

ORIGINAL ARTICLE

Effectiveness of Multifaceted Hand Hygiene Interventions in Long-Term Care Facilities in Hong Kong: A Cluster-Randomized Controlled Trial

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OBJECTIVE. To determine the effectiveness of World Health Organization (WHO) multimodal strategy in promoting hand hygiene (HH) among healthcare workers (HCWs) in long-term care facilities (LTCFs).

DESIGN. Cluster-randomized controlled trial.

SETTING. Eighteen homes for the elderly in Hong Kong were randomly allocated to 2 intervention arms and a control arm. Direct observation of HH practice was conducted by trained nurses. Either handrubbing with alcohol-based handrub (ABHR) or handwashing with liquid soap and water was counted as a compliant action. Disease notification data during 2007–2010 were used to calculate incidence rate ratio (IRR).

PARTICIPANTS. Managers and HCWs of the participating homes.

INTERVENTIONS. The WHO multimodal strategy was employed. All intervention homes were supplied with ABHR (WHO formulation I), ABHR racks, pull reels, HH posters and reminders, a health talk, video clips, training materials, and performance feedback. The only difference was that intervention arms 1 and 2 were provided with slightly powdered and powderless gloves, respectively.

RESULTS. A total of 11,669 HH opportunities were observed. HH compliance increased from 27.0% to 60.6% and from 22.2% to 48.6% in intervention arms 1 and 2, respectively. Both intervention arms showed increased HH compliance after intervention compared to controls, at 21.6% compliance (both $P < .001$). Provision of slightly powdered versus powderless gloves did not have any significant impact on ABHR usage. Respiratory outbreaks (IRR, 0.12; 95% confidence interval [CI], 0.01–0.93; $P = .04$) and methicillin-resistant *Staphylococcus aureus* infections requiring hospital admission (IRR, 0.61; 95% CI, 0.38–0.97; $P = .04$) were reduced after intervention.

CONCLUSIONS. A promotion program applying the WHO multimodal strategy was effective in improving HH among HCWs in LTCFs.

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The World Health Organization (WHO) promulgates hand hygiene (HH) as the single most important method to prevent and control healthcare-associated infections. In a study done in 2000, Pittet et al¹ showed that a multimodal, multidisciplinary strategy was needed to improve HH compliance. A well-designed campaign could produce sustained improvement in compliance, coinciding with a reduction of nosocomial infections and methicillin-resistant *Staphylococcus aureus* (MRSA) transmission.² Promotion of bedside antiseptic handrub contributed greatly to the increase in compliance.² Performance feedback was studied as an intervention to improve HH compliance.²⁻⁴ Alcohol-based handrub (ABHR) has been shown to be efficient and effective in protecting patients and healthcare workers (HCWs).^{5,6} Most studies on HH fo-

cused on hospital settings. Publications on long-term care facilities (LTCFs)⁷⁻⁹ were fewer.

The government of the Hong Kong Special Administrative Region (SAR) pledged support to WHO's First Global Patient Safety Challenge: Clean Care is Safer Care in 2005. Since then, HH programs have been conducted in public hospitals and clinics.

There are 4 types of LTCFs for the elderly in Hong Kong.¹⁰ They are classified according to nursing staff-to-resident ratios and residents' impairment levels. Nursing homes provide residential care to the most dependent, followed by care and attention (C&A) homes, homes for the aged, and hostels for the elderly. C&A homes provide 93% of residential-care places. The majority of them are private homes that are profit

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making and have limited resources for infection control. The remaining homes are non-profit-making subvented homes that receive subsidies from the government, have more resources, and are more spacious.

The Infection Control Branch (ICB) conducted a prospective interventional study adopting the WHO multimodal strategy in 8 nursing homes from May 2007 to January 2008. We found that HH compliance of HCWs increased from 45% at baseline to 80% at 4 months after intervention. After the pilot study, we decided to test whether a similar model could be applied in C&A homes, which have 1 registered nurse on duty during a given shift and are the most common type of home for the elderly in Hong Kong.

OBJECTIVES

1. Determine the effectiveness of the WHO multimodal strategy in promoting HH among HCWs in C&A homes.
2. Test whether provision of powderless gloves could lead to higher usage of ABHR, compared to use of slightly powdered gloves.
3. Evaluate the effectiveness of the intervention in reducing respiratory outbreaks and MRSA infections requiring hospitalization.
4. Explore the feasibility of resident participation in reminding HCWs to perform HH.

