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Major article

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
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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.

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.[7] 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 HAIs.[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

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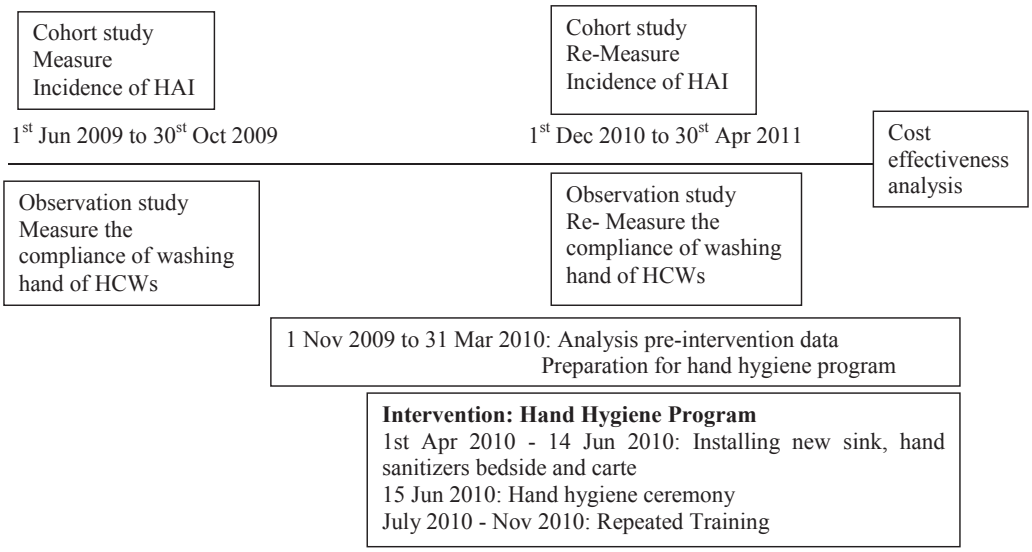

Fig 1. Schema of study. *HAI*, hospital-acquired infection; *HCW*, health care worker.

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%.[9] 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.[9]

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.[10] 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.[11]

The rate of hand hygiene compliance was reported to be as low as 20% in Cho Ray Hospital.[12] An increase of hand hygiene compliance was shown to be related to a reduction in surgical site infections on the surgical department.[13] 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.[14] 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.

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:

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

$$\begin{aligned} \textit{Annual Gross Savings} &= \textit{Costs of HAIs}_{\textit{Intervention}} - \textit{Costs of HAIs}_{\textit{No intervention}} \\ &= (\textit{HAIs}_{\textit{Internvention}} - \textit{HAIs}_{\textit{No internvention}}) \times \textit{Mean attributable cost HAI} \end{aligned}$$

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 computerized 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 HAIs 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 preintervention 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:

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:

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

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

Table 1
Characteristics of patients

Patient characteristics	Preintervention (n = 486)	Postintervention (n = 498)	*P* value
Age (y)	45.3 ± 20.3	44.5 ± 20.7	.54
Sex, male	331 (68.3)	322 (64.7)	.25
Underlying diseases	139 (28.7)	147 (29.6)	.76
APACHE score	15.3 ± 6.5	13.4 ± 6.6	.68
Coma	251 (51.8)	270 (54.3)	.46
Glasgow Coma Scale	6.7 (2.3)	6.3 (2.7)	.09
Operations	112 (23.0)	118 (23.7)	.92
Intubation	430 (88.5)	442 (88.8)	.46
Tracheotomy	125 (25.7)	126 (25.3)	.86
Mechanical ventilation	265 (54.5)	276 (55.4)	.65
Central line	96 (19.7)	101 (20.3)	.62

NOTE. Values are n (%), mean ± SD, or as otherwise indicated.
APACHE, Acute Physiology and Chronic Health Evaluation.

Table 2
Comparison of hand hygiene compliance in pre- and postintervention periods

Hand hygiene compliance	Preintervention (n = 3,010)	Postintervention (n = 3,033)	*P* value
Total compliance rate	775 (25.7)	1745 (57.5)	<.001
Categorized by 5 moments			<.001
Before patient contact	178/1,049 (17.0)	410/765 (53.6)	
Before aseptic procedures	131/412 (31.8)	193/364 (53.0)	
After blood or body fluid contact	149/263 (56.7)	210/268 (78.4)	
After patient contact	273/936 (29.2)	744/1,095 (67.9)	
After environment contact	80/350 (2.3)	188/541 (34.8)	
Categorized by participants			<.001
Physicians	197/741 (26.6)	456/748 (60.9)	
Nurses	505/1,923 (26.3)	780/1,243 (62.8)	

NOTE. Data are presented as n (%) or as otherwise indicated.

