3	12.3	8.5	10.8	16.9	40.2	-
Surgical	37	29,654	566	41,767	13.6	12.5	14.7	0.0	0.0	7.1	17.6	72.4
Trauma	7	10,260	379	35,460	10.7	9.6	11.8	0.0	8.5	27.5	32.4	-
Pooled (Adult and Pediatric ICUs)	455	498,997	16,099	1,193,606	13.5	13.3	13.7	0.0	0.0	8.4	21.7	39.0
NICU. Birth-weight category, Kg						**95% CI**		***Percentile***				

<0.750	70	1,739	26	7,807	3.3	2.2	4.9	0.0	0.0	0.0	0.0	14.2
0.750-1.000	70	2,442	62	12,582	4.9	3.8	6.3	0.0	0.0	0.0	0.0	24.3
1.001-1.500	70	10,223	298	22,650	13.2	11.7	14.7	0.0	0.0	0.0	16.3	48.8
1.501-2.500	70	9,492	114	17,728	6.4	5.3	7.7	0.0	0.0	0.0	0.0	30.4
>2.500	70	9,981	112	20,534	5.5	4.5	6.6	0.0	0.0	0.0	0.0	25.6
Pooled (NICUs)	70	33,877	612	81,301	7.5	6.9	8.1	0.0	0.0	0.0	2.1	31.2
Urinary catheter-associated UTI rate								***Percentile***				
Type of ICU	**Nº of ICUs**	**No of patients**	**No. of CAUTIs**	**Urinary catheter days**	**Pooled mean**	**95% CI**		**10%**	**25%**	**50% (median)**	**75%**	**90%**
Surgical cardiothoracic	21	22,979	148	65,836	2.2	1.9	2.6	0.0	0.0	0.3	2.4	6.2
Medical Cardiac	40	44,526	344	79,539	4.3	3.8	4.8	0.0	0.0	1.0	4.4	8.5
Medical	72	38,313	729	165,930	4.4	4.1	4.7	0.0	0.0	1.1	7.2	16.1
Medical/Surgical	185	304,958	6,527	1,274,202	5.1	5.0	5.2	0.0	1.0	3.0	7.0	15.1
Neuro Surgical	20	15,949	337	73,508	4.6	4.1	5.1	0.0	1.0	2.8	11.3	16.9
Neurologic	7	1,901	56	9,395	6.0	4.5	7.7	0.0	0.0	1.4	3.3	-
Oncology	3	832	9	3,441	2.6	1.2	5.0	0.7	0.7	9.4	-	-
Pediatric	57	27,486	425	80,782	5.3	4.8	5.8	0.0	0.0	0.0	5.1	20.5
Respiratory	6	2,139	155	23,132	6.7	5.7	7.8	0.0	3.2	6.1	11.2	-
Surgical	37	29,654	329	94,577	3.5	3.1	3.9	0.0	0.0	3.2	9.1	47.3
Trauma	7	10,260	153	43,622	3.5	3.0	4.1	0.0	0.0	3.3	6.9	-
Pooled (Adult and Pediatric ICUs)	455	498,997	9,212	1,913,964	4.8	4.7	4.9	0.0	0.0	2.4	6.5	14.7

ICU, intensive care unit; NICU, Neonatal intensive care unit; CLABSI, central-line associated bloodstream infection; CL, central line; BSI, bloodstream infection; VAP, ventilator-associated pneumonia; PNEU, pneumonia, CAUTI, catheter-associated urinary tract infection; DA, device-associated; CI, confidence interval.

***** *Percentile distribution comparisons were made with a minimum of 20 locations contributing to the strata*

Table 4.
International Nosocomial Infection Control Consortium report, data summary of 45 countries for 2012-2017.
Pooled means, 95% confidence intervals and key percentiles of the distribution of central line utilization ratios, and ventilator utilization ratios by type of location, in adult, pediatric, and neonatal intensive care units, and of urinary catheter utilization ratios, by type of location, in adult and pediatric intensive care units, DA module, 2012-2017

Central line utilization ratio							***Percentile***				
Type of ICU	**Nº of ICUs**	**Central line days**	**Patient days**	**Pooled mean**	**95% CI**		**10%**	**25%**	**50% (median)**	**75%**	**90%**
Surgical cardiothoracic	21	76,729	76,336	1.01	0.9	1.01	0.3	0.7	0.9	1.2	1.5
Medical Cardiac	40	86,395	355,575	0.24	0.24	0.24	0.1	0.2	0.3	0.6	0.8
Medical	72	143,716	374,411	0.38	0.38	0.39	0.1	0.3	0.5	0.7	0.9
Medical/Surgical	185	1,216,897	1,870,390	0.65	0.65	0.65	0.2	0.3	0.6	0.9	1.1
Neuro Surgical	20	44,466	89,881	0.49	0.49	0.50	0.1	0.2	0.4	0.7	0.8
Neurologic	7	5,883	12,925	0.46	0.44	0.47	0.0	0.2	0.5	0.7	-
Oncology	3	2,998	4,328	0.69	0.67	0.72	0.6	0.6	0.9	-	-
Pediatric	57	135,543	210,935	0.64	0.64	0.65	0.0	0.2	0.4	0.8	1.1
Respiratory	6	21,843	27,624	0.79	0.78	0.80	0.3	0.6	0.8	1.2	-
Surgical	37	81,013	118,523	0.68	0.68	0.69	0.2	0.4	0.6	0.8	1.0
Trauma	7	27,614	55,548	0.50	0.49	0.50	0.2	0.2	0.5	0.6	-
Pooled (Adult and Pediatric ICUs)	455	1,843,097	3,196,476	0.58	0.57	0.58	0.1	0.3	0.5	0.8	1.1
NICU, Birth-weight category, Kg							***Percentile***				
< 750gr	70	16435	7468	0.45	0.44	0.46	0.0	0.1	0.44	0.77	1.0
751 - 1000gr	70	39578	17553	0.44	0.43	0.45	0.0	0.14	0.43	0.74	1.0
1001 - 1500gr	70	111732	36978	0.33	0.32	0.33	0.0	0.03	0.24	0.53	0.77
1501 - 2500gr	70	97378	20310	0.21	0.21	0.21	0.0	0.0	0.09	0.28	0.5
> 2500gr	70	89084	19376	0.22	0.21	0.22	0.0	0.0	0.11	0.29	0.46
Pooled (NICUs)	70	354207	101685	0.29	0.29	0.29	0.0	0.02	0.2	0.49	0.77
Mechanical ventilator utilization ratio							***Percentile***				
Type of ICU	**Nº of ICUs**	**Ventilator days**	**Patient days**	**Pooled mean**	**95% CI**		**10%**	**25%**	**50% (median)**	**75%**	**90%**
Surgical cardiothoracic	21	39,073	76,336	0.51	0.51	0.52	0.05	0.20	0.33	0.42	0.65
Medical Cardiac	40	41,409	355,575	0.12	0.12	0.12	0.06	0.07	0.16	0.29	0.46
Medical	72	93,867	374,411	0.25	0.25	0.25	0.07	0.15	0.35	0.49	0.68
Medical/Surgical	185	771,025	1,870,390	0.41	0.41	0.41	0.11	0.23	0.39	0.60	0.74
Neuro Surgical	20	32,987	89,881	0.37	0.36	0.37	0.11	0.24	0.32	0.51	0.83
Neurologic	7	2,243	12,925	0.17	0.17	0.18	0.09	0.16	0.26	0.40	-
Oncology	3	1,574	4,328	0.36	0.35	0.38	0.0	0.0	0.32	-	-
Pediatric	57	114,845	210,935	0.54	0.54	0.55	0.15	0.32	0.45	0.55	0.67
Respiratory	6	19,356	27,624	0.70	0.69	0.71	0.18	0.34	0.68	0.79	0.92
Surgical	37	41,767	118,523	0.35	0.35	0.36	0.03	0.08	0.25	0.52	0.68
Trauma	7	35,460	55,548	0.64	0.63	0.65	0.06	0.08	0.25	0.57	-
Pooled (Adult and Pediatric ICUs)	455	1,193,606	3,196,476	0.37	0.37	0.37	0.07	0.18	0.36	0.53	0.70
NICU. Birth-weight category, Kg							***Percentile***				
<0.750	70	16435	7807	0.48	0.46	0.49	0.05	0.33	0.59	0.88	1.0
0.750-1.000	70	39578	12582	0.32	0.31	0.32	0.0	0.13	0.32	0.54	0.89

