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Major Article

A program to improve the hand hygiene compliance of Hong Kong preschoolers with an insight into their absenteeism

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Background: Hand hygiene prevents cross-infection and is the most effective defense against contagious diseases. Preschoolers, without proper hand hygiene skills, are a vulnerable group to such diseases. The aim of this study was to evaluate whether hand hygiene compliance training of preschoolers in Hong Kong improves their hand hygiene knowledge and performance, and whether the training reduces their absenteeism resulting from influenza symptoms.

Methods: This was a quasi-experimental study with a pretest-posttest design. A total of 110 preschoolers participated in a program consisting of 4 training sessions on hand hygiene. Before and after the program, their hand hygiene knowledge was assessed by 10 true or false questions, and their handwashing skills were assessed by photos of their hands taken before and after handwashing. Before handwashing, a fluorescent stain gel was used to cover their hands. To determine whether a causal relationship existed between compliance and absenteeism, the preschoolers' absenteeism data were collected during a period of 3 months for analysis.

Results: Significant differences were found in hand hygiene knowledge on handwashing steps, duration, and after playing with toys. Percentage increases were recorded for 8 questions. There was significant improvement in hand hygiene performance on the fronts and the backs of fingers, thumbs, and fingertips ($P < .05$). The findings showed a decrease in absence rates with influenza symptoms for the month before (31%), during (30%), and after (25%) the completion of the program in all participating schools.

Discussion: After the training program, the participants' hand hygiene knowledge and performance considerably improved. They washed their hands more thoroughly and there was a significant reduction in absences owing to influenza.

Conclusions: Good cooperation between schools and families is found to be important in helping students build positive attitudes and habits, even in performing simple routines like hand hygiene.

Influenza outbreaks occur every year. Pathogens, such as influenza viruses, can spread easily. Nonpharmaceutical interventions, such as hand hygiene,[1] if implemented properly, can help stop the spread of pathogens in community settings. To contain an infectious disease, we must intervene at an early stage of an outbreak. In this regard, we developed a structured program to train preschoolers, a vulnerable group, proper hand hygiene. The negative consequences of an influenza outbreak can be very great. For example, the statistics presented by the Department of Education in England showed 5,890,790 children missed school days in 2009-2010, mainly owing to illness. The 5 most common illnesses causing these children to stay away from school were the common cold, sore throats, stomach bugs, ear infections, and conjunctivitis. Many of these illnesses could be avoided if stringent infection control practices were established and implemented.[2] In Hong Kong, approximately 462 cases (2%) per month were attributable to sickness-related absenteeism in childcare centers and kindergarten schools in 2016.[3] From these statistics, absenteeism was defined as the number of episodes of acute respiratory illness per child per month and most of these cases involved cough (68.35%) and fever (65.82%).[3]

The physical environment in schools plays a key role in promoting hand hygiene. Hand hygiene, including handwashing or using alcohol handrub, is 1 of the health habits that may provide lifetime benefits

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in preventing infection when this is developed as a habit at an early age.[4] The importance of hand hygiene, however, has been overlooked because it has been taken for granted that it is a trivial routine that everybody knows. To remedy the situation, a preventive measure like hand hygiene requires proper training and active collaboration among school administrators, teachers, and health care professionals to make it work.

Hand hygiene information and training materials are important for the success of infection control in schools. Unfortunately, they are mostly designed for health care workers in health care settings, such as hospitals and nursing homes. A structured education program in local school settings has yet to be developed to consolidate, guide, and evaluate hand hygiene practices. For general practices, adaptation can be derived from the "Five Moments for Hand Hygiene," which has been developed by the World Health Organization (WHO) on the basis of its guidelines on hand hygiene in health care, although the guidelines, associated tools, and training kits focused on the spread of infections in health care settings and did not describe their application in community environments. Modification of these materials is needed for the school environment. With this in mind, we aimed to develop such a program and use it to train local preschoolers in hand hygiene compliance (washing one's hands in all hand hygiene opportunities) and subsequently evaluate its effectiveness in reducing absenteeism by direct observation.[5]

METHODS

This study adopted a quasi-experimental study with a pretest-posttest design. Ethics approval was granted by the university's human research ethics committee. Letters were sent to the principals of 15 kindergartens in Hong Kong to invite their preschool (K3) students to participate. The target participants were preschoolers aged 5-6 years. Both the schools and parents of the selected participants were informed about the objectives of the study, and their written consent was duly obtained.

