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Cost-effectiveness of a hand hygiene program on health care–associated infections in intensive care patients at a tertiary care hospital in Vietnam

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Key Words: Hand hygiene
Hospital-acquired infection
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Low- and middle-income country
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Cost-effectiveness

Background: The cost-effectiveness of a hand hygiene (HH) program in low- and middle-income countries (LMICs) is largely unknown. We assessed the cost-effectiveness of a HH program in a large tertiary Vietnamese hospital.

Methods: This was a before and after study of a hand hygiene program where HH compliance, incidence of hospital-acquired infections (HAIs), and costs were analyzed. The HH program was implemented in 2 intensive care and 15 critical care units. The program included upgrading HH facilities, providing alcohol-based handrub at point of care, HH campaigns, and continuous HH education.

Results: The HH compliance rate increased from 25.7% to 57.5% (P < .001). The incidence of patients with HAI decreased from 31.7% to 20.3% (P < .001) after the intervention. The mean cost for patients with HAI was $1,908, which was 2.5 times higher than the costs for patients without an HAI. The mean attributable cost of an HAI was $1,131. The total cost of the HH program was $12,570, which equates to a per-patient cost of $6.5. The cost-effectiveness was estimated at -$1,074 or $1,074 saved per HAI prevented. The intervention remained cost savings under various scenarios with lower HAI rates.

Conclusion: The HH program is an effective strategy in reducing the incidence of HAIs in intensive care units and is cost-effective in Vietnam. HH programs need to be encouraged across Vietnam and other LMICs.

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Programs that produce a sustained improvement in hand hygiene coincide with a reduction of hospital-acquired infections (HAIs) and a reduction in the transmission of health care–associated pathogens such as methicillin-resistant Staphylococcus aureus (MRSA), Acinetobacter baumannii, Pseudomonas aeruginosa, and Klebsiella pneumoniae.1,2 Successful hand hygiene programs that lead to significant improvement of hand hygiene compliance usually include a continuous education program and installation of accessible dispensers at the point of care (bedside) with alcohol-based handrub.3,4 Reductions in HAIs of at least 36% have been achieved in different studies since implementation of an alcohol-based handrub program.3,4

Several studies have shown that hand hygiene is a cost-effective method for preventing HAIs.5,6 It has been estimated that the total cost of hand hygiene promotion corresponds to <1% of the costs associated with HAIs.6 A study examined the effects of a standardized hand hygiene program on the rate of HAIs in very low birth weight infants and showed that the number of HAIs reduced significantly from 18.8% (16/85) to 6.3% (5/80), equivalent to 10 episodes of HAIs per year after the introduction of a standardized hand hygiene protocol, and saved $10,000 per HAI.8

As in other low and middle income countries (LMICs), hospitals in Vietnam are dealing with inadequate resources in hospital infrastructure, limited awareness, and a lack of infection control measures. Handwashing in between patients is usually not
performed because of the lack of hand hygiene facilities and limited awareness. A study to investigate the situation of hand hygiene in 12 general hospitals (3 central hospitals, 5 provincial hospitals, and 4 district hospitals) in Northern Vietnam in 2005 showed that the percentage of patient rooms with sinks was just 37.6%.

Furthermore, only 20% of sinks had dry towels. An observation of staff from medical wards of 9 general hospitals showed that on average 6.1% of staff washed their hand before examining patients, 13.4% washed their hands in between patients, and 14.7% washed their hands between clean and dirty procedures on the same patient.

Cho Ray Hospital is a 1,750-bed tertiary university hospital with an occupancy rate up to 143%, resulting in an average daily census of approximately 2,700 patients in 2010. HAI prevalence in Cho Ray Hospital was 5.8%, with a higher prevalence of 22.8% in the intensive care unit (ICU) and critical care unit (CCU) in 2010. HAI is most commonly caused by gram-negative bacteria, such as P. aeruginosa, Klebsiella spp, and Acinetobacter spp. There is a big gap in knowledge, attitude, and behavior among hospital staff; 96.7% think handwashing is necessary to reduce HAI, but only 56.7% said that they washed their hands.

The rate of hand hygiene compliance was reported to be as low as 20% in Cho Ray Hospital.