METHODS

Design

The study was a cluster-randomized controlled trial with 3 arms (2 intervention and 1 control), conducted in 4 phases (baseline, intervention, and 1 and 4 months after intervention) from November 2009 to July 2010. Intervention arms 1 and 2 were provided with slightly powdered and powderless gloves, respectively. Participants, but not observers, were blinded to the allocation to intervention or control arms.

Sample Size Calculation

We assumed that HH compliance was 45% at baseline, remained constant in the control arm, and increased to 60% and 75% in intervention arms 1 and 2, respectively, after intervention. With a statistical power of 80%, it was necessary to observe 150 HH opportunities in each phase in each arm. Assuming that 10 observations were made on each HCW and an intraclass correlation coefficient of 0.1703, the design effect was 2.5327 at the HCW level. Assuming that 20 HCWs were observed from each home and an intraclass correlation coefficient of 0.09729, the design effect was 2.8485 at the home level. Hence, 5 homes were needed in each arm. Assuming a 10% dropout rate, we recruited 6 homes in each arm.

Participants

We targeted the 109 subvented C&A homes because they had more resources and their management was generally more positive toward government initiatives. The 37 homes that had fewer than 50 bed places or were participating in other intervention programs were excluded. The 72 eligible homes were randomly allocated to one of the 3 arms with a random number generator. Phone calls were made according to a randomly generated order until 6 homes were successfully recruited in each arm. Our observation targets were HCWs, including doctors, registered/enrolled nurses (RN/EN), physiotherapists/occupational therapists (PT/OT), personal-care workers/assistants (PCW/A), and health workers (HW) of the participating homes.

Intervention

The WHO multimodal strategy was employed. All intervention homes received the same package of intervention, except that intervention arms 1 and 2 were provided with slightly powdered and powderless gloves, respectively. All were supplied with 100-mL pocket-size and 500-mL pump-size ABHR (WHO formulation I), ABHR racks to be placed at points of care, and pull reels to facilitate carriage of pocket-size ABHR. Colorful posters of 4 different designs and reminders of 4 different designs depicting HH indications such as tube feeding and changing diapers and proper HH techniques were supplied for posting in the intervention homes.

A 2-hour health talk was delivered by trained ICB nurses to HCWs of each intervention home. Topics included rationale, indications, and techniques for HH, methods to prevent skin dryness, and indications for glove use, with its limitations. Video clips tailor-made to HCWs' working environment were shown, and HH opportunities were pointed out to them. To convince HCWs that ABHR would not cause skin dryness, we measured the skin moisture level with a moisture checker before and after application of ABHR. A hand inspection cabinet and fluorescent dye were used as training aids to demonstrate the importance of proper HH techniques. We also employed the train-the-trainer approach and provided training materials (PowerPoint and video) to each intervention home so that new recruits to the homes could be trained subsequently. Furthermore, immediate feedback to HCWs was provided at the time of direct observation, and performance reports with anonymous and aggregated data were delivered to the management of each intervention home after each phase of data collection.

ABHR, gloves, posters, reminders, video clips, and performance feedback were not provided to the control homes. A different 2-hour health talk was delivered by trained ICB nurses to HCWs of each control home. Topics included personal, food, and environmental hygiene, healthy eating, and regular exercise. HH was mentioned as a component of personal hygiene, but nothing was said about HH indications and techniques.

Outcome Measures

Direct observation of HH practice. Direct observation of HH practice of HCWs in the participating homes was conducted at the baseline and 1 and 4 months after intervention by 8 trained ICB nurses. Interrater reliability was tested, and Cohen's Kappa ranged from 0.96 to 1.00. A standardized observational form consisting of the WHO 5 moments for HH was used, and the observed activities were recorded.¹¹ Two observers visited a home in both morning and afternoon sessions during each phase of observation. Either handrubbing with ABHR or handwashing with liquid soap and water was counted as a compliant action. HH compliance of each home was calculated by dividing the total number of compliant actions by the total number of HH opportunities observed. Stratified HH compliance rates in intervention homes were calculated with respect to the WHO 5 moments, activity index, and type of HCW.

Infection data. Disease notification data during March–September of 2007–2010 were used to calculate the incidence rate ratio (IRR). Data from the same 7 months of each year were selected to account for seasonal variations. Data on respiratory outbreaks requiring hospitalization in the participating homes were extracted from the Centre for Health Protection central notification system, whereas data on MRSA

admissions were extracted from the MRSA Surveillance System of the Hospital Authority.