The structured hand hygiene program was designed based on WHO and the Centers for Disease Control and Prevention guidelines by our research team. It consisted of 4 sessions, 1 per week for 4 consecutive weeks, with each session lasting for 45 minutes. In the sessions, information was given by an infection control nurse about common infectious diseases in children (ie, influenza and hand, foot, and mouth disease), personal hygiene (proper mask wearing and removal, 7-step hand hygiene technique),[3] and hygiene in school and household scenarios. The participating preschoolers had to learn the information provided in the program and answer 10 true or false questions on hand hygiene knowledge (eg, "There are 7 steps for proper hand hygiene." Is this right or wrong?) before and after the hand hygiene program. Table 1 shows the 10 true or false questions.

The questionnaire was used to assess the hand hygiene knowledge of the preschoolers. A panel of 3 experts affirmed its content validity. A test-retest reliability was obtained by inviting 5 kindergarten teachers and kindergarteners who were not involved in this study to complete the questionnaires. The scale-level content validity index was calculated to be 0.86, and content validity was established. For the test-retest reliability, the Pearson correlation coefficient was 0.75, indicating good correlation between the 2 measurements.

To investigate the preschoolers' hand hygiene skills, they were required to perform hand hygiene techniques with the help of a fluorescent stain gel (Brevis Corporation, South Salt Lake City, UT) as the germ tracker. A small amount (3 mL) of fluorescent stain gel was applied to the preschoolers' palms, which the preschoolers subsequently rubbed with hand soap before rinsing with water. In the process, pictures of the participating preschoolers' hands were taken, before and after handwashing. The colored stain on their hands was only visible through the use of an ultraviolet lamp. The percentages of the hands (backs and palms) of the preschoolers with color were computed by ImageJ software (http://imagej.nih.gov/ij/docs/index.html) to assess their skills in 2 steps: (1) before handwashing and (2) after handwashing. Before handwashing, the higher the percentage of colored areas on the preschoolers' hands, the more thoroughly they had rubbed their hands with the gel. After handwashing, the colored (dirty) areas on their hands represented the parts they missed washing. The lower the percentage of the hands with colored (dirty) areas, the better was the hand hygiene performance of the preschooler. Hand hygiene skills were compared via the pictures taken before and after handwashing by a preschooler, first with the third time handwashing and second with the fourth time handwashing, before and after the program (Fig 1).

An indicator of hand hygiene compliance and behavioral change of the preschoolers was constructed using the kindergartens' monthly influenza-related absenteeism records. All preschooler absences were recorded by school administrative staff for 3 consecutive months (ie, from the month before the training to the month after). The staff had recorded the names of the preschoolers, with their respective dates of absence and the reasons for their absence, in a standardized absentee form, which could easily record any influenza symptoms. The influenza symptoms (fever, cough, sore throat, runny nose, muscle pain, fatigue, headache, diarrhea, and vomiting) were suggested according to the guidelines issued by the Centre for Health Protection.[6] To show the seriousness of absenteeism for a preschooler, his or her absentee rate would be calculated, with his or her absent days divided by the total number of days under observation.

Within 1 month before, during, and after the training program, the parents were asked to submit a weekly report on any influenza symptoms of their participating children for the compilation of an index of hand hygiene compliance and behavioral change. These influenza

Table 1
True or false statements to assess preschoolers' hand hygiene knowledge

Statements on hand hygiene knowledge	Correct answers before training program (%)	Correct answers after training program (%)	McNemar test (P <.05)
1. There are 7 steps for proper hand hygiene.	57	89	.001
2. Proper hand hygiene takes 20 s to complete.	62	98	.001
3. We must wash our hands after using the toilet.	91	100	.063
4. We must wash our hands before eating.	86	97	.109
5. We do not need to wash our hands after playing with toys.	34	94	.001
6. We should wash our hands immediately when returning home.	97	97	1.000
7. We should apply soap when washing our hands.	89	100	.031
8. We can use alcohol handrub instead of water to clean our hands when no water is available.	82	100	.001
9. Proper hand hygiene is the most effective way to prevent infectious diseases.	94	94	1.000
10. We should not cough without covering our mouths when facing others.	83	95	.039