An increase of hand hygiene compliance was shown to be related to a reduction in surgical site infections on the surgical department.

A study in 1999 at Cho Ray Hospital estimated that the cost of HAIs was $1,248,192, approximately 8.2% of the annual total hospital budget that year (Cho Ray Hospital report). Currently, it is unknown whether a hand hygiene program is cost-effective in a LMIC. In this study we aim to assess the effectiveness of a hand hygiene program through evaluating the impact of this program on reducing HAI in ICUs and CCUs, increasing level of compliance with hand hygiene by health care workers (HCWs), and cost-effectiveness.

**METHODS**

**Design**

This is a before and after study with a hand hygiene program as the intervention. We compared the compliance rate of hand hygiene and the incidence of HAIs before and after the intervention, and we included a cost analysis. The study was approved by the Cho Ray Hospital Ethical Committee.

**Study site and population**

Cho Ray Hospital is a 1,750-bed tertiary university hospital based in Ho Chi Minh City, Vietnam, with a bed occupancy rate of up to 143%, resulting in an average daily census of approximately 2,700 patients in 2010. It is one of the largest hospitals in Vietnam, with all specialties, and it is a referral hospital for other hospitals. The study was conducted in 2 main ICUs and 15 CCUs (7 CCUs in internal medicine departments and 8 CCUs in 8 surgery departments).

**Intervention**

The hand hygiene program in the studied wards started on April 1, 2010, and was maintained afterward. The contents of the program included a ceremony with a quiz on hand hygiene for all HCWs of the hospital and a continuous hand hygiene education program for HCWs using posters, flyers, and seminars. HCWs were educated on the importance of hand hygiene and the right handwashing technique through in-service workshops. The World Health Organization’s (WHO’s) My 5 Moments of Hand Hygiene were used as the key moments for HCWs’ handwashing at our hospital. Hand hygiene education was also provided to patients and their families admitted to the ICUs and CCUs. Appropriate hand hygiene stations were installed, including new sinks, hand disinfectant solutions, and disposable towel dispensers. Alcohol-based handrub was provided in 500-mL wall-mounted and bed-mounted dispensers for use by HCWs at the point of care. Additional handrub dispensers were also installed on medication and treatment carts. Portable 100-mL bottles were provided for nursing staff and doctors working in studied units to carry in their pockets.

The schedule of study was described in Figure 1.

**Outcome variables**

The outcome variables included hand hygiene compliance and the incidence of HAIs during hospitalization. HAIs were classified by site of infections, including nosocomial pneumonia, surgical site infections, urinary tract infections, bloodstream infections, skin infections, and others.

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**Fig 1.** Schema of study. HAI, hospital-acquired infection; HCW, health care worker.

### Schedule of Study

**Intervention: Hand Hygiene Program**

1. **1 Nov 2009 to 31 Mar 2010:** Analysis pre-intervention data
2. **1st Apr 2010 - 14 Jun 2010:** Installing new sink, hand sanitizers bedside and carte
3. **15 Jun 2010:** Hand hygiene ceremony
4. **1st Apr 2010 - 14 Jun 2010:** Installing new sink, hand sanitizers bedside and carte
5. **15 Jun 2010:** Hand hygiene ceremony
6. **July 2010 - Nov 2010:** Repeated Training
7. **1st Dec 2010 to 30st Apr 2011:** Observation study
8. **Observation study**
   - Measure the compliance of washing hand of HCWs
9. **Observation study**
   - Measure the compliance of washing hand of HCWs
10. **Observation study**
    - Measure the compliance of washing hand of HCWs

**Outcome variables**

1. **1 Nov 2009 to 31 Mar 2010:** Analysis pre-intervention data
2. **Preparation for hand hygiene program**
3. **Intervention:** Hand Hygiene Program
4. **Hand hygiene program**
5. **Evaluation of hand hygiene program**
6. **Cost effectiveness analysis**
Hand hygiene compliance assessments

