# Impact of the International Nosocomial Infection Control Consortium (INICC) Multidimensional Hand Hygiene Approach During 3 Years in 6 Hospitals in 3 Mexican Cities

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**Objectives:** To evaluate the impact of the International Nosocomial Infection Control Consortium (INICC) multidimensional hand hygiene (HH) approach in Mexico, and analyze predictors of poor HH compliance.
**Methods:** From June 2002 to April 2006, we conducted a prospective, observational, before-and-after study in 8 intensive care units (ICUs) from 6 hospitals in 3 cities of Mexico. The approach included administrative support, availability of supplies, education and training, reminders in the workplace, process surveillance, and performance feedback.
**Results:** A total of 13,201 observations for HH opportunities were done in each ICU, during randomly selected 30-minute periods. Overall, HH compliance increased from 45% to 79% (95% confidence interval [CI], 69.1–86.5; $P = 0.01$). Univariate and multivariate analyses showed that several variables were significantly associated with poor HH compliance: males versus females (61% versus 66%; 95% CI, 0.91–0.96; $P = 0.0001$), physicians versus nurses (62% versus 67%; 95% CI, 0.91–0.97; $P = 0.0001$), and adult versus neonatal ICUs (67% versus 54%; 95% CI, 0.79–0.84; $P = 0.0001$), among others.
**Conclusions:** Hand hygiene programs should focus on variables found to be predictors of poor HH compliance.

**Key Words:** hand hygiene, intensive care unit, bundle, multidimensional approach, developing countries

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For more than a century ago, at the time the relation between improved hand antisepsis and reduced mortality from puerperal sepsis was being studied by Semmelweis,[1] it was shown that appropriate hand hygiene (HH) before patient contact was a fundamental tool for infection prevention. Different studies have reported that an improved HH practice was associated with the reduction of antimicrobial resistance and rates of health care–associated infection (HAI).[2–4]

Health care–associated infections pose a serious threat to patient safety that includes morbidity and mortality.[5] As shown in the mainstream scientific literature, most studies addressing HAIs have been conducted in industrialized countries.[6] In contrast, in limited-resource countries (LRC), this public health problem had not been systematically studied until 2002, when the International Nosocomial Infection Control Consortium (INICC) began to apply standardized methods for measuring and analyzing HAI rates.[7–11]

Hand hygiene practice plays a crucial role in preventing cross transmission of HAIs, and successful interventions to improve HH have been reported in the mainstream literature from developed [12] and developing economies.[3,13,14] From the 1980s, investigators have analyzed the effectiveness of interventions to improve HH.[15,16] In a study conducted in the United States in 1997, Larson et al[16] explicitly referred to the value of a multidimensional approach that considered several interventions. Similarly, Rosenthal et al[3,14] have implemented programs in Argentina since 1993 that combined administrative support, availability of supplies, education and training, process surveillance, and performance feedback, whose successful results were evidenced by sustained improvements in HH compliance and associated reductions in HAI rates.

In 2002, the Centers for Disease Control and Prevention (CDC) published their HH guideline.[17] Similarly, but from a global angle, in 2005, the World Health Organization (WHO) launched the program "Clean Care is Safer Care",[18] and in 2009, the WHO published its guidelines presenting a compilation of previously published data, and a new formulation for alcohol-based hand rub products, among several other recommendations.[4]

As far as we are concerned, there are no previous publications showing HH compliance in hospitals of Mexico. The aim of this study was to establish the baseline HH compliance rate by health care workers (HCWs) before patient contact in 8 intensive care units (ICUs), in 6 hospitals, in 3 cities of Mexico, to analyze risk factors for poor adherence, and to evaluate the impact of implementing the INICC multidimensional HH approach (IMHHA). The IMHHA includes the following elements: (1) administrative support, (2) availability of supplies, (3) education and training, (4) reminders in the workplace, (5) process surveillance, and (6) performance feedback.