pneumonia (16.1% vs 21.6%, $P = .005$), ventilator-associated pneumonia (23.7 vs 42.2/1,000 ventilator days), surgical site infections (6.5% vs 11.1%, $P = .001$), hospital-acquired bloodstream infections (1.2% vs 1.4%), central line–associated bloodstream infections (2.8 vs 4.2/1,000 catheter days, $P = .05$), urinary tract infections (3.8% vs 5.7%), and catheter-associated urinary tract infections (6.5 vs 8.2/1,000 catheter days, $P = .02$). Risk factors of HAIs before the intervention were old age (odds ratio [OR] = 3.38; 95% confidence interval [CI], 2.32-4.93), underlying diseases (OR = 2.45; 95% CI, 1.73-3.49), presence of tracheotomy (OR = 7.39; 95% CI, 3.54-15.40), and requiring mechanical ventilation (OR = 4.99; 95% CI, 2.98-8.38). The risk factors of HAIs after the intervention were old age (OR = 3.36; 95% CI, 2.36-4.76) and underlying disease (OR = 2.2; 95% CI, 1.56-3.11).

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%. According to the WHO's My 5 Moments for Hand Hygiene, the compliance was 17% before patient contact, 31.8% before aseptic procedures, 56.7% after blood or body fluid contact, 29.2% after patient contact, and 12.3% after environmental contact. No significant differences in compliance were detected per type of HCW.

During the postintervention period, there were 3,033 observations, with the following distribution: nurses (74.6%), physicians (24.7%), technicians (0.4%), and others (0.5%).The average compliance was 57.5% and was significantly higher compared with preintervention ($P < .001$) (Table 2). The compliance was 53.6% before patient contact, 53.0% before aseptic procedures, 78.4% after blood or body fluid contact, 67.9% (288/428) after patient contact, and 34.8% after environment contact. The compliance among participants was 60.9% among physicians, 56.5% among nurses, and 66.7% among others.

Cost-effectiveness analysis

Costs of HAI

The mean cost for patients with an HAI overall was $1,908, which is 2.5 times higher than the costs for patients without an HAI ($777). The mean attributable cost of HAI was $1,131. Detailed cost estimates by different categories of hospital charges are presented in Table 3. The greatest contributor to costs was medication costs.

Cost of the intervention program

The cost of the intervention program was calculated based on the resources used during the program. The total cost (including fixed costs and variable costs) of the hand hygiene program was $12,570 (Table 4). The variable costs were $5,530. Given an estimated patient population of 850 ICU and CCU patients over the 10-month intervention period, this equates to a per-patient cost of $6.5.

Cost-effectiveness analysis

The incidence of HAIs decreased from 31.7% in the preintervention 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).

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.[14,16] 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.[1,17] 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 doctors and nurses before and after the intervention. This is different from other studies that show that nurses usually have higher compliance than doctors. The reasons for this is unclear. It is possible that Vietnamese culture or education may be important in this, but this requires a different kind of investigation.

The assessors for hand hygiene compliance were not naïve to the intervention, which may cause observation bias. However, the assessors were trained to evaluate the compliance using a standard

Table 3
Hospital costs stratified by HAIs in details

Cost	Food and bed		Medication		Equipment		Laboratory		Imaging		Other	
	HAI	No HAI	HAI	No HAI	HAI	No HAI	HAI	No HAI	HAI	No HAI	HAI	No HAI
Mean ± SD	211.9 ± 223.3	75.4 ± 72.5	1,113.6 ± 1,070.1	359.6 ± 382.8	188.5 ± 104.4	101.5 ± 92.8	49.3 ± 55.1	11.6 ± 17.4	307.4 ± 275.5	174 ± 179.8	150.8 ± 165.3	58 ± 75.4
% of total	8.9		56.3		9.0		1.8		18.9		5.1	

HAI, hospital-acquired infection.

Table 4
Cost of the hand hygiene program

Resources	Quantity	Units	Cost/unit	Total cost
Fixed cost				
Supplies and equipment				
New sinks	20	Piece	102	2,040
Dispensers	40	Piece	50	2,000
Training materials	100	Set	8	800
Pamphlets	2,500	Piece	0.4	1,000
Posters	20	Piece	60	1,200
Total				7,040
Variable cost				
Personnel incentives				
Trainers	10	Month	50	500
Clinical staff	10	Month	50	500
Dispensers maintenance staff	10	Month	30	300
Supplies and equipment				
Handwashing solution	220	Bottle	4.5	990
Hand sanitizer solution 500 mL	450	Bottle	3.2	1,440
Hand sanitizer solution 50 mL	1,000	Bottle	1.8	1,800
Total				5,530
Grand total				12,570

Table 5
Calculation of the cost-effectiveness of the intervention

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

HAI, hospital-acquired infection; *SSI*, surgical site infection.

method according to WHO guidelines.[14] 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.[13] 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[18] or €12,853 for hospital-acquired bacteremia in a Belgian hospital.[19] 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.[6,7,20] 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 6
Sensitive analysis

Situation	Attributable cost	Intervention cost	Preintervention		Postintervention		Incremental cost
			Rate	Cost	Rate	Cost	
Base case	1,131	6.5	31.7	35,852.7	20.3	23,609.3	-12,243.4
Change rate of HAI							
			31.7		25.3	29,264.3	−6,588.4
					31.1	35,824.1	−28.6
Change attributable cost of HAI							
	500			15,850		10,800	-5,050
	58			1,827		1,838	−11.2
Change cost of intervention							
		65		35,852.7		29,459.3	-6,393.4
		129				32,034.3	−6.6

