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A CLUSTER-RANDOMIZED CONTROLLED TRIAL EVALUATING THE EFFECT OF A HANDWASHING-PROMOTION PROGRAM IN CHINESE PRIMARY SCHOOLS

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Abstract. Intensive handwashing promotion can reduce diarrheal and respiratory disease incidence. To determine whether less intensive, more scalable interventions can improve health, we evaluated a school-based handwashing program. We randomized 87 Chinese schools to usual practices: standard intervention (handwashing program) or expanded intervention (handwashing program, soap for school sinks, and peer hygiene monitors). We compared student absence rates, adjusting for cluster design. In control schools, children experienced a median 2.0 episodes (median 2.6 days) of absence per 100 student-weeks. In standard intervention schools, there were a median 1.2 episodes ($P = 0.08$) and 1.9 days ($P = 0.14$) of absence per 100 student-weeks. Children in expanded intervention schools experienced a median 1.2 episodes ($P = 0.03$) and 1.2 days ($P = 0.03$) of absence per 100 student-weeks. Provision of a large-scale handwashing promotion program and soap was associated with significantly reduced absenteeism. Similar programs could improve the health of children worldwide.

INTRODUCTION

Each year, diarrheal and respiratory diseases kill > 5.5 million people and lead to > 140 million disability-adjusted life-years lost.[1] The vast majority of these deaths occur among children in low- and middle-income countries, where access to health-care services is suboptimal.[2] In such settings, preventive measures are vital.

Appropriate handwashing can prevent infectious illness, including diarrheal and respiratory diseases. These effects have been demonstrated in both clinical and community settings around the world.[3,4] In two recent meta-analyses, community handwashing interventions were associated with diarrheal disease reductions of 47%[5] and respiratory infection reductions of 16%.[6] If mortality due to diarrheal and respiratory disease were similarly reduced, appropriate handwashing-promotion activities could save many lives each year.[5]

However, health behaviors such as handwashing can be difficult to change. Handwashing programs including regular household visits to small numbers of families repeated over weeks or months have been associated with significant reductions in infectious illnesses.[7,8] Such programs, however, are expensive and labor-intensive.[8] To reach a greater proportion of the population that would benefit most from improved handwashing behavior, a more efficient model for program delivery is required. School-based handwashing programs could reach large numbers of students while hygiene habits are developing.[9] Studies of small, school-based handwashing programs in industrialized countries have demonstrated impacts on student health and school attendance.[10,11] Nevertheless, the greatest burden of diarrheal and respiratory disease resides in developing countries, where health impacts of large-scale handwashing programs have not been evaluated. To address this question, we measured the health impact of a school-based handwashing program that has been delivered to > 20 million schoolchildren in China since 1999.

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METHODS

Setting. Fujian Province is located on China's southeast coast, and its population is primarily rural. Provincial health officials identified one mountainous (FuAn), one coastal (QuanGang), and one peri-urban (MinHou) county with water and road infrastructure. Eligible schools met the following criteria: classification as a public primary school; ≥ 20 students in first grade during the 2003–2004 academic year; no overnight boarders; ≥ 1 running water tap available for every 30 first-grade students; no compulsory handwashing or provision of hand-cleansing products before school lunch; and no commercial handwashing-promotion programs at the school during the previous 5 years.

Handwashing promotion program. Procter & Gamble's Safeguard promotion program has been delivered in Chinese schools since 1999. Teachers present the program to first-grade children during a single 40-minute classroom session. Children are instructed in handwashing technique and asked to wash their hands before meals and after using the toilet. The program includes a single 2-hour training session for each first-grade teacher by Procter & Gamble staff and provision of a teacher's pack, animated videotape for classroom use, and a take-home pack for each student. The teacher's pack contains a guidebook outlining five handwashing steps (wet hands, lather fingers, lather palms and backs of hands, rinse, and dry with a clean towel) and basic information about infectious disease transmission. It also contains five posters describing handwashing procedures and five wall charts designed for classroom hygiene competitions. The student take-home pack includes a hygiene board game, a parents' booklet about handwashing, and a 50-gram bar of Safeguard soap. This program does not include soap or hand-drying supplies for the schools.