Feedback from intervention homes. To explore the effectiveness of the program and the feasibility of resident participation in reminding HCWs to perform HH, exploratory interviews and a structured focus group were conducted for managers and frontline HCWs of the intervention homes, respectively. The manager of each intervention home was invited to nominate 1 HCW to participate in the focus group.

Statistical Methods

Demographics of the control and intervention arms were compared by means of a χ^2 test for categorical variables and the Kruskal-Wallis test for continuous variables. Generalized estimating equations (GEEs) with robust estimates of variance were used to account for correlations of observations within a home. A binomial GEE was used to compare HH compliance between control and intervention arms. A Poisson GEE was used to examine the impact of intervention on the number of outbreaks and infections. An intervention dummy variable was created (1 for after intervention, 0 for no intervention). Adjusted IRRs were estimated by a model accounting for year and group effects. Statistical analyses were

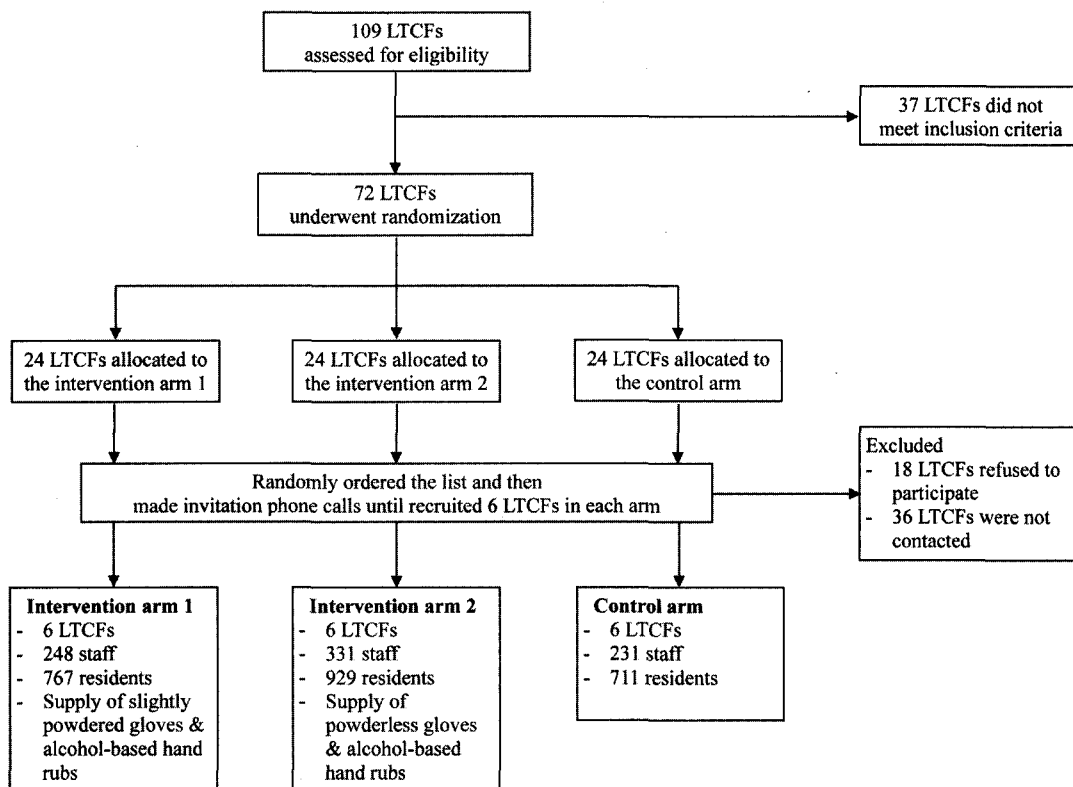


FIGURE 1. Flow diagram of long-term care facility (LTCF) recruitment in the hand hygiene program.