1.001-1.500	70	111732	22650	0.20	0.20	0.21	0.0	0.02	0.11	0.31	0.53
1.501-2.500	70	97378	17728	0.18	0.18	0.18	0.0	0.03	0.08	0.20	0.38
>2.500	70	89084	20534	0.23	0.23	0.23	0.0	0.04	0.14	0.8	0.46
Pooled (NICUs)	70	354207	81301	0.23	0.23	0.23	0.0	0.01	0.15	0.38	0.64
Urinary catheter utilization ratio							***Percentile***				
Type of ICU	**Nº of ICUs**	**Urinary catheter days**	**Patient days**	**Pooled mean**	**95% CI**		**10%**	**25%**	**50% (median)**	**75%**	**90%**
Surgical cardiothoracic	21	65,836	76,336	0.86	0.86	0.86	0.18	0.43	0.69	0.90	0.99
Medical Cardiac	40	79,539	355,575	0.22	0.22	0.23	0.28	0.49	0.84	0.95	1.0
Medical	72	165,93	374,411	0.44	0.44	0.44	0.11	0.26	0.43	0.63	0.85
Medical/Surgical	185	1,274,202	1,870,390	0.68	0.68	0.68	0.23	0.44	0.71	0.87	0.99
Neuro Surgical	20	73,508	89,881	0.82	0.82	0.82	0.28	0.54	0.75	0.92	0.99
Neurologic	7	9,395	12,925	0.73	0.72	0.73	0.04	0.39	0.85	0.93	-
Oncology	3	3,441	4,328	0.80	0.78	0.81	0.07	0.07	0.81	-	-
Pediatric	57	80,782	210,935	0.38	0.38	0.39	0.03	0.17	0.34	0.49	0.76
Respiratory	6	23,132	27,624	0.84	0.83	0.84	0.71	0.88	0.99	1.0	-
Surgical	37	94,577	118,523	0.80	0.80	0.80	0.24	0.55	0.78	0.94	1.0
Trauma	7	43,622	55,548	0.79	0.78	0.79	0.24	0.30	0.80	0.93	--
Pooled (Adult and Pediatric ICUs)	455	1,913,964	3,196,476	0.60	0.60	0.60	0.18	0.43	0.69	0.90	0.99

ICU, intensive care unit; NICU, Neonatal intensive care unit; CI, confidence interval.

Table 5.
International Nosocomial Infection Control Consortium report, data summary of 45 countries for 2012-2017.
Comparison of device-associated healthcare-associated infection rates, per 1000 device-days in the intensive care units of the INICC (2012- 2017) and the U.S. National Healthcare Safety Network (2012)

	CLABSI rate		VAP rate		CAUTI rate	
ICU, type	**INICC 2012–2017 Pooled Mean (95% CI)**	**U.S. NHSN 2013 Pooled Mean (95% CI)**	**INICC 2012–2017 Pooled Mean (95% CI)**	**U.S. NHSN 2012* / 2013** Pooled Mean (95% CI)**	**INICC 2012–2017 Pooled Mean (95% CI)**	**U.S. NHSN 2013 Pooled Mean (95% CI)**
Surgical cardiothoracic	2.20 (1.8-2.6)	0.8 (0.8-0.9)	7.4 (6.5-8.3)	1.7 (1.5-1.9)	2.2 (1.9-2.6)	1.8 (1.7-1.9)
Medical Cardiac	5.08 (4.6-5.6)	1.0 (0.9-1.1)	17.7 (16.5-19.1)	1.0 (0.8-1.1)	4.3 (3.8-4.8)	2.3 (2.2-2.4)
Medical	4.47 (4.1-4.8)	1.1 (1.0-1.2)	12.7 (12.0-13.4)	0.9 (0.8-1.1)	4.4 (4.1-4.7)	2.0 (1.9-2.1)
Medical/Surgical	5.05(4.9-5.2)	0.8 (0.8-0.9)	14.1 (13.8-14.4)	0.9 (0.8-1.0)	5.1 (5.0-5.2)	1.7 (1.6-1.8)
Neuro Surgical	4.43 (3.8-5.1)	0.9 (0.8-1.1)	13.6 (12.4-15.0)	2.1 (1.9-2.5)	4.6 (4.1-5.1)	5.3 (5.1-5.5)
Neurologic	2.55 (1.4-4.2)	1.1 (0.9-1.4)	13.8 (9.4-19.6)	3.0 (2.3-3.8)	6.0 (4.5-7.7)	4.5 (4.1-4.9)
Oncology	14.68 (10.7-19.7)		8.3 (4.4-14.1)		2.6 (1.2-5.0)	
Pediatric	7.19 (6.7-7.7)	1.2 (1.1-1.3)	11.8 (11.2-12.5)	0.7 (0.6-0.8)	5.3 (4.8-5.8)	2.5 (2.2-2.7)
Respiratory	2.47 (1.9-3.2)	1.0 (0.5-1.9)	10.7 (9.3-12.3)	0.7 (0.2-1.7)	6.7 (5.7-7.8)	2.1 (1.5-3.0)
Surgical	5.23(4.7-5.6)	0.9 (0.8-1.0)	13.6 (12.5-14.7)	2.0 (1.7-2.3)	3.5 (3.1-3.9)	2.0 (1.9-2.2)
Trauma	5.47 (4.6-6.4)	1.4 (1.3-1.6)	10.7 (9.3-12.3)	3.6 (3.3-3.9)	3.5 (3.0-4.1)	4.3 (4.1-4.5)
NICU. Birth-weight category, Kg						
< 750gr	18.3 (15.4-21.7)	2.1 (1.9-2.3)	3.3 (2.2-4.9)	1.0 (0.8-1.3)	--	--
751 - 1000gr	14.5 (12.8-16.4)	1.3 (1.2-1.5)	4.9 (3.8-6.3)	1.1 (0.8-1.6)	--	--
1001 - 1500gr	15.3 (14.1-16.6)	0.8 (0.7-0.9)	13.2 (11.7-14.7)	0.7 (0.3-1.2)	--	--
1501 - 2500gr	7.7 (6.5-9.0)	0.6 (0.5-0.7)	6.4 (5.3-7.7)	0.5 (0.2-1.1)	--	--
> 2500gr	9.3(8.0-10.8)	0.7 (0.6-0.9)	5.5 (4.5-6.6)	0.1 (0.0-0.4)	--	--

ICU, intensive care unit; CI, Confidence interval; NICU, neonatal intensive care unit; CLABSI, central line-associated bloodstream infection; CAUTI, catheter-associated urinary tract infection; VAP, ventilator-associated pneumonia; INICC, INICC; NHSN, National Healthcare Safety Network; INICC, International Nosocomial Infection Control Consortium.
*To compare VAP rates for adult ICUs we use US NSHN report with data of 2012
**To compare VAP rates for pediatric ICU and NICU we use US NSHN report with data of 2013

Table 6.
International Nosocomial Infection Control Consortium report, data summary of 45 countries for 2012-2017.
Antimicrobial resistance rates in the intensive care units of the INICC, and comparison of antimicrobial resistance rates (%) in the intensive care units of the INICC and the U.S. National Healthcare Safety Network

	No. of pathogenic isolated tested at INICC ICUs, pooled	*Resistance percentage at INICC ICUs, %*	*No. of pathogenic isolated tested at INICC ICUs, pooled*	*Resistance percentage at INICC ICUs, %*	*No. of pathogenic isolated tested at INICC ICUs, pooled*	*Resistance percentage at INICC ICUs, %*	*Resistance percentage at CDC NSHN ICUs, %*
Pathogen, antimicrobial	**(VAP)**	**(VAP)**	**(CAUTI)**	**(CAUTI)**	**(CLABSI)**	**(CLABSI)**	**(CLABSI)**
Staphylococcus aureus							
OXA	141	41.8	7	57.1	51	64.7	50.7
Enterococcus faecalis							
VAN	12	16.7	54	5.6	27	18.5	9.8
Pseudomonas aeruginosa							
FQs	436	34.6	87	40.2	110	20.0	30.2
PIP or TZP	367	39.2	68	38.2	91	33.0	18.4
Escherichia Coli							
FQs	108	53.7	269	55.0	81	49.38	49.3

CLABSI, central line-associated bloodstream infection; VAP, ventilator-associated pneumonia; CAUTI, catheter-associated urinary tract infection; FQs, fluoroquinolones (ciprofloxacin, levofloxacin, moxifloxacin, or ofloxacin); OXA, oxacillin; PIP, piperacillin; TZP, piperacillin-tazobactam; VAN, vancomycin; INICC, International Nosocomial Infection Control Consortium.