Study groups. We evaluated two interventions during this study. The standard intervention group received the handwashing-promotion program as described but did not receive explicit instructions about supplying soap at school sinks or about enforcing handwashing behaviors. The expanded intervention group received the handwashing-promotion program plus a continuous supply of Safeguard bar soap for use at school sinks; additionally, one student from each first-grade class was recruited to assist peers with handwashing technique and to remind them of key handwashing opportunities (before eating, after toilet use) while at school. Teachers were asked to encourage this student on a weekly basis to continue these activities but were not instructed to enforce handwashing behaviors. Students in all three groups received standard government hygiene educational programming consisting of a cursory statement annually about washing hands after using the toilet and before eating.

Data collection. Before interventions were delivered, school vice-principals provided information about school characteristics and parents provided information about household characteristics via self-administered questionnaires. At the conclusion of the study, parents in the intervention groups also completed a self-administered questionnaire about use of program materials.

First-grade teachers recorded student absences each school day as standard practice. For the study, teachers were trained by a pediatrician using standardized case definitions to identify 10 symptoms or signs of illness and to record these symptoms in association with student absences (Table 1). Since 2003, teachers in China have routinely measured temperatures of children reporting symptoms of a fever; government-issued thermometers were available at all schools for this purpose. When parents reported an infectious syndrome as a cause of absence, teachers recorded the name of the syndrome and asked the parent whether the ill student suffered any of the 10 individual symptoms, and verified verbally that reports of diarrhea met the case definition used in this study. Partial-day absences were marked as 1 day of absence. Illness information was not collected for weekends or school breaks. Teachers were told that the study was designed to examine student knowledge and attitudes about health practices and student illness rates. The need for complete and accurate recording of illness and absence data was highlighted repeatedly during teacher training sessions.

Teachers also recorded symptoms of illness among the students present in the classroom on a fixed day each week, using the case definitions described above. Teachers recorded signs they observed among their students or symptoms that were reported to them; teachers did not actively solicit illness information from students.

Teachers began collecting illness and absence data 7 days after the interventions were initiated and weekly thereafter for 5 months.

Statistical methods. We estimated a target sample size assuming 100 first-grade students per school, 10% drop-out, and 80% power to detect with 95% confidence 1, 0.85, and 0.8 student absence events per 100 student-weeks of observation in the control, standard intervention, and expanded intervention groups, respectively. After doubling to adjust for clustering, the required sample size was 30 schools per study group monitored over 10 weeks.

After stratifying by county, we used a random number generator to assign 30 schools to each control, standard intervention, and expanded intervention group (Figure 1). All first-grade students in each school were eligible for enrollment. Due to a miscommunication, the student take-home packets were distributed to students in 24 control schools during the week before data collection began. These schools were excluded from the study. Replacement control schools were randomly selected from among the entire pool of remaining eligible schools because an insufficient number of eligible schools remained in QuanGang County. The replacement schools were enrolled during the second week of data collection. Replacement control schools did not significantly differ from original control schools with respect to size or water infrastructure; however, FuAn County was over-represented and QuanGang County was under-represented among the replacement schools.

We hypothesized that fewer illnesses and absences, particularly those due to upper respiratory tract infections and diarrheal illness, would be observed among intervention groups. We defined an episode of absence as an individual student absent for any number of consecutive or non-consecutive days during a single calendar week because of symptoms affecting the same organ system or systems (e.g., respiratory, digestive). Absences of an individual student on non-consecutive days of a single calendar week with symptoms affecting different organ systems were recorded as distinct absence episodes. The total number of days of absence, excluding weekends, associated with each episode of illness was recorded. We defined absence incidence as the number of episodes of absence and absence prevalence as the number of days of absence among first grade students per 100 student academic-weeks of observation (student-weeks). Illness incidence was defined as the number of episodes of illness without absence among first grade students per 100 student-weeks. Rates of illness due to individual symptoms were calculated as number of occurrences of the symptom without absence for every 100 student-weeks. Rates of absence because of specific symptoms were calculated from the number of absences in association with the symptom per 100 student-weeks. Teachers could record multiple symptoms per student each week.