## MATERIALS AND METHODS

The INICC is an open nonprofit HAI surveillance multicentric network that applies methods based on the US CDC/National Healthcare Safety Network (NHSN).[19] The INICC was established to measure and control HAIs worldwide in hospitals through the analysis of standardized data collected on a voluntary

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basis by its member hospitals and fosters the use of evidence-based preventive measures. Since its international inception in 2002, INICC has increasingly gained new members and is now comprised of nearly 1000 hospitals in 200 cities of 50 countries in Latin America, Asia, Africa, Middle East, and Europe, becoming the only source of aggregate standardized international data on the epidemiology of HAIs internationally.[11]

This study was conducted in 8 ICUs of 6 INICC member hospitals from Mexico, which were successively incorporated into the study over a period of 3 years and 10 months.

Each hospital has an infection control team (ICT) with at least one infection control practitioner (ICP) and one physician, but this number of members is variable depending on the ICU. The ICT member in charge of process surveillance at each hospital has at least 2 years of experience in monitoring of HAI rates and infection control practices.

Professional categories of HCWs included nurses, physicians, and ancillary staff (including para medical technicians, nurse aides, laboratory team members, radiology team members, physiotherapists, patient care technicians, paramedical personnel, and patient lift teams.)

The institutional review boards at each hospital approved the study protocol.

From June 2002 to April 2006, we conducted an observational, prospective, cohort, interventional, before-and-after multicentric study. The study was divided into 2 periods: a baseline period that included episodes recorded at each hospital during their first 3 months of participation and a follow-up period that included episodes recorded after the fourth month of participation.

Each ICU started to participate in the study at different times, and therefore, they have different lengths of follow-up; but for all ICUs, the length of the baseline period is exactly the same (3 months). For compliance rate comparison, the ICUs were aligned independently of the date at which they started to participate in the study.

Upon joining the INICC program, each hospital begins to implement the IMHHA, which includes the following 6 elements: 1, administrative support; 2, availability of supplies; 3, education and training; 4, reminders in the workplace; 5, process surveillance; and 6, performance feedback. These elements act interactively, and all of them should be implemented simultaneously for the effectiveness of any "multidimensional" approach.

## Administrative Support

Hospital administrators of the participating hospitals agreed to the study committed to provide their support and attended infection control meetings to discuss study findings, and the allocation of supplies of HH products.

## Availability of Supplies

During the whole study period, sinks with water supply, soap, and paper towels were available at the ICUs' entrances, nursing stations, and common areas of ICUs.

## Education and Training

The ICT members provided 30-minute education and training sessions to HCWs from each participating ICU in each work shift at the beginning of the study period and periodically during the follow-up period. Education and training sessions included basic information about HH observations and the correct procedures and technique for HH.

## Reminders in the Workplace

Poster reminders were displayed all around the hospital settings (i.e., hospital entrance corridors, ICU entrances, nursing stations, ICT office, and beside each sink). They included simple instructions on HH performance in accordance with the contents of the education and training sessions.

## Process Surveillance

Process surveillance of HH practices consisted of the registrations of potential opportunities for HH,[4] and the actual number of HH episodes with water and soap. Health care workers' HH practices were directly monitored by an observer of the ICT, who followed a standardized protocol and completed HH process surveillance INICC forms.[7] Observations were conducted at specific time periods distributed in 3 work shifts (morning, afternoon, and evening) unobtrusively, that is, HCWs were not aware of the observation schedule. Observations included HH compliance before patient contact, and before an aseptic task, because by the time we started the study in June 2002, the "Five moments for HH" proposed by the WHO were not published until 2009. Potential confounders of HH included type of ICU, professional category, sex, work shift, and type of contact.

## Performance Feedback

On a monthly basis, each participating ICU received a final month-by-month report on compliance with HH, which was prepared by the INICC headquarters team. These charts contained a running record of HCWs' HH compliance in the participating ICUs, and compliance comparing several variables, such as sex, HCW professional status, ICU type, contact type, and work shift. The charts were reviewed at monthly ICT meetings and were posted in the ICUs to give performance feedback to the HCWs of the participating ICUs. The performance feedback process started at the third month of participation.[7]

## Data Collection and Analyses

Investigators in the ICT team were self-trained, with a procedure manual sent to them from the INICC headquarters in Buenos Aires, specifying how to fill in the INICC forms and how to conduct HH process surveillance.[7] Additionally, ICT members had continuous telephone or e-mail and webinar access to a support team at the INICC headquarters.