TABLE 1. Baseline Demographic Characteristics

Characteristics	Intervention arm 1 (6 homes)	Intervention arm 2 (6 homes)	Control arm (6 homes)	<i>P</i>
Size, no. of houses				.645
51–100 residents	2	2	4	
101–180 residents	3	2	1	
>180 residents	1	2	1	
No. of residents/no. of staff (ratio)	767/248 (3.1 : 1)	929/331 (2.8 : 1)	711/231 (3.1 : 1)	.372 ^a
Residents with dementia (%)	370 (48.2)	437 (47.0)	224 (31.5)	.359 ^a
No. of HCWs (%) ^b				
Sex				.014
Male	11 (6.1)	11 (4.5)	22 (11.6)	
Female	169 (93.9)	232 (95.5)	167 (88.4)	
Age, years				.389
21–30	15 (8.2)	11 (4.5)	19 (9.5)	
31–40	32 (17.4)	54 (22.2)	35 (17.4)	
41–50	86 (46.7)	107 (44.0)	87 (43.3)	
>50	51 (27.7)	71 (29.2)	60 (29.9)	
Type of HCW				.385
RN/EN	37 (19.4)	55 (20.5)	38 (18.3)	
HW	25 (13.1)	28 (10.4)	36 (17.3)	
PCW/A	115 (60.2)	173 (64.3)	122 (58.7)	
PT/OT	14 (7.3)	13 (4.8)	12 (5.8)	
Years of working in LTCFs				.131
0–1	16 (8.5)	40 (15.4)	27 (13.4)	
2–5	60 (31.9)	86 (33.1)	75 (37.1)	
>5	112 (59.6)	134 (51.5)	100 (49.5)	

NOTE. HCW, healthcare worker; HW, health worker; LTCF, long-term care facility; PCW/A, personal-care worker/assistant; PT/OT, physiotherapist/occupational therapist; RN/EN, registered/enrolled nurse.

^a By Kruskal-Wallis test; the rest were by Pearson χ^2 test.

^b The total number of HCWs may not add up to 810 because of missing data.

performed with STATA, version 10.1. The threshold for statistical significance was $P \leq .05$.

Ethical Issues

The study was approved by the Ethics Committee of the Department of Health, Hong Kong SAR. Verbal consent was obtained from the management and staff representatives of participating homes.

RESULTS

Baseline Characteristics

Thirty-six invitation calls were made, and 18 homes were successfully recruited, an overall response rate of 50% (Figure 1). There was no loss to follow-up of these 18 homes, which had a total of 810 HCWs. The number of floors in each home ranged from 1 to 6. All homes had both male and female

TABLE 2. Hand Hygiene (HH) Compliance Rates in 18 Homes Before and After the Intervention

Phase	Control arm (6 homes)		Intervention arm 1 (6 homes)		Intervention arm 2 (6 homes)	
	Compliance ^a	<i>P</i>	Compliance ^a	<i>P</i>	Compliance ^a	<i>P</i>
Baseline	326/1,671 (19.5)	...	325/1,204 (27.0)	.080	313/1,410 (22.2)	.980
1 month after intervention	299/1,508 (19.8)	...	699/1,181 (59.2)	<.001	763/1,274 (59.9)	<.001
4 months after intervention	301/1,393 (21.6)	...	662/1,093 (60.6)	<.001	454/935 (48.6)	<.001
Change in % within arm ^b	2.1	.851	33.6	<.001	26.4	<.001

^a Proportion of HH opportunities resulting in compliant action (%).

^b Change in HH compliance rates between baseline and 4 months after intervention within each arm.