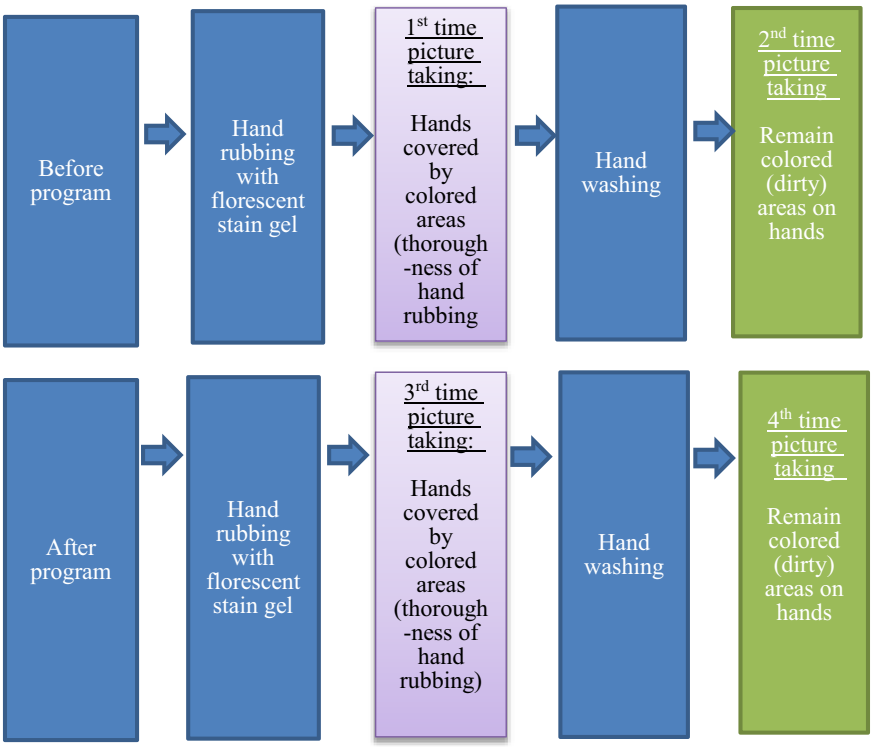

Fig 1. Measured colored areas of hands before and after the hand hygiene training program.

symptoms were recorded along with their sick leave records. Within these 3 months, the preschoolers were also observed and recorded by teachers on whether the preschoolers had washed their hands after toileting at school.

Data analysis

The Student t test for continuous variables was used to examine the change in hand hygiene skills before and after the intervention. In addition, 1-way analysis of variance was performed to obtain a pre and postassessment as a within-subject variable. The Pearson correlation analysis was conducted to determine the relationship between the hand hygiene compliance and absenteeism of the participants. The statistical significance for this study was set at $P < .05$.

RESULTS

Knowledge and attitude

A total of 114 K3 students had consented to participate in the program; however, 4 students had to drop out because of sickness. Of the remaining 110 preschoolers, 64.5% were boys and 35.5% were girls. The preschoolers had to answer 10 true or false questions on hand hygiene to enable the research team to compare their knowledge before and after the training program. It was observed that the percentages in correct scores for 8 of the questions (ie, questions 1, 2, 3, 4, 5, 7, 8, and 10) had increased with the exception of 2 questions (ie, questions 6 and 9), the percentages of which had remained the same without any change. The percentage of the participating kindergarteners who knew that there were 7 steps in the hand hygiene technique had increased from 57%-89%. In the question asking them the time needed for rubbing their hands (question 2), the percentage selecting 'not less than 20 seconds' as the true answer had improved from 62%-98%. Question 5 asked the participating children to confirm if they had to wash their hands after playing with toys. The percentage of correct answers increased from 34%-94%, and the percentage of those who considered alcohol handrub as an alternative, in case there was no water, increased from 82%-100%. The McNemar test was used to analyze the data, and significant differences were found in questions 1, 2, 5, 7, 8, and 10, with a P value <.05 (Table 1).