The evaluation of hand hygiene compliance was performed using the direct observation technique. The WHO’s observation form with My 5 Moments of Hand Hygiene was used to evaluate the rate of hand hygiene. Every ward was observed for 30 minutes twice a week in the daytime by infection control nurses. Two observers were required to work at the same time at the same location to check if there is inter-rater reliability between the observers and to control observation bias. The same observers worked before and after the intervention periods. All HCWs in the participating departments (doctors, nurses, technicians, physiotherapists, and medical students) were observed to evaluate their compliance with hand hygiene. The compliance of hand hygiene was calculated as follows:

$$\text{Compliance}(\%) = \left( \frac{\text{Actions}}{\text{Opportunities}} \right) \times 100$$

Hospital-acquired infection assessments

The incidence of HAIs was evaluated through a prospective cohort study at the participating departments. All patients admitted to the participating ICUs and CCUs between June 1, 2009-October 30, 2009 (before intervention) and December 1, 2010-April 30, 2011 (after intervention) were followed-up to determine the incidence and risk factors of HAIs. Patients who had an HAI before admission to the ICU were excluded. HAI case definitions from the U.S. Centers for Disease Control and Prevention were used to assess HAIs.15

Cost-effectiveness analysis

Costs of patients with and without an HAI in the study were estimated for both the pre- and postintervention periods. Full financial records on total charges incurred during the period of hospitalization were sought for each patient from the automated hospital financial system. Information obtained encompassed hotel (bed and food), medication, equipment, pathology, and imaging diagnosis charges. All charges are reported in U.S. dollars using the 2011 conversion rate of 20,800 Vietnam dong to 1 US dollar. HAI-attributable costs were calculated as the difference between the costs for patients with HAI and those without HAI for each study period. The costs of the hand hygiene program included implementation costs (fixed cost), cost for installing new sinks, new dispensers, printing training materials, pamphlets, posters and maintenance costs (variable cost), cost for personnel, and cost for handwashing-handrubbing solutions. An average cost of hand sanitization per patient was calculated as the costs of the hand hygiene program divided by the estimated number of patients in the ICUs and CCUs during the intervention period. The estimates of the effectiveness data of the hand hygiene program compared with usual care were conducted through comparison of the different mean attributable cost of HAI preintervention and postintervention periods. The costs of the intervention were calculated as the costs of the hand hygiene program plus the mean attributable inpatient costs for HAI, for each patient infected with an HAI while in hospital during the postintervention phase. The costs of no intervention were estimated as the mean attributable in-patient costs for HAI, for each patient infected with an HAI while in hospital during the pre-intervention phase.

Because the recruited number of patients is not totally similar between the preintervention and postintervention groups, it is not possible to compare the costs between these 2 groups. Therefore, we will calculate the cost per 100 patients based on the real cost data for the cost analysis. This is also required for the sensitive analysis.

The budgetary impact of HAIs was estimated in terms of the estimated annual net savings. Annual net savings were estimated by subtracting the annual cost for intervention from the estimated gross annual cost saving as follows:

$$\text{Annual Gross Savings} = \text{Costs of HAIs}_{\text{Intervention}} - \text{Costs of HAIs}_{\text{No intervention}}$$

$$\text{Annual Gross Savings} = (\text{HAIs}_{\text{Intervention}} - \text{HAIs}_{\text{No intervention}}) \times \text{Mean attributable cost of HAI}$$

The gross annual cost saving was calculated by multiplying the estimated number of HAIs in the year with and without intervention, by the mean attributable costs as follows:

$$\text{Annual Net Savings} = \text{Annual Gross Savings for HAI} - \text{Costs of intervention}$$

Statistical analysis

Data were entered and analyzed using Stata 10.0 (StataCorp, College Station, TX). Two-sided Student t tests were used to assess the differences in the mean costs between groups (with and without HAIs). In case the distribution of frequencies was skewed, Wilcoxon rank-sum test (nonparametric equivalent) was used for comparing the costs. The results from the before and after comparison were used in a simple 1-way and multiway sensitivity analyses to determine the robustness of the results. Sensitivity analyses were done to test the assumptions by varying the incidence of HAIs, varying the mean attributable cost and the intervention costs. These analyses also included threshold analysis to determine when the intervention would become cost neutral.