Once completed, INICC process surveillance forms were sent every month from each participating ICU to the INICC headquarters. The team at the INICC headquarters uploaded the data into a database and analyzed them. Then, a report of HH compliance was sent to ICT members of each participating ICU to show HH compliance by month, by sex, by HCW profession, by ICU, by work shift, and by type of contact.[7]

## Statistical Methods

### Univariate Analysis of Variables Associated With Poor HH, and of Impact of HH Approach

The aggregated independent variables (type of hospital, sex of HCWs, profession of HCWs, type of ICU, type of contact, etc.) of all observed HH opportunities and HH compliance during all the study, and comparison of HH compliance during the baseline period and during the follow-up period were compared using the Fisher exact test for dichotomous variables and unmatched Student *t* test for continuous variables. Relative risk ratios were calculated for comparisons of analyzed variables associated with HH using EPI Info V6. Ninety-five percent confidence intervals

**TABLE 1.** Characteristics of the Participating Hospitals (From June 2002 to April 2006)

| Data | ICUs, n | ICU HH Observations, n |
|---|---|---|
| Type of ICU, n (%) | | |
| Medical surgical | 5 (62) | 9418 |
| Neurosurgical | 1 (13) | 1229 |
| Newborn | 1 (13) | 1595 |
| Pediatric | 1 (12) | 959 |
| All ICUs | 8 (100) | 13,201 |
| Type of hospital, n (%) | | |
| Public | 5 (83.3) | 10,704 |
| Academic teaching | 1 (16.7) | 2497 |
| All hospitals | 6 (100) | 13,201 |

were calculated using VCStat (Castiglia). $P < 0.05$ by 2-tailed tests was considered significant.

### Multivariate Analysis of Variables Associated With Poor HH

The aggregated described independent variables of all observed HH opportunities and HH compliance during all the study were compared using logistic regression for dichotomous and continuous variables. Odds ratios with 95% confidence intervals were calculated for comparisons of analyzed variables associated with HH using PASW Statistics 18. $P < 0.05$ by 2-tailed tests were considered significant.

### Multivariate Analysis of Impact of INICC HH Multidimensional Approach

Hand hygiene opportunities and HH compliance during baseline and during follow-up were explored for changes in HH compliance rates after an ICU joins INICC. We looked at the follow-up period stratified by 3-month periods over the first year, and yearly for second and third year of participation. We present the results of a logistical regression model to consider change in HH compliance in INICC participating ICUs over time since the beginning of the HH surveillance. Odds ratios are presented, comparing each time period since the start of the surveillance with the baseline of 3 months. This is a large data set, with 13,201 observations, and so we were able to adjust for the effect of each ICU on HH compliance as a categorical variable in the analysis. Because of the different length of follow-up of each ICU (from 3 months to 3 years), for each time period only ICUs with follow-up in that time period were included in the baseline period used for calculating the odds ratio of HH compliance for that period.

## RESULTS

From June 2002 to April 2006 (3 years and 10 months), we recorded a total 13,201 opportunities for HH before patient contact and before aseptic task. Characteristics of participating hospitals are shown in Table 1. T1

### Predictors of Poor HH Compliance

We observed 10,704 procedures in public hospitals and 2497 in academic hospitals; 2866 procedures in male individuals, and 10,335 in female individuals; 9987 in nurses, 2295 in physicians, and 919 in ancillary staff; 4837 were before noninvasive patient contacts, and 8360 were before invasive procedures; 10,647 in adult ICUs, 959 in pediatric ICUs (PICUs), and 1595 in neonatal ICUs; 6425 during the morning, 3820 during the afternoon, and 2956 during the night shift.

Table 2 shows HH compliance distribution among the different ICU types for baseline and follow-up periods.

Tables 3 and 4 show HH compliance according to each variable (type of hospital, sex, HCW professional status, work shift, type of procedure, and type of unit) and association with poor HH, analyzed with univariate and multivariate statistical methods.