After the program intervention, the preschoolers confirmed in their answers that they washed their hands more frequently, especially after nose wiping, coughing, or sneezing, with the frequency increased from 85%-98.5%. About 35% of the preschoolers were observed washing their hands after toileting and the percentage who forgot to wash their hands after toileting reduced from 61%-26.5%.

Hand hygiene skill test

Before the program, the average percentage of colored areas before handwashing for all preschoolers were 73.7% on both hands and 61.5% on the backs of their hands. After the program, the average percentages of colored (thoroughness of handrubbing) areas before handwashing were 87.7% on both hands and 83.4% on the backs of their hands. A paired Student t test was performed to measure the differences in the mean percentages before and after the program, yielding significant differences for both palms and backs of the hands with P value = .001 ($P < .05$) and the overall hand hygiene performance with P value = .001 ($P < .05$) (Fig 2).

After handwashing, the remaining colored (dirty) areas on the preschoolers' hands represented the part that had not been washed properly. A lower percentage of the colored areas indicated that the preschoolers had washed their hands more thoroughly (Supplementary Fig S1). Before the program, the average percentages of the colored (dirty) areas on both hands and on the backs of the hands of the preschoolers were 12% and 14%, respectively. After the program, the average percentages of the colored areas (dirty areas) on both hands were 5% and on the backs of the hands were 7%. A paired Student t test was

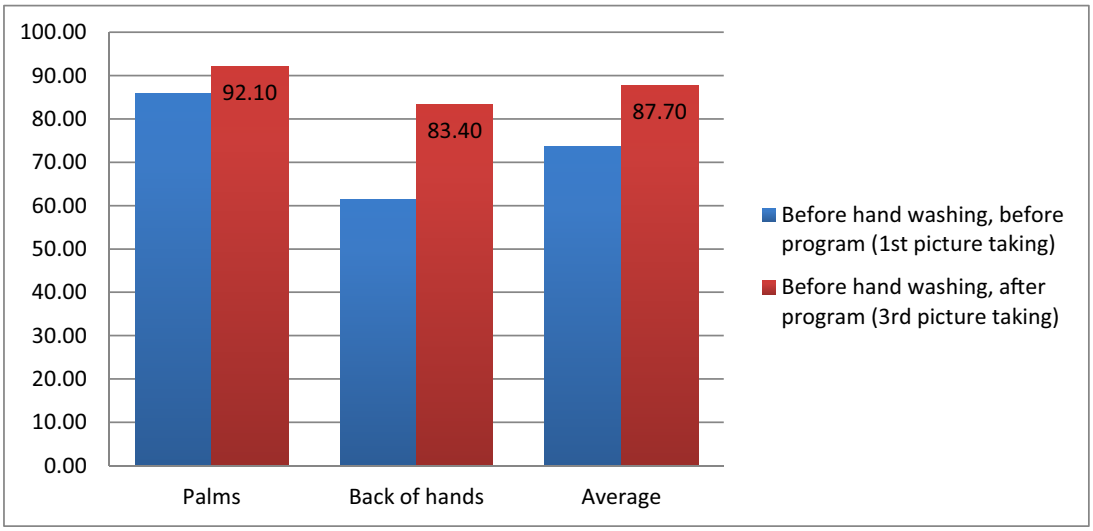

Fig 2. Percentage of colored areas (thoroughness of handrubbing) before hand washing, measured before and after the hand hygiene training program.

performed to measure the differences in the percentages of the colored (dirty) areas after handwashing before and after the program, and significant differences were found on the colored (dirty) areas on the backs of fingers with $P = .002$, thumbs with $P = .001$, finger tips with $P = .001$, between fingers with $P = .001$, backs of fingers with $P = .001$, and wrists with $P = .001$ ($P < .05$). However, an insignificant difference was found on the colored (dirty) areas on palms with $P = .321$ (Fig 3).