RESULTS

Situation of HAIs in intensive care units

The total number of patients included in the cohort study was 984, with 486 patients assessed before the intervention and 498 patients after. The characteristics of patients were not different between the 2 periods (Table 1). The incidence of HAIs decreased from 31.7% (154/486) in the preintervention group to 20.3% (101/498) in the postintervention group, a significant reduction of 36% ($P = .005$). Compared with the preintervention group, all 4 main types of HAIs were reduced significantly in the post-intervention group: hospital-acquired...
Compliance with hand hygiene

In the preintervention period, there were 3,013 observations of hand hygiene compliance, with the following distribution among HCWs: nurses (67.5%), physicians (24.6%), technicians (3.1%), and others (4.8%). The average compliance for all HCWs was 25.7%. The hand hygiene program at our hospital in Vietnam was successful in increasing the compliance of hand hygiene among HCWs and also in reducing the incidence of HAIs in ICUs and CCUs. In this program, we focused on the steps recommended by the WHO, including upgrading hand hygiene facilities, training, surveillance, and feedback.4,10 With the limited resources, most hospitals in Vietnam have not invested sufficiently in hand hygiene facilities, which is prohibitive to improving hand hygiene compliance. In addition, training for staff is a key component to improve adherence to hand hygiene recommendations.17,19 In this study, we found relatively lower compliance before patient contact and after environmental contact. Hand hygiene training should focus on improving compliance during moments with low compliance.

The hand hygiene compliance rates did not differ between the intervention group to 20.3% in the postintervention group. Therefore, the effectiveness of the hand sanitizer program was 36%, resulting in 11.4 HAIs prevented per 100 patients in the prevention group. The cost-effectiveness was estimated at -$1,074 per HAI prevented or $1,074 saved per HAI prevented (Table 5).

Cost-effectiveness analysis

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Sensitivity analyses

Sensitivity analyses are presented in Table 6. From these analyses it can be ascertained that the intervention remains cost savings under most scenarios examined, including when the reduction in HAI incidence is reduced to 0.6%. The intervention becomes cost neutral when the mean attributable cost is $58, approximately 5% of that estimated and used in the base case analysis, and also when the cost of hand hygiene program per patient is $290, about 20 times the cost used in the base case analysis.

DISCUSSION

The hand hygiene program at our hospital in Vietnam was successful in increasing the compliance of hand hygiene among HCWs and also in reducing the incidence of HAIs in ICUs and CCUs. In this program, we focused on the steps recommended by the WHO, including upgrading hand hygiene facilities, training, surveillance, and feedback.4,10 With the limited resources, most hospitals in Vietnam have not invested sufficiently in hand hygiene facilities, which is prohibitive to improving hand hygiene compliance. In addition, training for staff is a key component to improve adherence to hand hygiene recommendations.17,19 In this study, we found relatively lower compliance before patient contact and after environmental contact. Hand hygiene training should focus on improving compliance during moments with low compliance.

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method according to WHO guidelines. The WHO guideline for evaluating hand hygiene compliance guides clearly indications that staff should follow hand hygiene in clinical settings; which can help to minimize observing bias.

After applying the hand hygiene program, the incidence of HAIs reduced by 36% for all types of HAIs. Before the intervention, the risk factor of HAI was particularly related to invasive procedures, such as tracheotomy and mechanical ventilation. After the intervention, the risk factors were mainly patient-related characteristics; however, the patient characteristics and the number of invasive procedures, such as tracheotomy and mechanical ventilation, were similar between the 2 periods. This finding may emphasize that HH compliance in invasive procedures is important in reducing infections related to invasive procedures. This result is similar to a previous study in 786 neurosurgery patients at Cho Ray Hospital. We also found that improving hand hygiene reduced surgical site infections by 54% (8.3% to 3.8%; \( P = .09 \)). Superficial surgical site infections were eliminated after the intervention (\( P = .007 \)).