### Components of the INICC Multidimensional HH Approach

During the follow-up period, the 6 elements of the IMHHA were applied simultaneously: 100% counted on administrative support and available supplies for HH; 100% educated HCWs (66.6% of them every month, 16.7% every 3 months, and 16.7% every 6 months); 100% posted reminders (100% of them at ICU entrance, 100% in common ICU areas, and 10% beside each bed); 100% conducted process surveillance; 100% provided performance feedback (83.3% of them every month and 16.7% every 6 months).

### Impact of the IMHHA on HH Compliance

The baseline period of the INICC ICUs was 3 months, and their average follow-up period was 9.32 months (range, 1–26 months).

In Table 5 and Figure 1, we present the results of a logistic regression model to consider change in HH compliance in INICC participating ICUs over the whole study period.

## DISCUSSION

This is the first study that has shown an improvement in HH compliance in Mexico owing to the implementation of the IMHHA. We analyzed the impact of the IMHHA in a diverse ICU population from 3 cities of Mexico, showing that the 6 measures of the IMHHA implemented in each ICU were followed by very substantial improvements in HH practices.

**TABLE 2.** Distribution of HH Compliance by Type of ICU

| | ICUs (n) | Baseline Period (HH Compliance / HH Observations) | Intervention Period (HH Compliance / HH Observations) | RR (95% CI) | *P* |
|---|---|---|---|---|---|
| Medical surgical | 5 | 33.6% (485/1444) | 69.2% (5521/7974) | 2.06 (1.9–2.3) | 0.0001 |
| Neurosurgical | 1 | 88.2% (292/331) | 89.6% (805/898) | 1.02 (0.9–1.2) | 0.8184 |
| Neonatal | 1 | 45.9% (232/505) | 57.8% (630/1090) | 1.26 (1.1–1.5) | 0.0024 |
| Pediatric | 1 | 53.1% (156/294) | 66.0% (439/665) | 1.24 (1.0–1.5) | 0.0176 |
| All | 8 | 45.3% (1165/2574) | 69.6% (7395/10,627) | 1.54 (1.4–1.6) | 0.0001 |

CI, confidence interval; RR, relative risk.

**TABLE 3.** Hand Hygiene Compliance by Type of Variable: Univariate Analysis

| | Variable | % (No. of HH / No. of Opportunities) | Comparison | RR | 95% CI | *P* |
|---|---|---|---|---|---|---|
| Type of hospital | Public | 81% (2027/2497) | Pu versus Ac | 0.75 | 0.71–0.80 | 0.0001 |
| | Academic | 61% (6533/10704) | | | | |
| Sex | Female | 66% (6798/10335) | F versus M | 0.93 | 0.91–0.96 | 0.0001 |
| | Male | 61% (1762/2866) | | | | |
| HCW | Nurses | 67% (6656/9987) | Ns versus Ph | 0.94 | 0.91–0.97 | 0.0001 |
| | Physicians | 62% (1431/2295) | Ns versus AS | 0.77 | 0.75–0.8 | 0.0001 |
| | Ancillary staff | 51% (473/919) | Ph versus AS | 0.83 | 0.77–0.88 | 0.0001 |
| Procedure | Noninvasive | 72% (3497/4837) | NI versus I | 0.84 | 0.80–0.88 | 0.0001 |
| | Invasive | 61% (5063/8360) | | | | |
| Unit | Adult ICU | 67% (7103/10647) | Ad versus Nb | 0.81 | 0.79–0.84 | 0.0001 |
| | Newborn | 54% (862/1595) | Ad versus Ped | 0.93 | 0.9–0.96 | 0.0001 |
| | Pediatric | 62% (595/959) | Ped versus Nb | 0.87 | 0.79–0.97 | 0.0085 |
| Work shift | Morning | 65% (4206/6425) | M versus A | 0.97 | 0.93–1.0 | 0.3 |
| | Afternoon | 67% (2570/3820) | M versus N | 0.92 | 0.89–0.96 | 0.0001 |
| | Night | 60% (1784/2956) | A versus N | 0.9 | 0.85–0.94 | 0.0001 |

A, afternoon work shift; Ad, adult; AS, ancillary staff; F, female; I, invasive; M, male; M, morning work shift; N, night work shift; Nb, newborn; Ni, noninvasive; NS, nursing staff; Ped, pediatric; Ph, physicians.