Analysis was based on intent-to-treat. To adjust for the cluster design, we calculated mean illness and absence rates and mean proportions of other characteristics for each school. Because mean values were not normally distributed within each group, we used the Wilcoxon rank-sum test to compare the median of the control school means to the median of

TABLE 1

Symptoms and signs recorded by teachers on student surveillance forms

Complaint	Definition
Headache	Report of headache
Conjunctivitis	Observation or report of 2 of the following: red or swollen conjunctiva; mucopurulent ocular discharge; ocular pain
Otalgia	Report of ear pain
Rhinorrhea	Report of runny/congested nose or observation of $\geq$ 2 episodes of blowing or wiping nose during single school day
Sore throat	Report of sore throat
Cough	Report or observation of $\geq$ 2 episodes of coughing during a single school day
Stomachache	Report of stomachache or upset stomach
Vomiting	Report of vomiting or observation of $\geq$ 1 vomiting episode unrelated to coughing during single school day
Diarrhea	Report of $\geq$ 3 loose stools per 24-hour period
Fever	Measured temperature (oral, axillary, or aural) $\geq$ 38°C, or parental report of same

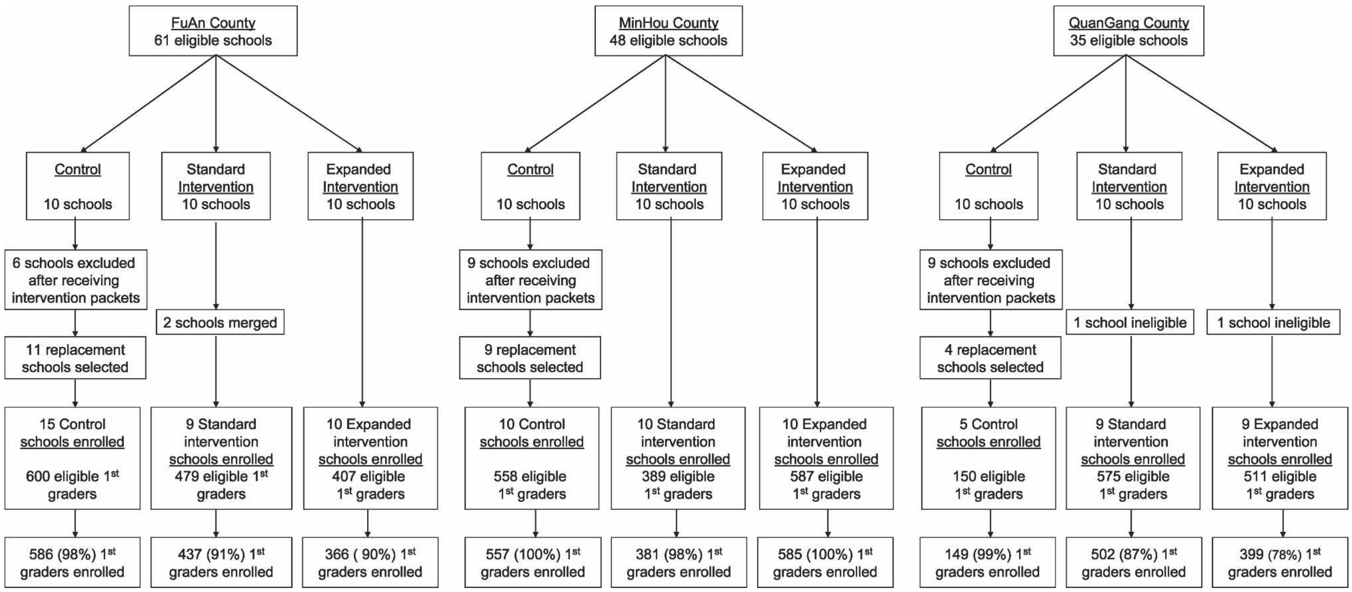

FIGURE 1. Enrollment of schools and students.

either intervention group's school-based means. We considered P values < 0.05 to be significant.