Absenteeism with influenza symptoms

The findings showed that preschooler absence owing to influenza symptoms had decreased in each of the 3 months, from 31%-30% and then to 25%, showing a decreasing trend in the 3 months in all participating kindergartens (Table 2). This decreasing absenteeism was in sync with the decrease in the remaining dirty areas on the hands after the training. One-way analysis of variance was performed to compare the median of the influenza symptoms among the preschoolers. Results showed students with fever have a higher mean of influenza symptoms than those without fever. There was significant difference among the preschoolers with fever ($P = .038$). No significant differences were found among the students in coughing, sore throat, running nose, fatigue, diarrhea, or vomiting. In addition, there was no significant correlation between hand hygiene compliance and absenteeism of the preschoolers.

DISCUSSION

Preschools have significant environmental factors that facilitate the transmission of infectious diseases, and most of the time, the hands of children serve as the primary vehicles for the transmission. However, limited studies have been conducted on preschoolers and their hand hygiene techniques. A structured hand hygiene program with local applications can teach preschoolers more effectively to enhance their knowledge in and cultivate proper attitudes toward these basic, yet important, infection control skills. This study, targeting preschoolers, was similar to the studies of Kumar et al,[7] Vivas et al, [8] and Guinan et al,[9] which targeted primary and preschoolers. However, none of these studies measure the students' hand hygiene skills nor the thoroughness of their handrubbing.

Our study measured handrubbing techniques and identified the missed areas. Most of the preschoolers studied missed washing their thumbs, fingertips, and wrists before the 7-step hand hygiene technique

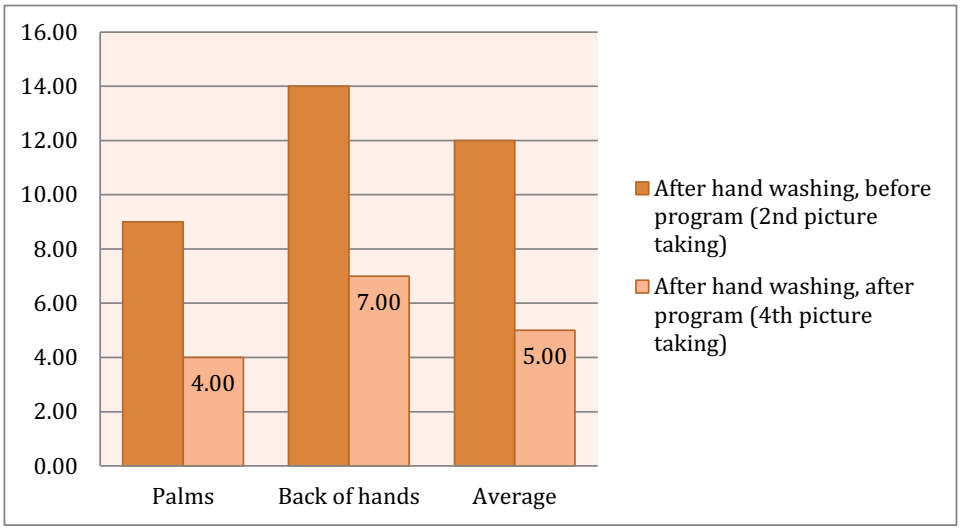

Fig 3. Percentage of colored (dirty) areas after handwashing, measured before and after the hand hygiene training program.

Table 2
Absenteeism of the preschoolers owing to influenza symptoms measured over 3 months in all participating kindergartens

	Before training program	During training program	After completion of training program
Absenteeism rate	31%	30%	25%

was taught in the intervention program. After the program, there was significant improvement in performing hand hygiene steps among their fingers, backs of fingers, thumbs, and fingertips ($P < .05$). The results showed that the program enabled the preschoolers to clean their fingers and thumbs more properly in handwashing. These results were similar to those found in previous studies on health care professionals in clinical settings. The most frequently missed areas found on them were also finger tips, thumbs, and between fingers.[10-13] In the Haidegger et al study,[14] the most frequently missed areas of a surgical hand disinfection procedure were finger tips, thumbs, and wrists. Through this structured hand hygiene program, the preschoolers could see the stain for themselves, which helped them focus on areas they missed, and frequently they were found to rub their hands repeatedly and more thoroughly and cautiously with hand soap. With the help of the fluorescent stain and photo imaging, our researchers found not only could the children assess their own hand hygiene skills, but the school teachers could fully spot areas their students most often missed washing, assessing their hand hygiene techniques in an objective and measurable way.[10,11,13,15,16] As a suggestion, our program can also be adapted to hand hygiene in hospital settings for training health care professionals and educating patients and their relatives.