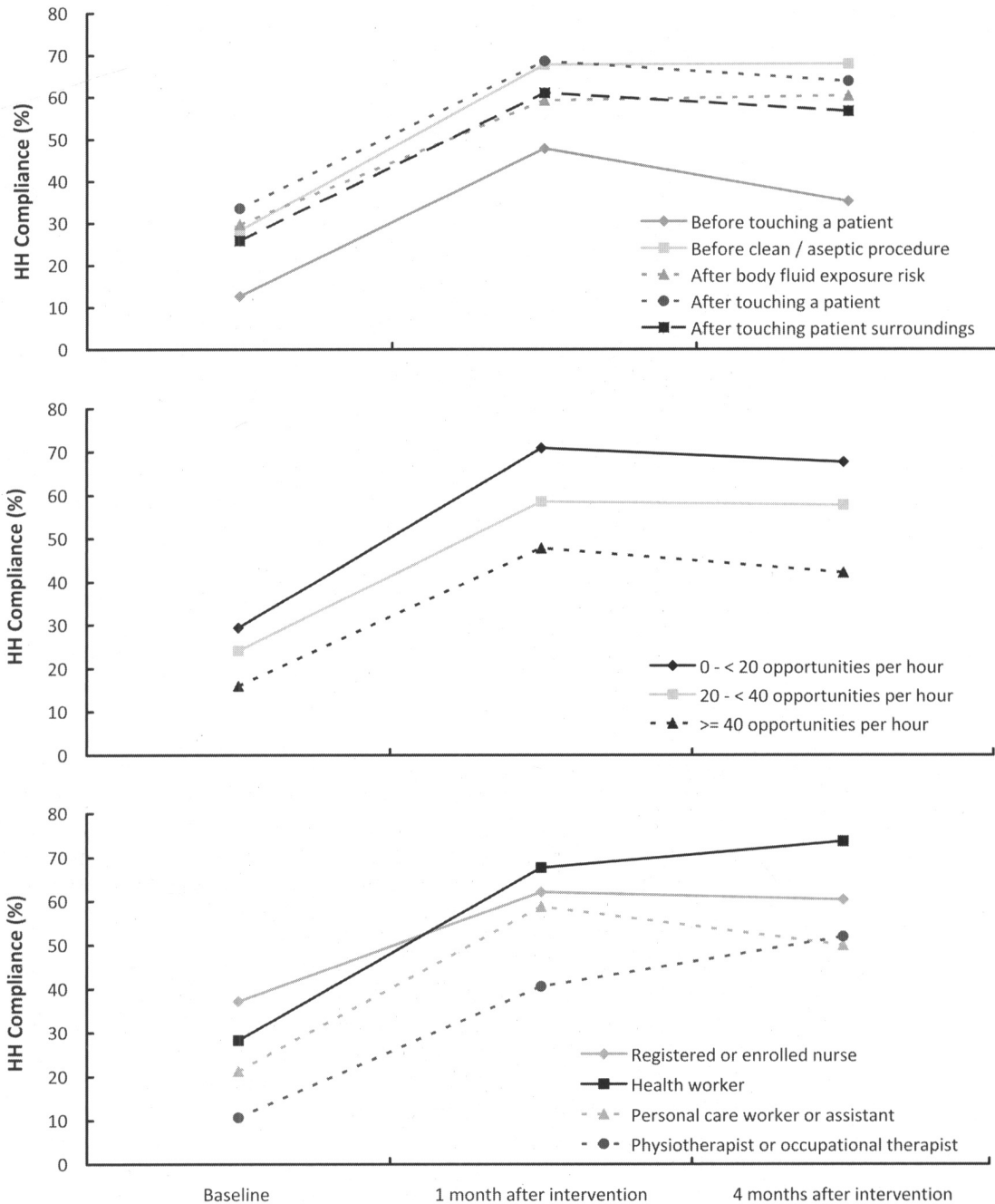


FIGURE 2. Hand hygiene (HH) compliance rates by WHO 5 moments (top), activity index (middle), and type of healthcare worker (bottom) among intervention homes.

residents, except one control home with male residents only. Average occupancy rate was 95%. Residents were aged from 62 to 112 years, and most had chronic underlying diseases.

Baseline demographics were similar among the 3 arms (Table 1). Before the study, different types of ABHR and latex, polyvinyl chloride, and disposable gloves were used in the homes.

HH Compliance

A total of 11,669 HH opportunities (4,285 at baseline and 3,963 and 3,421 at 1 and 4 months after intervention, respectively) were observed, and the total duration of observation was 333 hours. Among HCWs, one visiting doctor accounted for 6 (0.1%) HH opportunities, EN/RN for 1,171

TABLE 3. Respiratory Outbreaks and MRSA Admissions in Participating Homes, March–September 2007–2010

Year	No. of respiratory outbreaks			No. of MRSA admissions		
	Intervention arm 1	Intervention arm 2	Control arm	Intervention arm 1	Intervention arm 2	Control arm
2007	1	2	1	2	8	4
2008	2	1	2	37	27	11
2009	2	5	0	21	32	24
2010	2	0	4	15	47	31

NOTE. MRSA, methicillin-resistant *Staphylococcus aureus*.

(10.0%), HW for 2,335 (20.0%), PCW/A for 7,715 (66.1%), and PT/OT for 442 (3.8%).

HH compliance increased from 27.0% to 60.6% and from 22.2% to 48.6% in intervention arms 1 and 2, respectively (Table 2). Both intervention arms showed increases in HH compliance after intervention compared to controls, where the compliance rate was 21.6% (both $P < .001$). The proportions of ABHR usage among compliant actions increased from 53.2% to 94.6% and from 33.9% to 90.3% in intervention arms 1 and 2, respectively.