Table 7.
Short-term peripheral venous catheters-related bloodstream infection rates per 1,000 peripheral venous catheters -Days. Reported by Hospitals from Economies Defined as Low-, or Lower-Middle, or Upper-Middle Income by the World Bank

Country	ICU Type	Number of patients	PVC-BSI per 1,000 CL-days	Year of publication	Reference
INICC Report 2020- with pooled data of 42 countries.*	Adult	149,609	2.41	2020	[111]
INICC Report 2020- with pooled data of 8 countries of Asia.*	Adult	83,295	2.65	2020	[112]
INICC Report 2020- with pooled data of 14 countries of Middle East.*	Adult	31,083	2.32	2020	[113]
INICC Report 2020- with pooled data of 19 cities of India.*	Adult	7,513	2.91	2020	[114]

*Scientific research conducted by INICC members, using INICC software, and published by INICC Team.

ICU, Intensive care unit; PVC-BSI PICU, peripheral venous catheters-related bloodstream infection; INICC, International Nosocomial Infection Control Consortium.

- INICC Report 2020- with pooled data of 42 countries: 727 intensive care units of 268 hospitals in 141 cities of 42 countries of Africa, the Americas, Eastern Mediterranean, Europe, South East Asia, and Western Pacific Regions.
- INICC Report 2020- with pooled data of 8 countries of Asia: 262 intensive care units, from 78 hospitals in 32 cities of 8 countries in the South-East Asia Region: China, India, Malaysia, Mongolia, Nepal, Philippines, Thailand, and Vietnam.
- INICC Report 2020- with pooled data of 14 countries of Middle East: 246 intensive care units (ICUs), , from 83 hospitals in 52 cities of 14 countries in the Middle East (Bahrain, Egypt, Iran, Jordan, Kingdom of Saudi Arabia, Kuwait, Lebanon, Morocco, Pakistan, Palestine, Sudan, Tunisia, Turkey, and United Arab Emirates.
- INICC Report 2020- with pooled data of 19 cities of India 204 intensive care units, from 57 hospitals in 19 cities of India.

Table 8.
Surgical Site Infection Rates per Procedure Reported by Hospitals from Economies Defined as Low-, Lower-Middle, and Upper-Middle Income by the World Bank.

Country	Pooled SSI rate (%)	Year of publication	Reference
Africa (Sub-Sahara)	23.6	2009	[346]
Bolivia	12	2003	[347]
Brazil	23.6	2004	[348]
Brazil	11	2006	[349]
Brazil	24.5	2006	[350]
Brazil	10.3	2010	[351]
Brazil.*	0.6	2015	[352]
Burkina Faso	23.4	2011	[353]
Colombia.*	3.8	2014	[221]
Columbia	2.6	2003	[354]
Cote d'Ivoire	13.2	2009	[355]
Ethiopia	11.4	2012	[356]
Georgia (Republic of)	14.6	2007	[357]
India	18.86	2003	[358]
India.*	4.2	2014	[359]
Kosovo	12	2008	[360]
Mexico.*	5.5	2014	[220]
Morocco	5.2	2005	[361]
Nepal	7.3	2008	[362]
Nigeria	17.4	2011	[363]
Pakistan	13	2008	[364]
Peru.*	2.5	2015	[365]
Russian Federation	9.5	2007	[366]
Tanzania	24.0	2006	[367]
Tanzania	26.0	2011	[368]
Tanzania	19.4	2011	[369]
Thailand	2.7	1995	[370]
Thailand	9.1	2005	[371]

Thailand	1.4	2009	[372]
Thailand	1.2	2009	[372]
Turkey	6.2	2005	[373]
Turkey.*	4.3	2015	[374]
Vietnam.*	5.5	2016	[375]
INICC Report. Pooled data of 30 countries.*	2.9	2013	[68]

*Scientific research conducted by INICC members, using INICC software, and published by INICC Team.
SSI, Surgical Site Infection; RR, relative risk; CI, confidence interval.

- INICC Report 2013- with pooled data of 30 countries: Argentina, Brazil, Colombia, Cuba, Dominican Republic, Egypt, Greece, India, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Salvador, Saudi Arabia, Serbia, Singapore, Slovakia, Sudan, Thailand, Turkey, Uruguay, and Vietnam).*

Table 9.
Surgical site infections, International Nosocomial Infection Control Consortium report, data summary of 30 countries, 2005-2010.
Features of the participating International Nosocomial Infection Control Consortium hospitals, 2005-2010

	Latin America	***Asia***	***Africa***	***Europe***	***All***
Countries, name	Argentina, Brazil, Colombia, Cuba, Dominican Republic, Mexico, Panama, Peru, El Salvador, Uruguay	India, Lebanon, Malaysia, Pakistan, Philippines, Saudi Arabia, Singapore, Thailand, Vietnam	Egypt, Morocco, Sudan	Greece, Kosovo, Lithuania, Macedonia, Poland, Serbia, Slovakia, Turkey	-
Countries, n	10	9	3	8	30
Cities, n	23	17	3	23	66
Hospitals, n	28	22	5	27	82
Academic teaching, n, (%)	9 (32%)	10 (45%)	4 (80%)	22 (81%)	47 (55%)
Public, n, (%)	9 (32%)	4 (18%)	0 (0%)	3 (11%)	16 (20%)
Private community, n, (%)	10 (36%)	8 (36%)	1 (20%)	2 (7%)	21 (25%)
Surgical procedures, n	124,099	68,415	5,706	62,753	260,973
Surgical site infections, n	2,047	2,580	181	2,715	7,523

Table 10.
Surgical site infections, International Nosocomial Infection Control Consortium report, data summary of 30 countries, 2005-2010.
Surgical Site infections of the participating International Nosocomial Infection Control Consortium hospitals, 2005-2010

CODE	Procedure name	Procedures, n	INICC SSI, n	INICC SSI rate, %	No. of hospitals	10th PCT	25th PCT	50th PCT	75th PCT	90th PCT
AAA	Abdominal aortic aneurysm repair	13	1	7,7%	1	-	-	-	-	-
AMP	Limb amputation	4040	111	2,7%	14	-	-	-	-	-
APPY	Appendix Surgery	13668	395	2,9%	21	0.12	1.5	2.0	5.3	8.2
BILI	Bile duct, liver or pancreatic surgery	1262	116	9,2%	13	-	-	-	-	-
BRST	Breast surgery	4148	72	1,7%	12	-	-	-	-	-