At our study's ICUs, baseline HH compliance (45.2 %) by HCWs was similar to that shown in previous studies, which is in consonance with the wide range of percentages reported for HH compliance in the scientific literature (9% to 75%).[4] Our target was to increase HH by at least 30%, and through the implementation of the IMHHA, overall HH compliance in our ICUs increased from 45% to 79%.

The results of the multivariate analysis showed that compliance was higher in the female individuals, which was also identified in individuals unrelated to health care, such as the findings of Guinan et al,[20] showing higher compliance by female students. Compliance was higher among nurses, as shown in a study by Rosenthal et al[3] in Argentina in 2005, in which compliance was lower among physicians and ancillary staff compared to nurses. We also showed that the highest HH compliance was in adult ICUs. Watanakunakorn et al[21] found remarkable variations by unit, with compliance being 56% in ICUs, compared to 23% in non-ICUs. Our findings showed that type of contact influenced HH performance: Superficial contacts were associated with higher compliance. By contrast, Lipsett et al[22] showed that lower HH compliance was found in low-risk situations.

Our approach included 6 components, including administrative support. In 2003, Rosenthal et al[14] showed that higher HH adherence was associated to higher administrative support. We also included availability of supplies. In 2000, Bischoff et al[23] showed that easily accessible dispensers of alcohol-based hand rub revealed the more dispensers per bed, the higher HH compliance. Education and training were also provided in the participating ICUs, which were other basic independent interventions identified to foster adequate HH performance. Back in 1990, Dubbert et al[24] showed how educational intervention with regular classes improved HH compliance by 97% over 4 weeks. Likewise, but within the context of LRCs, Rosenthal et al[14] showed that HCWs' education improved HH adherence and that compliance increased further if performance feedback was also implemented. We also included reminders at workplace. In 1989, Conly et al[25] showed the importance of reminders to raise HCWs' awareness of the relation between correct HH performance and HAI reduction.

We measured a total of 13,201 opportunities for HH. Every month, the ICT team provided performance feedback to HCWs of each ICU. This is a most motivating aspect of the IMHHA for HCWs. Knowing the outcome of their efforts reflected by the measurement of their practices and HAI incidence can be a conscious-raising factor to ensure the IMHHA's effectiveness. Continuous feedback to industrial workers on the results of monitoring the quality of the final product to improve product quality stems from the epochal contributions of Deming.[26] From 1998, in Argentina,[14,27] and 2002 internationally,[7–11] INICC has introduced process surveillance and performance feedback as a means to improve quality in health care to a new level, monitoring and

**TABLE 4.** Hand Hygiene Compliance by Type of Variable. Logistic Regression, Multivariate Analysis

| Variable | Adjusted OR | 95% CI | *P* |
|---|---|---|---|
| Type of hospital (baseline: public) | 1.0 | | |
| Academic | 0.36 | 0.33–0.40 | 0.0001 |
| Sex (baseline: male) | 1.0 | | |
| Female | 0.98 | 0.89–1.1 | 0.8 |
| Type of professional (baseline: ancillary staff) | 1.0 | | |
| Physicians | 0.76 | 0.68–0.85 | 0.0001 |
| Nurses | 0.51 | 0.44–0.6 | 0.0001 |
| Type of contact (baseline: invasive) | 1.0 | | |
| Noninvasive | 0.58 | 0.53–0.62 | 0.0001 |
| Type of ICU (baseline: adult) | 1.0 | | |
| Newborn | 0.53 | 0.48–0.6 | 0.0001 |
| Pediatric | 0.87 | 0.75–1.0 | 0.048 |
| Work shift (baseline: morning) | 1.0 | | |
| Afternoon | 0.91 | 0.84–1.0 | 0.04 |
| Night | 0.74 | 0.67–0.82 | 0.0001 |

OR, odds ratio.