Figure 2 depicts the stratified HH compliance rates in intervention homes with respect to the WHO 5 moments, the activity index, and type of HCW. The WHO moment “before touching a patient” and an activity index of at least 40 opportunities/h were associated with less improvement.

Respiratory Outbreaks and MRSA Admissions

Table 3 presents the number of respiratory outbreaks and MRSA infections requiring hospitalization in the participating homes. The risks of respiratory outbreaks (IRR, 0.12; 95% confidence interval [CI], 0.01–0.93; $P = .04$) and MRSA infections requiring hospital admission (IRR, 0.61; 95% CI, 0.38–0.97; $P = .04$) were reduced after intervention.

Feedback from Managers

Managers of the 12 intervention homes were individually interviewed in August 2010. All were satisfied with the program and opined that it could reduce disease transmission and outbreaks. They observed improved HH practice among the frontline HCWs. Most stated that scarcity of resources was the greatest difficulty. Heavy workload and the relatively low education level of HCWs were other obstacles. Most considered resident participation not feasible because the majority of HCWs did not like to be reminded by residents.

Feedback from HCWs

Nine female frontline HCWs participated in a focus group in September 2010. All found the HH posters and reminders helpful. However, the majority of them did not like to be reminded by residents and considered it discouraging and jeopardizing to staff morale. Instead, they suggested investing

more resources in manpower, ABHR, and education of HCWs, residents, and their relatives.

DISCUSSION

We showed that a promotion program applying the WHO multimodal strategy was effective in improving HH compliance among HCWs in participating C&A homes. Since wearing powdered gloves after application of ABHR would lead to feelings of grittiness, it was believed that provision of powderless gloves could increase the willingness of HCWs to use ABHR instead of liquid soap and water, but this was not shown by our data. The risks of respiratory outbreaks and MRSA infections requiring hospital admission were reduced after intervention.

Compared to the cross-sectional studies conducted in Canada⁷ and Italy,⁸ which showed baseline HH compliances of 14.7% and 17.5%, respectively, LTCFs in Hong Kong had higher baseline compliance. Our pilot study in nursing homes revealed a baseline compliance of 45.4%. Another local study, conducted by Yeung et al,⁹ showed a baseline compliance of 25.8%. Our study in C&A homes revealed baseline compliance ranging from 19.5% to 27.0%.

A prospective interventional trial conducted in the United States showed that introduction of ABHR increased self-reported HH compliance but resulted in no change in nosocomial infection rates.⁶ The Yeung group’s study was a clustered, randomized controlled trial, and the LTCFs were recruited via snowball sampling.⁹ Their 6 participating homes were a mixture, with different sources of funding, nursing staffing levels, and residents’ impairment levels.⁹ Their interventions were based on the WHO model and consisted of provision of ABHR, reminder materials, and education for HCWs.⁹ Performance feedback was not included in their original plan but was added in the middle of the trial because of a decrease in HH compliance.⁹ They revealed an increase of compliance from 25.8% at baseline to 33.3% at 7 months after intervention.⁹ They also showed reduced incidence of serious infections per 1,000 resident-days after intervention.⁹

There were potential limitations in our study. We did not have demographics for the homes that refused to participate. Selection bias was possible because participating homes might have been more enthusiastic toward HH promotion. Observers were not blinded to the allocation of homes. HCWs

being observed might have behaved differently in the presence of outsiders. All might have been biased toward overestimation of compliance in intervention homes. Differences in baseline HH compliance rates were observed among the 3 arms. Homes allocated to intervention arm 1 had the highest HH compliance throughout the study. This bias probably resulted from the process of recruiting participating homes.

Impact on milder infections that did not require hospitalization was not assessed. However, our data sources provided reliable information on severe infections because more than 90% of hospitalizations in Hong Kong took place in Hospital Authority facilities.

In a study conducted in 2004, McGuckin et al¹² found that a patient education model was successful in improving HH compliance among HCWs. However, the idea of resident participation was not accepted by HCWs in local C&A homes. They did not like to be reminded to perform HH by the residents. This is probably because Chinese culture generally does not welcome the potential for dispute.

In conclusion, our study showed that a promotion program applying the WHO multimodal strategy was effective in improving HH among HCWs in LTCFs.

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Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

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