CBGB	Coronary bypass with chest and donor incision	36057	1615	4,5%	35	0.0	1.0	3.2	71	10.8
CARD	Cardiac Surgery	14070	781	5,6%	21	0.0	1.2	2.8	6.6	18.9
CHOL	Gallbladder surgery	9980	247	2,5%	21	0.0	0.0	1.4	3.8	5.7
COLO	Colon surgery	4285	402	9,4%	15	-	-	-	-	-
CRAN	Craniotomy	12501	551	4,4%	32	0.0	0.7	3.0	6.0	9.0
CSEC	Cesarean section	85254	606	0,7%	18	-	-	-	-	-
FUSN	Spinal fusion	990	32	3,2%	9	-	-	-	-	-
FX	Open reduction of fracture	6642	281	4,2%	15	-	-	-	-	-
GAST	Gastric surgery	1221	67	5,5%	8	-	-	-	-	-
HER	Herniorrhaphy	9843	173	1,8%	25	0.0	0.5	12.3	3.1	4.9
HPRO	Hip prosthesis	8607	225	2,6%	38	0.0	0.2	2.1	4.5	5.9
HYST	Abdominal hysterectomy	3875	106	2,7%	20	0.0	0.0	2.1	4.9	10.5
KPRO	Knee prosthesis	9299	153	1,6%	28	0.0	2.4	1.2	4.1	10.3
LAM	Laminectomy	5352	91	1,7%	17	-	-	-	-	-
NECK	Neck surgery	695	26	3,7%	11	-	-	-	-	-
NEPH	Kidney surgery	1575	49	3,1%	15	-	-	-	-	-
PRST	Prostate surgery	2221	47	2,1%	15	-	-	-	-	-
PVBY	Peripheral vascular bypass surgery	2184	54	2,5%	7	-	-	-	-	-
REC	Rectal surgery	385	9	2,3%	2	-	-	-	-	-
SB	Small bowel surgery	1921	106	5,5%	15	-	-	-	-	-
SPLE	Spleen surgery	287	16	5,6%	13	-	-	-	-	-
THOR	Thoracic surgery	7880	482	6,1%	16	-	-	-	-	-
THYR	Thyroid and/or parathyroid surgery	307	1	0,3%	4	-	-	-	-	-
VHYS	Vaginal hysterectomy	1584	31	2,0%	10	-	-	-	-	-
VSHN	Ventricular shunt	2623	338	12,9%	18	-	-	-	-	-
XLAP	Exploratory abdominal surgery	8204	339	4,1%	23	0.0	2.2	4.0	6.8	15.7
All		260973	7523	2.9%						

INICC, International Nosocomial Infection Control Consortium; SSI, Surgical Site Infection. PCT, percentile

Table 11.
Surgical site infections, International Nosocomial Infection Control Consortium report, data summary of 30 countries, 2005-2010. Comparison of Surgical Site Infection rates, in the hospitals of the INICC and the U.S. National Healthcare Safety Network.

CODE	Procedure name	INICC 2005-2010, SSI rate, %	CDC- NHSN 2006-2008 SSI rate (pooled risk categories)	RR	95% CI	P value
AAA	Abdominal aortic aneurysm repair	7.7%	3.2%	2.41	0.33- 17.40	0.3668
AMP	Limb amputation	2.7%	2.3%	1.18	0.80 - 1.74	0.4099
APPY	Appendix Surgery	2.9%	1.4%	2.05	1.61 - 2.59	0.0001
BILI	Bile duct, liver or pancreatic surgery	9.2%	9.9%	0.93	0.70 - 1.22	0.5945
BRST	Breast surgery	1.7%	2.3%	0.77	0.55 - 1.06	0.1111
CBGB	Coronary bypass with chest and donor incision	4.5%	2.9%	1.52	1.44 - 1.61	0.0001
CARD	Cardiac Surgery	5.6%	1.3%	4.32	3.81 - 4.88	0.0001
CHOL	Gallbladder surgery	2.5%	0.6%	3.94	3.10 - 5.01	0.0001
COLO	Colon surgery	9.4%	5.6%	1.69	1.52 - 1.87	0.0001
CRAN	Craniotomy	4.4%	2.6%	1.69	1.46 - 1.96	0.0001
CSEC	Cesarean section	0.7%	1.8%	0.39	0.34 - 0.43	0.0001

FUSN	Spinal fusion	3.2%	1.5%	2.10	1.48 - 3.00	0.0001
FX	Open reduction of fracture	4.2%	1.7%	2.44	2.02 - 2.93	0.0001
GAST	Gastric surgery	5.5%	2.3%	2.41	1.82 - 3.19	0.0001
HER	Herniorrhaphy	1.8%	2.3%	0.78	0.63 - 0.96	0.0197
HPRO	Hip prosthesis	2.6%	1.3%	2.06	1.80 - 2.37	0.0001
HYST	Abdominal hysterectomy	2.7%	1.6%	1.66	1.36 - 2.03	0.0001
KPRO	Knee prosthesis	1.6%	0.9%	1.84	1.56 - 2.18	0.0001
LAM	Laminectomy	1.7%	1.0%	1.67	1.33 - 2.09	0.0001
NECK	Neck surgery	3.7%	3.5%	1.07	0.60 - 1.91	0.8116
NEPH	Kidney surgery	3.1%	1.5%	2.12	1.07 - 4.18	0.0267
PRST	Prostate surgery	2.1%	1.2%	1.82	0.97 - 3.43	0.0598
PVBY	Peripheral vascular bypass surgery	2.5%	6.7%	0.37	0.28 - 0.49	0.0001
REC	Rectal surgery	2.3%	7.4%	0.32	0.16 - 0.63	0.0005
SB	Small bowel surgery	5.5%	6.1%	0.91	0.72 - 1.14	0.3937
SPLE	Spleen surgery	5.6%	2.3%	2.39	0.93 - 6.10	0.0606
THOR	Thoracic surgery	6.1%	1.1%	5.50	3.59 - 8.44	0.0001
THYR	Thyroid and/or parathyroid surgery	0.3%	0.3%	1.27	0.13 -12.19	0.8366
VHYS	Vaginal hysterectomy	2.0%	0.9%	2.24	1.52 - 3.28	0.0002
VSHN	Ventricular shunt	12.9%	5.6%	2.30	1.96 - 2.69	0.0001
XLAP	Exploratory abdominal surgery	4.1%	2.0%	2.05	1.64 - 2.55	0.0001
All		2.9%	2.0%	1.45		

RR, relative risk; CI, confidence interval; INICC, INICC; SSI, Surgical Site Infection; CDC, Centers for Diseases Control and Prevention; NHSN, National Healthcare Safety Network; INICC, International Nosocomial Infection Control Consortium.

Table 12,
Crude length of stay of intensive care unit patients with device-associated health care-associated infections, adult, pediatric intensive care units combined, and infants in neonatal intensive care units.
Reported by Hospitals from Economies Defined as Low-, or Lower-Middle, or Upper-Middle Income by the World Bank.

Country	ICU	Pooled average LOS, without DA-HAI, days	Pooled average LOS, with CLABSI, days	Pooled average LOS, with VAP, days	Pooled average LOS, with CAUTI, days	Year of publication	Reference
Argentina.*	Adult	12,14	26,08	22,14	17,5	2003	[120]
Brazil.*	Adult	5,7	13	16,8	14,1	2008	[225]
China.*	Adult	3	18	23,5	30	2012	[294]
Costa Rica.*	Adult	2,8	11,2	13,6	-	2016	[66]
Cuba.*	Adult	4,9	23,3	23,8	-	2011	[66]
Ecuador.*	Adult	5.3	12.7	10.1	14.5	2017	[67]
El Salvador.*	PICU	6.2	19.1	18.6	13.5	2011	[70]
El Salvador.*	NICU	16.7	37.7	42.3	-	2011	[70]
India.*	Adult	4,4	9,4	15,3	12,4	2007	[71]
India.*	Adult	4,6	14,1	13,6	14,6	2014	[71]
Iran.*	Adult	4,8	28,3	25,5	12,9	2015	[210]
Kuwait.*	Adult	5,2	19,9	22,2	19,2	2016	[197]
Kuwait.*	NICU	8.7	35.8	33.5	-	2006	[197]
Lebanon.*	Adult	7,4	13,8	18,8	15,8	2012	[75]
Malaysia.*	Adult	4,8	11,2	17,1	5,2	2016	[78]
Mongolia.*	Adult	4,03	15,15	7,81	8,17	2016	[295]
Morocco.*	Adult	5,1	9	10,6	13,7	2008	[226]
Peru.*	Adult	4	13,1	13,4	10,8	2008	[82]
Philippines.*	Adult	4.3	16.2	12.4	11.9	2011	[227]
Philippines.*	PICU	5.6	17	10.7	-	2011	[227]
Philippines.*	NICU	12.6	28	-	-	2011	[227]
Poland.*	Adult	6.9	10	15.5	15	2011	[121]
Saudi Arabia.*	Adult	5,4	20,2	17,5	27,6	2017	[198]
Turkey.*	Adult	7.9	19.4	16.6	18	2014	[376]
Turkey.*	NICU	8.9	22.1	25.1	-	2014	[376]