**TABLE 5.** Hand Hygiene Improvement by Year of Participation

| Years Since Joining INICC | HH Observations | Number of ICUs Included | Number of Hospitals Included | HH % (95% CI) | Adjusted OR | *P* |
|---|---|---|---|---|---|---|
| First 3 months (baseline) | 2574 | 10 | 6 | 45% (43.3–47.2) | – | – |
| Second 3 months | 2975 | 10 | 6 | 62% (60.3–63.9) | 2.25 (2.0–2.5) | 0.0001 |
| Third 3 months | 3483 | 8 | 5 | 70% (68.5–71.5) | 3.2 (2.82–3.6) | 0.0001 |
| Fourth 3 months | 2075 | 6 | 4 | 72% (69.9–73.9) | 3.0 (2.6–3.5) | 0.0001 |
| 2nd year | 2000 | 5 | 4 | 77% (75.1–78.9) | 3.12 (2.7–3.7) | 0.0001 |
| 3rd year | 94 | 1 | 1 | 79% (69.1–86.5) | 2.1 (1.2–3.7) | 0.01 |

providing continuous feedback not only on outcome data, including rates of HAI, but also on the results of process surveillance—rates of HH compliance and other basic and effective evidence-based infection control practices—and has shown that combining education with feedback on surveillance data can bring quantum reductions in the risk of life-threatening HAIs in ICUs.[3,14]

Through the past decade, INICC has undertaken a global effort in America, Asia, Africa, Middle East, and Europe to respond to the burden of HAIs and has achieved extremely successful results, by increasing HH compliance, improving compliance with other infection control interventions as described in several INICC publications, and consequently reducing the rates of HAI and mortality. Since 2002, in adult ICUs in 15 countries, INICC has reduced the rate of CLAB by 54%,[28] of CAUTI by 37%,[29] of VAP by 56%,[30] and of mortality by 58%.[28]

Our study has several limitations. The INICC did not measure "My five moments for HH", as advised recently by WHO, because the INICC program started the IMHHA in 1998 in Argentina,[3,14] and in 2002 internationally,[7] and the recommendation of the WHO were published later in 2009. Nonetheless, since 2009, INICC has included WHO's "My five moments for HH" in its process surveillance forms and manuals.[4] In addition, owing to the fact that our study design applies observational methods on HCWs' practice behaviors, evidence may be less solid or have less corroborative value than in other study designs. Direct observation of adherence typically involves a Hawthorne effect and has inherent weaknesses, including assuring interobserver reliability. Finally, the level of quality of HH technique is hard to capture, and we were not able to include many details in this investigation.

## CONCLUSIONS

Our study showed that the IMHHA improved HH compliance in Mexico's ICUs. Through the continuous implementation of the IMHHA, we expect to improve further our compliance percentages, and as a future implication of our research, our HH program should focus on those variables found to be predictors of poor HH compliance. It is INICC's primary objective to foster infection control practices by freely facilitating elemental and resourceful tools to deal with this problem effectively, leading to steady adherence to infection control programs that include HH compliance and to the correlated reduction of HAIs and their consequences, such as mortality and extra cost.

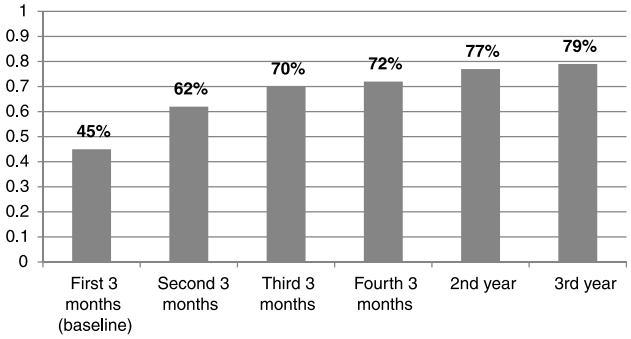


**FIGURE 1.** Hand hygiene improvement by year of participation.

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