Our study illustrates that hand hygiene interventions can also be cost-effective in an LMIC such as Vietnam. The mean attributable cost of an HAI was $1,131, lower than results from other developed countries. The attributable cost of an HAI was £3,154 in an English hospital or €12,853 for hospital-acquired bacteremia in a Belgian hospital. Improving hand hygiene compliance from 48.6% to 87.0% resulted in savings of 11.6 neonatal intensive care unit days and $66,397 in hospital charges in a pediatric hospital in the United States. We found the cost-effectiveness to be $1,074 saved per HAI prevented. This amount is similar to other studies. A study in The Netherlands showed that a hand hygiene program found the

### Table 4

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<th>Resources</th>
<th>Quantity</th>
<th>Units</th>
<th>Cost/unit</th>
<th>Total cost</th>
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<tr>
<td>Fixed cost Supplies and equipment</td>
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<tr>
<td>Variable cost Personnel incentives</td>
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<td>Trainers</td>
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<td>Dispensers maintenance staff</td>
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<td>Grand total</td>
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### Table 5

<table>
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<th>Indicators</th>
<th>Before intervention</th>
<th>After intervention</th>
<th>Increment</th>
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<tr>
<td>Incidence rate</td>
<td>31.7</td>
<td>20.3</td>
<td>11.4</td>
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<tr>
<td>Cost of HAI assuming a cohort of 100 patients</td>
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<td>22,959.3</td>
<td>12,243.4</td>
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<tr>
<td>Cost of intervention for 100 patients</td>
<td>650</td>
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<tr>
<td>Total cost of HAI</td>
<td>35,852.7</td>
<td>23,609.3</td>
<td>12,243.4</td>
</tr>
<tr>
<td>Cost savings per additional SSI prevented</td>
<td>1,074</td>
<td></td>
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</tbody>
</table>

HAI, hospital-acquired infection; SSI, surgical site infection.
cost effectiveness to be €622 per HAI prevented. Sensitivity analyses ascertained that the intervention remains cost savings even when the reduction in incidence of HAIs is reduced to 0.6%. The intervention only becomes ineffective when the mean attributable cost is $58, or when the cost of hand hygiene program per patient is $290.

Our study indicates that the hand hygiene program is an effective strategy in reducing the incidence of HAIs in ICUs and is cost-effective in an LMIC. With the growing rates of multidrug-resistant pathogens and the difficulties in controlling antibiotic use, the improvement of hand hygiene compliance could reduce HAIs and therefore contribute to reducing AB use and multidrug-resistant pathogens. Also, the cost associated with HAIs is high, and the cost savings from this program was significant. Hand hygiene therefore is a cost-effective means of preventing HAIs. The results of this study provide a background for future investigations into the impact of other infection control programs on HAIs and AB resistance.

An obstacle to implementing infection control programs, such as hand hygiene, is that treatment costs, including those for HAIs, are paid for by the insurance companies or the patients, whereas any infection control intervention needs to come from the hospital budget. Therefore, hospital leaderships are often reluctant to make investments when the cost savings benefit the insurance company while the investment needs to come from the hospital to reach these savings. Therefore, financial incentives need to be provided to the hospitals to encourage them to implement infection control programs. This low-cost intervention has huge benefit for both the patients and health care costs. It is unethical to withhold these programs from hospitals that are shown to be effective and cost-saving. Hospital leaders usually do not invest money for handwashing because they think that this can cause higher costs for the hospital. It is therefore necessary to implement a hand hygiene program and evaluate the cost effectiveness of the handwashing program.

This study has some limitations. This is a before-after intervention study with only 2 time points analyzed; a time series analysis would be preferred. The available resources did not allow us to do a more robust study. There were no other interventions or changes in infection control during the study period in the hospital. However, there may have been some unobserved changes over time that could have potentially influenced the HAIs prevalence beside hand hygiene. For example, the knowledge and awareness of staff about infection control may have improved over time. The hand hygiene cost was estimated using economic costs. We have calculated the fixed cost, including fixed supplies and equipment, plus variable cost, including personnel incentives and consumables. However, these estimates may still underestimate the true costs.

Following a set of generic, transferable costing guidelines needs to be considered in future analyses.

**CONCLUSION**

Improving hand hygiene should be encouraged in the hospitals in developing countries, such as Vietnam, to bring about significant improvement in the quality of health care. With the proven cost savings of this program, it is obvious that all hospitals should pay more attention in supporting hand hygiene programs. If the hospitals cannot afford the cost of hand hygiene, soap, and hand sanitizers, these costs need to be added to the current cost per bed day and charged to insurance companies or other sources of health care funding. Such an approach would be of overall benefit to patients, not only in generating cost savings, but also in reducing morbidity and mortality. Further studies need to be done to provide further understanding of the impact of hand hygiene programs.

**References**