Venezuela.*	Adult	3.8	11.8	13.4	9.5	2017	[90]
Vietnam.*	Adult	7.3	8.9	13.2	17.6	2018	[296]
Vietnam.*	NICU	5	36.7	35.7	-	2018	[296]
INICC Report 2010- with pooled data of 25 countries.*	Adult	5	17.14	15.58	14.51	2010	[110]
INICC Report 2010- with pooled data of 25 countries.*	NICU	11.12	33.3	27.3	-	2010	[110]
INICC Report 2012- with pooled data of 36 countries.*	Adult	6.2	17.1	18	18.5	2012	[117]
INICC Report 2012- with pooled data of 36 countries.*	NICU	10.9	30.3	34.0	-	2012	[117]
INICC Report 2014- with pooled data of 43 countries.*	Adult	6.1	19.47	19.66	20.29	2014	[97]
INICC Report 2014- with pooled data of 43 countries.*	NICU	10.75	23.22	35.83	-	2014	[97]
INICC Report 2016- with pooled data of 50 countries.*	Adult	7.08	17.36	16.98	10.3	2016	[196]
INICC Report 2016- with pooled data of 50 countries.*	NICU	17.46	37.82	36.16	-	2016	[196]
INICC Report 2019- with pooled data of 45 countries.*	Adult	8.16	17.6	17.6	17.7	2019	[99]
INICC Report 2019- with pooled data of 45 countries.*	NICU	13.1	40	43.6	-	2019	[99]

*Scientific research conducted by INICC members, using INICC software, and published by INICC Team.

LOS, Length of stay; DA-HAI, device-associated healthcare-associated infection; CLABSI, central line-associated bloodstream infection; CAUTI, catheter-associated urinary tract infection; VAP, ventilator-associated pneumonia; Pediatric intensive care unit; NICU, neonatal intensive care unit; INICC, International Nosocomial Infection Control Consortium.

- INICC Report 2010- with pooled data of 25 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Thailand, Tunisia, Turkey, Venezuela, Vietnam.
- INICC Report 2012- with pooled data of 36 countries: Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Puerto Rico, Republic of Singapore, Saudi Arabia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Vietnam.
- INICC Report 2014- with pooled data of 43 countries: Argentina, Bolivia, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Puerto Rico, Republic of Singapore, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.
- INICC Report 2016- with pooled data of 50 countries: Argentina, Bahrain, Bolivia, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Indonesia, Iran, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Puerto Rico, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Uruguay, Venezuela, Vietnam.
- INICC Report 2019- with pooled data of 45 countries: Argentina, Bahrain, Brazil, Bulgaria, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Palestine, Panama, Papua New Guinea, Peru, Philippines, Poland, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.

Table 13.
Crude mortality of intensive care unit patients with device-associated health care-associated infections, adult, pediatric intensive care units combined, and infants in neonatal intensive care units.
Reported by Hospitals from Economies Defined as Low-, or Lower-Middle, or Upper-Middle Income by the World Bank

Country	ICU	Pooled average mortality, without DA-HAI, (%)	Pooled average mortality, with CLABSI, (%)	Pooled average mortality, with VAP, (%)	Pooled average mortality, with CAUTI, (%)	Year of publication	Reference
Argentina.*	Adult	37,2	62,5	71,4	42,9	2003	[120]
Brazil.*	Adult	19,3	47,1	34,5	30	2008	[225]
China.*	Adult	4	18	26	47	2012	[294]
Colombia.*	Adult	18,1	36,6	35	28,6	2006	[61]
Costa Rica.*	Adult	3,8	0	29,4	-	2016	[66]
Cuba.*	Adult	33	50	80	-	2011	[66]
Ecuador.*	Adult	15.8	46.7	30.2	33.3	2017	[70]
El Salvador.*	PICU	13.6	25	19	18.2	2011	[67]
El Salvador.*	NICU	12.3	38	23	-	2011	[67]
India.*	Adult	6,6	10,6	25,6	18,2	2007	[71]
India.*	Adult	6,9	23,2	29,6	23,5	2014	[71]
Kuwait.*	Adult	7,4	27,3	38,2	18,5	2016	[377]
Kuwait.*	NICU	7.9	38.9	-	-	2016	[377]
Lebanon.*	Adult	19,1	60	15	12,5	2012	[75]
Malaysia.*	Adult	7,8	60,9	22,6	40,0	2016	[78]
Mongolia.*	Adult	19,9	38,46	37	25	2016	[295]
Morocco.*	Adult	24,9	100	81,6	43,6	2008	[226]
Peru.*	Adult	14	29	38,5	18,2	2008	[82]
Philippines.*	Adult	6.8	10	9.7	3.8	2011	[227]
Philippines.*	PICU	3.8	50	-	-	2011	[227]
Philippines.*	NICU	5.6	25	-	-	2011	[227]
Saudi Arabia.*	Adult	17,7	56,1	49,5	36,7	2017	[198]
Turkey.*	Adult	25.2	37.3	35.7	44.6	2007	[122]
Turkey.*	Adult	3.5	18.9	14	-	2014	[376]
Venezuela.*	Adult	8.1	11.1	12.5	25	2017	[90]
Vietnam.*	Adult	17.5	21.4	36.5	-	2018	[296]
Vietnam.*	NICU	15.8	33.3	38.9	-	2018	[296]
INICC Report 2008-with pooled data of 18 countries.*	Adult	15.3	29.6	42.8	35.8	2008	[195]
INICC Report 2008-with pooled data of 18 countries.*	NICU	14.3	39.7	46.5	-	2008	[195]
INICC Report 2010-with pooled data of 25 countries.*	Adult	14.4	38.1	43.7	32.9	2010	[110]
INICC Report 2010-with pooled data of 25 countries.*	NICU	8.8	34.5	27.1	-	2010	[110]
INICC Report 2012-with pooled data of 36 countries.*	Adult	10	24.7	25.2	17.3	2012	[117]
INICC Report 2012-with pooled data of 36 countries.*	NICU	9.1	35.3	24	-	2012	[117]
INICC Report 2014-with pooled data of 43 countries.*	Adult	7.9	24.9	23.4	13.3	2014	[97]

INICC Report 2014- with pooled data of 43 countries.*	NICU	6.2	17.6	19.7	-	2014	[97]
INICC Report 2016- with pooled data of 50 countries .*	Adult	14.7	38.4	35.9	25.4	2016	[196]
INICC Report 2016- with pooled data of 50 countries .*	NICU	19	29.7	28.4	-	2016	[196]
INICC Report 2019- with pooled data of 45 countries.*	Adult	13.5	41.6	36.6	26	2019	[99]
INICC Report 2019- with pooled data of 45 countries.*	NICU	9.5	32	25.8	-	2019	[99]

*Scientific research conducted by INICC members, using INICC software, and published by INICC Team.

DA-HAI, device-associated healthcare-associated infection; CLABSI, central line-associated bloodstream infection; CAUTI, catheter-associated urinary tract infection; VAP, ventilator-associated pneumonia; Pediatric intensive care unit; NICU, neonatal intensive care unit; INICC, International Nosocomial Infection Control Consortium.

- INICC Report 2008- with pooled data of 18 countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, India, Kosovo, Lebanon, Macedonia, Mexico, Morocco, Peru, Philippines, El Salvador, Turkey, Uruguay.
- INICC Report 2010- with pooled data of 25 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Thailand, Tunisia, Turkey, Venezuela, Vietnam.
- INICC Report 2012- with pooled data of 36 countries: Argentina, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Jordan, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Puerto Rico, Republic of Singapore, Saudi Arabia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, Uruguay, Venezuela, Vietnam.
- INICC Report 2014- with pooled data of 43 countries: Argentina, Bolivia, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, El Salvador, Greece, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Poland, Puerto Rico, Republic of Singapore, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.
- INICC Report 2016- with pooled data of 50 countries: Argentina, Bahrain, Bolivia, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Indonesia, Iran, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Panama, Papua New Guinea, Peru, Philippines, Poland, Puerto Rico, Romania, Russia, Saudi Arabia, Serbia, Singapore, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Uruguay, Venezuela, Vietnam.
- INICC Report 2019- with pooled data of 45 countries: Argentina, Bahrain, Brazil, Bulgaria, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Greece, Honduras, India, Iran, Jordan, Kingdom of Saudi Arabia, Kosovo, Kuwait, Lebanon, Lithuania, Macedonia, Malaysia, Mexico, Mongolia, Morocco, Nepal, Pakistan, Palestine, Panama, Papua New Guinea, Peru, Philippines, Poland, Romania, Russia, Serbia, Slovakia, Sri Lanka, Sudan, Thailand, Tunisia, Turkey, United Arab Emirates, Venezuela, Vietnam.