HAI, hospital-acquired infection.

cost effectiveness to be €622 per HAI prevented.[21] 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.[22] 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

1. Al-Tawfiq JA, Abed MS, Al-Yami N, Birrer RB. Promoting and sustaining a hospital-wide, multifaceted hand hygiene program resulted in significant reduction in health care-associated infections. Am J Infect Control 2013;41:482-6.
2. Alp E, Altun D, Cevahir F, Ersoy S, Cakir O, McLaws ML. Evaluation of the effectiveness of an infection control program in adult intensive care units: a report from a middle-income country. Am J Infect Control 2014;42:1056-61.
3. Souweine B, Lautrette A, Aumeran C, Bénédit M, Constantin JM, Bonnard M, et al. Comparison of acceptability, skin tolerance, and compliance between handwashing and alcohol-based handrub in ICUs: results of a multicentric study. Intensive Care Med 2009;35:1216-24.
4. Hilburn J, Hammond BS, Fendler EJ, Groziak PA. Use of alcohol hand sanitizer as an infection control strategy in acute care facility. Am J Infect Control 2003;31:109-16.
5. Chen YC, Sheng WH, Wang JT, Chang SC, Lin HC, Tien KL, et al. Effectiveness and limitations of hand hygiene promotion on decreasing healthcare-associated infections. PLoS One 2011;6:e27163.
6. Akyol A, Ulusoy H, Ozen I. Handwashing: a simple, economical and effective method for preventing nosocomial infections in intensive care units. J Hosp Infect 2006;62:395-405.
7. Pittet D, Sax H, Hugonnet S, Harbarth S. Cost implications of successful hand hygiene promotion. Infect Control Hosp Epidemiol 2004;25:264-6.
8. Capretti MG, Sandri F, Tridapalli E, Galletti S, Petracci E, Faldella G. Impact of a standardized hand hygiene program on the incidence of nosocomial infection in very low birth weight infants. Am J Infect Control 2008;36:430-5.
9. Muc PD. Therapy department. Ministry of Health of Vietnam Evaluation of infection control activities in hospitals in Vietnam. [In Vietnamese]. J Med Practice 2009;20:97-102.
10. Tien NP, Van DT, Thoa VT, Thu Le TA. Situation of nosocomial infections at Cho Ray Hospital. [In Vietnamese]. J Med Practice 2012;518:47-8.
11. Đang TV, Le TA Evaluation of knowledge, attitude and behaviour of health care workers about infection control practices. [Vietnamese]. J Med Practice 2005;518:117-22.
12. Dang TV, Le TA Hand hygiene compliance rate based on WHO the 5 moments. [Vietnamese]. Journal of Ho Chi Minh Medicine 2010;14:436-8.
13. Le TA, Dibley MJ, Vo VN, Archibald L, Jarvis WR, Sohn AH. Reduction in surgical site infections in neurosurgical patients associated with a bedside hand hygiene program in Vietnam. Infect Control Hosp Epidemiol 2007;28:583-8.
14. World Health Organization. World Alliance for Patient Safety. WHO guidelines on hand hygiene in health care 2009. Geneva, Switzerland: WHO Press; 2009.

15. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control 2008;36:309-32.
16. Allegranzi B, Storr J, Dziekan G, Leotsakos A, Donaldson L, Pittet D. The First Global Patient Safety Challenge "Clean Care is Safer Care": from launch to current progress and achievements. J Hosp Infect 2007;(65 Suppl): 115-23.
17. Chun HK, Kim KM, Park HR. Effects of hand hygiene education and individual feedback on hand hygiene behaviour, MRSA acquisition rate and MRSA colonization pressure among intensive care unit nurses. Int J Nurs Pract; 2014 Oct 30. [Epub ahead of print].
18. Plowman R, Graves N, Griffin MA, Roberts JA, Swan AV, Cookson B, et al. The rate and cost of hospital-acquired infections occurring in patients admitted to selected specialties of a district general hospital in England and the national burden imposed. J Hosp Infect 2001;47:198-209.
19. Pirson M, Dramaix M, Struelens M, Riley TV, Leclercq P. Costs associated with hospital-acquired bacteraemia in a Belgian hospital. J Hosp Infect 2005;59:33-40.
20. Song X, Stockwell DC, Floyd T, Short BL, Singh N. Improving hand hygiene compliance in health care workers: strategies and impact on patient outcomes. Am J Infect Control 2013;41:e101-5.
21. Huis A, Hulscher M, Adang E, Grol R, van Achterberg T, Schoonhoven L. Cost-effectiveness of a team and leaders-directed strategy to improve nurses' adherence to hand hygiene guidelines: a cluster randomised trial. Int J Nurs Stud 2013;50:518-26.
22. Page K, Graves N, Halton K, Barnett AG. Humans, 'things' and space: costing hospital infection control interventions. J Hosp Infect 2013;84:200-5.