Only a few earlier studies had examined the thoroughness of the routine handwashing practice by health care practitioners in clinical settings.[17] The frequency of handwashing, instead, was most often recorded and documented in these studies probably because this was the most straightforward aspect to observe and record. In their experiments, a standard handwashing technique was used, and it could be argued that the removal of a virus or microorganisms could be attributed to the action of the cleaning agent being tested, rather than the thoroughness of the handwashing. The WHO hand hygiene observation tool disseminated in 2009 was using the opportunity count, but not the thoroughness of handrubbing. The lack of progress during the last 20 years in reinstating handwashing as an activity that is central to daily health care practice deserves urgent review.

For full hand hygiene compliance, it has been suggested that not only handwashing but also hand hygiene opportunities are needed to be observed.[7] Prior to this program, the preschoolers were confused about the handwashing steps, timing, and duration of performing proper hand hygiene techniques. They were uncertain about when to wash hands or when to apply alcohol handrub (eg, after playing with toys). In other words, they were not aware of the moments that constituted hand hygiene opportunities. With the "Five Moments for Hand Hygiene," the students were taught to wash their hands before as well as after playing with shared toys. After the intervention of this program, they were found washing their hands more frequently, especially before touching their eyes, nose, or mouth. More preschoolers realized that they also needed to wash their hands after nose wiping, coughing, or sneezing, and after touching garbage. They could identify the hand hygiene opportunities more readily in their daily lives. Although some studies[8,19] worked on absenteeism, none of them explored hand hygiene opportunities nor absenteeism of preschoolers.

The results in this study showed that absenteeism owing to influenza-related symptoms decreased in the month following the intervention of the hand hygiene program in all the participating schools. We found the decrease of absenteeism in the participating preschoolers was quite significant given there was an upsurge of local influenza activity during our study, from October 2016 to February 2017, in Hong Kong.[19] This might have been brought about by our program, as it focused on knowledge of hand hygiene, skills training, and observations. The results from the survey indicated that both the childrens' and their parents' awareness of good health behaviors and habits had been raised. In the studies of Talaat[18] and Guinan,[9] absenteeism decreased, but they did not mention if there was any outbreak of influenza during the research period. It was therefore unclear whether the decrease of absenteeism was owing to reduced incidence of influenza at the time of these studies.

One of the limitations of this study was that its scope was restricted to kindergarten 3 students and did not cover the parents' hand hygiene compliance at home. This study has short-term follow-up period for compliance. Moreover, further investigation can be expanded to junior students of kindergarten 1 and kindergarten 2, teachers, and even minor staff in preschools. We recommend a further study to examine the impact from parent engagement in hand hygiene practice on reducing absenteeism in preschoolers.

CONCLUSIONS

There is an urgent need for a structured hand hygiene program in school settings, using an objective hand hygiene competence assessment tool. The participants in our study demonstrated an improvement in their hand hygiene routine markedly after receiving 4 sessions of the training, and they paid better attention to washing those frequently missed hand areas in the 7-step hand hygiene technique. The percentage of the preschoolers who were aware of the importance of hand hygiene in disease prevention had increased from 67%-91%. Our program could help both the teachers and students to cultivate good habits of minimizing disease spreading as well as outbreaks in their schools. This was evidenced by the reduction in absenteeism with influenza-like illnesses in the ensuing month of the program. Hence, the program is a nonpharmaceutical alternative to tackle influenza-related absenteeism and minimize the loss of school days.

Good cooperation between schools and families is found to be important in helping students build positive attitudes and habits, even in performing simple routines like hand hygiene. Through using our program (with an online version) at schools, parents and children can improve their personal hygiene awareness and skills, and hopefully, may bring the benefits to their home.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ajic.2018.11.014.

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