Table 14.
Extra Cost of Central Line–Associated Bloodstream Infection Reported by Hospitals from Economies Defined as Low-, Lower-Middle, and Upper-Middle Income by the World Bank.

Country	DA-HAI	Cost of controls (no HAI) (USD)	Cost of patient with CLA-BSI (USD)	Extra cost (USD)	Year of publication	Reference
Argentina.*	CLAB	7,971.74	3,083.32	4,888.42	2003	[115]
Mexico.*	CLAB	28,966.34	17,375.41	11,590.93	2007	[228]
Algeria	CLAB	—	—	1,315	2008	[378]
Argentina.*	VAP	4,946.46	2,693.58	2,252.88	2005	[118]

*Scientific research conducted by INICC members, using INICC software, and published by INICC Team.

DA-HAI, Device associated healthcare-associated infection; CLA-BSI, central line–associated bloodstream infection; VAP, ventilator-associated pneumonia; INICC, International Nosocomial Infection Control Consortium.

Table 15.
Results Reported by Programs to Improve Hand Hygiene Compliance Reported by Hospitals from Economies Defined as Low-, Lower-Middle, and Upper-Middle Income by the World Bank

Country	HH compliance, Baseline Rate, %	HH compliance, Intervention Rate, %	RR	95% CI	P Value	Year of publication	Reference
Argentina.*	17	44	2.65	2.33 - 3.02	< 0.001	2003	[201]
Argentina.*	41	68	1.66	1.45 - 1.90	0.0001	2004	[379]
Argentina.*	23.1	64.5	2.79	2.46 - 3.18	< 0.001	2005	[258]
Argentina.*	7.8	54.5	7.01	4.22 -11.67	0.0001	2006	[380]
Argentina.*	28.3	64.8	2.3	2.19 – 2.46	.0001	2015	[335]
Brazil.*	27	58	2.9	2.3 – 3.6	0.0001	2015	[381]
China	40	53	1.3			2004	[382]
China	51	80	1.57	73.2-87.8	0.004	2015	[334]
Colombia.*	50	77	1.55	1.43 – 1.68	0.0001	2013	[313]
El Salvador	33.8	40.5	1.19			2009	[383]
India.*	36.9	82	7.3	79.3 – 84.5	0.001	2014	[384]
Mali	8.0	21.8	2.75			2010	[385]
Mexico.*	28	84	3.03	2.35 - 3.90	< 0.001	2003	[386]
Mexico.*	21.16	56.3	2.66	2.11 - 3.36	0.0001	2005	[387]
Mexico.*	45	79	2.1	69.1 – 86.5	0.01	2014	[388]
Mexico.*	38.76	63.63	1.64	1.42 – 1.90	0.0000	2005	[389]
Mexico.*	35.8	75.8	2.11			2004	[390]
Mexico.*	46.3	67.7	1.46			2005	[391]
Mexico.*	46.35	69.71	1.50	1.31 – 1.72	0.0001	2005	[389]
Peru.*	82.2	90.2	1.10	1.01 – 1.19	0.0246	2006	[392]
Peru.*	20.0	64.3	3.21	1.61 – 6.40	0.0004	2006	[92]
Philippines.*	62%	88%	1.41	-	-	2010	[188]
Russia	44.2	48.0	1.08			2003	[393]
Turkey.*	35.16	55.4	1.58	1.27 – 1.96	0.0001	2005	[394]
Turkey.*	11.95	43.99	3.68	3.14 – 4.31	0.0001	2005	[309]
Turkey.*	27	58	2.9	2.3 – 3.6	0.0001	2014	[395]
Turkey.*	11.9	43.9	3.68			2005	[396]
INICC Report 2008- with pooled data of 12 countries.*	36.6	59.2	1.62	1.57-1.66	<0.01	2008	[397]
INICC Report 2008- with pooled data of 14 countries.*	35.1	60.7	1.73	1.68 - 1.78	<0.01	2008	[398]
INICC Report 2013- with pooled data of 19 countries.*	48.3	71.4	1.47	-	<0.01	2013	[288]

***Scientific research conducted by INICC members, using INICC software, and published by INICC Team.

HH, Hand hygiene; INICC, International Nosocomial Infection Control Consortium; RR, Relative Risk; CI, Confidence Interval.

- INICC Report 2008- with pooled data of 12 countries: Argentina, Brazil, Colombia, El Salvador, India, Macedonia, Mexico, Morocco, Pakistan, Peru, Philippines, and Turkey.
- INICC Report 2008- with pooled data of 14 countries: Argentina, Brazil, Colombia, Costa Rica, El Salvador, India, Kosova, Nigeria, Mexico, Morocco, Pakistan, Peru, Philippines, and Turkey.
- INICC Report 2013- with pooled data of 19 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, Greece, El Salvador, India, Lebanon, Lithuania, Macedonia, Mexico, Pakistan, Panama, Peru, Philippines, Poland, and Turkey.

Table 16.
Impact of the International Nosocomial Infection Control Consortium multidimensional hand hygiene approach over 13 years in 51 cities of 19 LMIC from Latin America, Asia, the Middle East, and Europe.
Characteristics of the Participating Hospitals (from April 1999 to December 2012).

Data	ICUs, n	Number of observations
Country		
Argentina	11	23616
Brazil	4	4837
China	5	2079
Colombia	11	13925
Costa Rica	1	303
Cuba	1	434
Greece	1	2315
El Salvador	3	1691
India	18	32869
Lebanon	1	1728
Lithuania	1	1565
Macedonia	1	3418
Mexico	10	13201
Pakistan	3	1830
Panama	1	551
Peru	5	6610
Philippines	9	17844
Poland	1	102
Turkey	12	22840
All countries	99	151,758
Type of ICU, n		
Adult	80 (81%)	133913
Pediatric	9 (9%)	9081
New Born	10 (10%)	8764
All ICUs	99 (100%)	151.758
Type of hospital, n (%)		
Academic Teaching	27 (42%)	50515
Public Hospital	16 (25%)	40530
Private Community	22 (34%)	60713
All hospitals	65 (100%)	151,758

ICU, intensive care unit; HH, hand hygiene.

Table 17.
Impact of the International Nosocomial Infection Control Consortium multidimensional hand hygiene approach over 13 years in 51 cities of 19 LMIC from Latin America, Asia, the Middle East, and Europe.
Distribution of hand hygiene compliance per ICU Type.

	ICUs (n)	Opportunities for HH (n)	HH compliance (n)	HH Compliance Means, % (95% CI)
Burn	1	1324	1176	89% (87 – 90.5)
Medical Cardiac	7	16836	10729	64% (63 – 64.5)
Cardiosurgical	3	4975	3943	79% (78.1 – 80.4)
Medical	4	8873	7150	81% (79.7 – 81.4)
Medical-Surgical	48	75945	47350	62% (62 – 62.7)
New Born	9	8764	7101	81% (80.2 – 81.8)
Neurosurgical	6	9715	7767	80% (79.1 – 80.7)
Pediatric	10	9081	6443	71% (70 – 71.9)
Respiratory	1	413	272	66% (61.1 – 70.4)
Surgical	8	8299	4963	60% (58.7 – 60.9)
Trauma	1	6671	5449	82% (80.7 – 82.6)
Ward	1	862	757	88% (85.4 – 89.9)
All	99	151,758	103,100	68% (67.7 – 68.2)

ICU, intensive care unit; HH, hand hygiene; CI, Confidence Interval.

Table 18.
Impact of the International Nosocomial Infection Control Consortium multidimensional hand hygiene approach over 13 years in 51 cities of 19 LMIC from Latin America, Asia, the Middle East, and Europe.
Hand Hygiene Compliance According to Each Variable. Logistic Regression, Multivariate analysis

Variable	Adjusted OR	95% CI	P Value
Gender (baseline: Female)	1.0		
Male	0.91	0.89 – 0.93	< 0.001
Type of professional (baseline: nurses)	1.0		
Physicians	0.68	0.66 – 0.70	< 0.001
Ancillary Staff	0.53	0.51 – 0.54	< 0.001
Type of contact (baseline: invasive)	1.0		
Non-invasive	0.95	0.93 – 0.98	< 0.001
Type of ICU (baseline: New Born)	1.0		
Adult ICU	0.49	0.47 – 0.52	< 0.001
Pediatric ICU	0.60	0.56 – 0.65	< 0.001
Work Shift (baseline: Night)	1.0		
Afternoon	0.78	0.75 – 0.81	< 0.001
Morning	0.83	0.81 – 0.86	< 0.001

HH, hand hygiene; HCW, health care worker; ICU, intensive care unit; AS, ancillary staff; F, female; M, male; Ni, non-invasive; I, invasive; Ad, adult; Pe, Pediatric; Nb, newborn; M, morning work shift; A, afternoon work shift; N, night work shift; NS, nursing staff; Ph, physicians; AS, ancillary staff; OR, Odds Ratio; CI, Confidence Interval.

Table 19.
Impact of the International Nosocomial Infection Control Consortium multidimensional hand hygiene approach over 13 years in 51 cities of 19 LMIC from Latin America, Asia, the Middle East, and Europe.
Hand Hygiene improvement by Country

Country	HH compliance, Baseline %	HH compliance, Intervention, %	RR	95% CI	P value
Argentina	20.3%	63.8%	3.14	2.83 - 3.49	0.0001
Brazil	26.7%	47.7%	1.79	1.61 - 1.99	0.0001
China	51.5%	67.3%	1.31	1.16 - 1.48	0.0001
Colombia	56.3%	78.4%	1.39	1.30 - 1.50	0.0001
Costa Rica	77.3%	87.1%	1.13	0.80 - 1.45	0.3496
Cuba	43.8%	61.4%	1.40	1.04 - 1.89	0.0250
El Salvador	40.8%	53.8%	1.32	1.10 - 1.58	0.0024
Greece	26.5%	32.3%	1.22	1.04 - 1.43	0.0154
India	70.9%	83.5%	1.18	1.13 - 1.23	0.0001
Lebanon	87.2%	91.6%	1.05	0.75 - 1.48	0.7757
Lithuania	68.5%	71.7%	1.05	0.91 - 1.20	0.5198
Macedonia	83.9%	97.5%	1.16	1.02 - 1.33	0.0288
Mexico	45.3%	69.6%	1.54	1.45 - 1.64	0.0001
Pakistan	28.5%	39.8%	1.40	1.16 - 1.69	0.0004
Panama	79.4%	80.7%	1.02	0.76 - 1.35	0.0986
Peru	72.4%	79.0%	1.09	1.02 - 1.17	0.1367
Philippines	65.3%	82.9%	1.27	1.21 - 1.34	0.0001
Poland	51.6%	62.5%	1.21	0.72 - 2.04	0.4726
Turkey	28.8%	49.5%	1.72	1.60 - 1.84	0.0001
ALL	**48.3%**	**71.2%**	**1.47**	**1.44 - 1.50**	**0.0001**

HH, Hand hygiene; RR, relative risk; CI, Confidence Interval.

Table 20.
Impact of the International Nosocomial Infection Control Consortium multidimensional hand hygiene approach over 13 years in 51 cities of 19 LMIC from Latin America, Asia, the Middle East, and Europe.
Hand Hygiene improvement by year of participation

Years since joining INICC	HH observations	HH compliance, % (95% CI)	Adjusted OR
First 3 months (baseline)	11267	48.3% (47.6 – 49.0)	1.0
Second 3 months	7214	61.2% (60.5 – 61.9)	1.72 (1.65 – 1.81)
Third 3 months	5511	67.2% (66.4 – 67.8)	2.10 (1.99 – 2.2)
Fourth 3 months	4639	69.4% (68.6 – 70.1)	2.21 (2.10 – 2.33)
2nd year	8190	71.4% (70.9 – 71.9)	3.07 (2.92 – 3.23)
3rd year	5573	69.1% (68.4 – 69.7)	3.03 (2.84 – 3.22)
4th and 5th year	4278	81.2% (80.1 – 81.6)	3.3 (3.07 – 3.52)
6th and 7th year	1120	86.0% (85.2 – 86.8)	2.87 (2.57 – 3.19)

INICC, International Nosocomial Infection Control Consortium; HH, Hand hygiene; RR, relative risk; CI, Confidence Interval; OR, Odds Ratio.

Table 21.
Interventional Studies Aiming at Device-Associated Infection Reduction Reported by Hospitals from Economies Defined as Low-, Lower-Middle, And Upper-Middle Income by the World Bank.
Significative reduction Central line-associated bloodstream infection rates by 1000 central line days, Ventilator-associated pneumonia rates by 1000 ventilator days, and catheter-associated urinary tract infection rates by 1000 catheter days using INICC Methods

Country	DA-HAI Type	Baseline Rate *	Intervention Rate *	RR	P Value	Year of publication	Reference
Argentina.*	CLAB	11.10	4.63	0.25	< 0.001	2003	[123]
Argentina.*	CLAB	13.39	2.78	0.21	0.0001	2004	[124]
Argentina.*	CLAB	9.6	4.1	0.43	< 0.001	2018	[125]
Argentina.*	CLAB	45.94	11.10	0.24	0.001	2003	[123]
Argentina.*	CLAB	6.52	2.36	0.36	0.02	2004	[126]
Brazil	CLAB	20	16	0.8	-	2005	[127]
Brazil.*	CLAB	14.0	7.1	0.50	0.002	2005	[128]
Brazil.*	CLAB	7.1	3.2	0.45	0.02	2006	[129]
Brazil.*	CLAB	6.5	3.2	0.49	0.03	2009	[130]
Colombia.*	CLAB	12.9	3.5	0.27	0.002	2016	[192]
Colombia.*	CLAB	15.4	10.6	0.69	0.0125	2010	[131]
Colombia.*	CLAB	12.9	3.5	0.27	0.001	2016	[62]
Colombia.*	CLAB	54.8	6.0	0.10	0.01	2005	[132]
Colombia.*	CLAB	54.8	6.0	0.11	0.0163	2005	[132]
India.*	CLAB	12.0	5.05	0.42	0.0013	2007	[133]
India.*	CLAB	11.4	7.9	0.70	< 0.001	2009	[134]
India.*	CLAB	6.4	3.9	0.47	0.0001	2013	[135]
India.*	CLAB	6.4	2.21	0.35	0.006	2015	[136]
Mexico.*	CLAB	47.10	20.81	0.44	0.0009	2003	[140]
Mexico.*	CLAB	46.3	19.5	0.42	0.0001	2005	[141]
Mexico.*	CLAB	28.9	12.5	0.43	< 0.001	2009	[142]
Mexico.*	CLAB	17.0	3.0	0.17	0.001	2004	[143]
Mexico.*	CLAB	46.3	19.5	0.42	0.001	2007	[141]
Mexico.*	CLAB	16.1	3.2	0.19	<0.0001	2010	[144]
Mexico.*	CLAB	40.7	10.3	0.25	0.0152	2005	[145]
Morocco.*	CLAB	22.9	8.3	0.36	0.0334	2007	[146]
Senegal	CLAB	10.9	2.9	0.26	0.03	2011	[399]
Tunisia	CLAB	3.5	0.9	0.25	-	2007	[339]
Turkey.*	CLAB	10.0	1.8	0.18	0.0016	2006	[147]
Turkey	CLAB	5.3	1.6	0.30	0.452	2006	[148]
Turkey.*	CLAB	23.1	15.5	0.67	< 0.001	2009	[149]
Turkey	CLAB	5.3	2.1	0.39	<0.001	2012	[150]
Turkey.*	CLAB	13.04	7.6	0.61	0.004	2013	[151]
Turkey.*	CLAB	10.0	1.8	0.18	0.001	2006	[152]
Turkey.*	CLAB	29.1	13.0	0.44	0.007	2006	[153]
INICC Report 2008- with pooled data of 12 countries: Argentina, Brazil, Colombia, Cuba, El Salvador, India, Macedonia, Mexico, Morocco, Peru, Philippines, Turkey.*	CLAB	14.0	10.3	0.74	0.0001	2008	[154]
INICC Report 2008- with pooled data of 13 countries: Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, India, Macedonia, Mexico, Morocco, Philippines, Peru, Turkey.*	CLAB	16.1	10.1	0.63	0.0001	2008	[155]
INICC Report 2010- with pooled data of 15 countries	CLAB	16.0	7.4	0.46	< 0.001	2010	[156]
INICC Report 2013- with pooled data of 4 countries: El Salvador, Mexico, Philippines, Tunisia.*	CLAB	21.4	9.7	0.45	0.0001	2013	[157]
INICC Report 2009- with	CLAB	19.8	11.5	0.58	0.0014	2009	[63]

pooled data of 7 countries: Argentina, Colombia, El Salvador, Mexico, Peru, Philippines, Turkey.*							
INICC Report 2009- with pooled data of 5 countries: Colombia, El Salvador, India, Mexico, Philippines.*	CLAB	10.4	5.9	0.56	0.0489	2009	[158]
INICC Report 2012- with pooled data of 5 countries:: Colombia, India, Mexico, Philippines, Turkey.*	CLAB	10.7	5.2	0.48	0.02	2012	[159]
INICC Report 2010- with pooled data of 15 countries	CLAB	16.0	7.4	0.46	<0.001	2010	[137]
INICC Report 2012- with pooled data of 4 countries: El Salvador, Mexico, Philippines, Tunisia.*	CLAB	21.4	9.7	0.45	<0.001	2012	[138]
INICC Report 2011- with pooled data of 6 countries: Colombia, India, Malaysia, Mexico, Philippines, Turkey.*	CLAB	13.0	6.9	0.53	<0.001	2011	[139]
Argentina.*	VAP	51.2	35.5	0.69	< 0.03	2016	[160]
Argentina.*	VAP	19.9	9.4	0.48	0.001	2018	[161]
Argentina.*	VAP	19.9	9.4	0.47	0.001	2018	[162]
China.*	VAP	24.1	5.7	0.31	0.0001	2012	[163]
Colombia.*	VAP	11.7	4.2	0.36	0.0016	2007	[164]
Colombia.*	VAP	11.3	7.4	0.66	0.02	2009	[165]
Cuba.*	VAP	43.5	9.2	0.21	0.009	2008	[166]
Cuba.*	VAP	52.63	15.32	0.3	0.003	2013	[167]
India.*	VAP	3.8%	1.1%	0.31	0.0013	2007	[168]
India.*	VAP	17.43	10.81	0.62	0.0001	2013	[169]
India.*	VAP	26.3	10.9	0.41	0.005	2007	[168]
Mexico.*	VAP	17.6	8.3	0.47	0.0267	2010	[173]
Pakistan.	VAP	13.2	6.5	0.49	0.02	2004	[174]
Thailand.	VAP	40.5%	24%	0.59	<0.001	2005	[400]
Thailand.	VAP	20.6	8.5	0.41	0.001	2007	[401]
Turkey.*	VAP	29.1	13.0	0.45	0.0076	2006	[175]
Turkey.*	VAP	19.6	8.0	0.41	0.0065	2007	[176]
Turkey.*	VAP	17.6%	4.5%	0.26	< 0.001	2007	[176]
Turkey.*	VAP	31.14	16.82	0.54	0.0001	2013	[177]
INICC Report 2008- with pooled data of 13 countries: Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, India, Macedonia, Mexico, Morocco, Philippines, Peru, Turkey.*	VAP	22.5	18.6	0.83	0.0007	2008	[155]
INICC Report 2012- with pooled data of 14 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, India, Lebanon, Macedonia, Mexico, Morocco, Panama, Peru, Turkey.*	VAP	22.0	17.2	0.78	0.0004	2012	[97]
INICC Report 2012- with pooled data of 10 countries: Argentina, Colombia, El Salvador, India, Mexico, Morocco, Peru, Philippines, Tunisia, Turkey.*	VAP	17.8	12.0	0.67	0.001	2012	[178]
INICC Report 2009- with pooled data of 7 countries: Argentina, Colombia, El Salvador, Mexico, Peru,	VAP	11.1	5.6	0.50	0.0078	2009	[179]

Philippines, Turkey.*							
INICC Report 2012- with pooled data of 5 countries: Colombia, El Salvador, India, the Philippines Turkey.*	VAP	11.7	8.1	0.69	0.02	2012	[172]
INICC Report 2011- with pooled data of 11 countries: Argentina, Colombia, India, Malaysia, Mexico, Morocco, Peru, Philippines, El Salvador, Tunisia, Turkey.*	VAP	17.0	12.1	0.71	0.02	2011	[170]
INICC Report 2011- with pooled data of 16 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, India, Lebanon, Macedonia Malaysia, Mexico, Morocco, Panama, Peru, Philippines, Turkey.*	VAP	20.8	16.5	0.79	0.0002	2011	[171]
INICC Report 2011- with pooled data of 5 countries: Colombia, El Salvador, India Philippines, Turkey.*	VAP	11.7	8.1	0.69	0.02	2011	[172]
Argentina.*	CAUTI	21.3	12.39	0.58	0.006	2004	[180]
India.*	CAUTI	7.4	2.2	0.30	0.481	2007	[181]
India.*	CAUTI	2.0	0.5	0.27	0.0030	2007	[181]
India.*	CAUTI	4.2	1.3	0.31	< 0.001	2009	[182]
Lebanon.*	CAUTI	13.07	2.21	0.17	0.0002	2013	[187]
Philippines.*	CAUTI	7.92	2.66	0.34	0.0107	2010	[188]
Philippines.*	CAUTI	11.0	2.66	0.24	0.0001	2013	[189]
Philippines.*	CAUTI	7.92	2.66	0.33	0.010	2010	[188]
Saudi Arabia.*	CAUTI	4.1	2.3	0.56	0.012	2018	[190]
Turkey.*	CAUTI	10.2	5.7	0.55	<0.001	2012	[150]
Turkey.*	CAUTI	10.63	5.65	0.53	0.0001	2013	[191]
INICC Report 2008- with pooled data of 11 countries: Argentina, Brazil, Colombia, Cuba, India, Macedonia, Mexico, Morocco, Peru, Philippines and Turkey.*	CAUTI	9.1	6.1	0.67	0.0001	2008	[183]
INICC Report 2008- with pooled data of 13 countries: Argentina, Brazil, Colombia, Costa Rica, Cuba, El Salvador, India, Macedonia, Mexico, Morocco, Philippines, Peru and Turkey.*	CAUTI	8.2	6.9	0.85	0.0282	2008	[155]
INICC Report 2012- with pooled data of 6 countries: Colombia, El Salvador, India, Mexico, Philippines, and Turkey.*	CAUTI	5.9	2.6	0.43	0.03	2012	[184]
INICC Report 2011- with pooled data of 7 countries: Colombia, El Salvador, India, Malaysia, Mexico, Philippines, and Turkey.*	CAUTI	5.9	2.7	0.45	<0.01	2011	[185]
INICC Report 2012- with pooled data of 15 countries: Argentina, Brazil, China, Colombia, Costa Rica, Cuba, India, Lebanon, Macedonia, Mexico, Morocco, Panama, Peru, Philippines, and Turkey.*	CAUTI	7.86	4.95	0.63	0.0001	2012	[186]

*Scientific research conducted by INICC members, using INICC software, and published by INICC Team.

DA-HAI, Device associated healthcare-associated infection; CLABSI rate, Central line-associated bloodstream infections per 1000 central line days; CL, central line; VAP rate, Ventilator-associated pneumonia per 1000 mechanical ventilator days; MV, mechanical ventilator; CAUTI rate, Catheter-associated urinary tract infection per 1000 catheter days; UC, urinary catheter; HAI, healthcare-associated infection; ICU, intensive care unit; PICU, pediatric intensive care unit; NICU, neonatal intensive care unit; RR, relative risk; CI, confidence interval; INICC, International Nosocomial Infection Control Consortium.

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