Ethics. We obtained written informed consent from teachers and parents of enrolled students; written assent was obtained from students. The Institutional Review Boards of the China Centers for Disease Control and Prevention and the United States Centers for Disease Control and Prevention approved the study protocol. The standard intervention was offered to control schools at the conclusion of the study.

Role of the funding source. Two authors (W.B. and T.L.) were used by the funding source (Procter & Gamble, Cincinnati, OH); both provided feedback on the study protocol and manuscript but were not involved with study implementation or data analysis. The corresponding author (A.B.) had full access to all study data and was responsible for the decision to submit the manuscript for publication. CDC maintained the right to publish results without approval from Procter & Gamble.

RESULTS

Of the 4256 first-grade students attending the enrolled schools, 3962 (93%) agreed to participate (Figure 1). Participation rates were high in all study groups and counties. Households among the study groups were similar in demographics and socioeconomic status; however, improved household sanitation facilities were significantly more prevalent in the intervention groups, while household piped water access tended to be more common among the control group (Table 2). Schools did not differ significantly in total number of students, number of first-grade students, class size, or hygiene infrastructure (Table 3). Few schools had soap for handwashing at baseline.

Teachers reported 52,342 student-weeks of observation. Decreased rates of illness (Table 4) and absence (Table 5) were consistently reported among intervention schools. When compared with control schools, those that received the standard handwashing intervention reported lower absence incidence and prevalence; however, these differences failed to attain statistical significance. Expanded intervention schools that enlisted student handwashing champions and received soap in addition to the handwashing-promotion program reported 42% fewer absence episodes, 54% fewer days of absence, and 71% fewer in-class illnesses; absence incidence and prevalence differed significantly from control, while in-class

TABLE 2
Student household characteristics at baseline

Characteristic	Control (N = 1265)	Standard intervention (N = 1275)	Expanded intervention (N = 1270)
1st grade student age, years (median [IQR])	7.53 [7.37, 7.75]	7.51* [7.30, 7.75]	7.32* [7.06, 7.64]
1st grade student sex (median % male [IQR])	56.3 [50.0, 65.0]	58.2 [50.0, 61.9]	56.3 [52.0, 63.2]
Number living in household (median [IQR])	4.50 [4.15, 4.67]	4.27 [4.11, 4.50]	4.39 [4.25, 4.64]
Household monthly income < 500 yuan (~$61) (median % [IQR])	18.6 [12.2, 3.3]	14.5 [9.1, 25.3]	19.4 [13.8, 27.3]
Households with pit latrine (median % [IQR])	75.0 [63.2, 85.7]	55.6* [35.8, 73.6]	68.8* [45.5, 76.9]
Households with flush latrine (median % [IQR])	23.7 [14.3, 30.8]	33.3* [17.0, 44.7]	25.0 [14.0, 31.3]
Households with flush toilet (median % [IQR])	0 [0, 0]	10.1* [6.2, 18.2]	7.1* [2.2, 17.6]
Piped water available in home (median % [IQR])	45.1 [30.7, 55.0]	27.6 [18.8, 49.2]	26.7 [17.8, 46.7]
Boil drinking water before use (median % [IQR])	93.8 [88.5, 98.0]	94.9 [88.8, 100]	94.7 [84.4, 98.0]
Smoker lives in house (median % [IQR])	56.0 [51.1, 67.3]	57.1 [48.7, 65.8]	59.2 [53.3, 69.7]

* Significantly different from control group, P < 0.05.

TABLE 3
School characteristics at baseline*

	Control (N = 30)	Standard intervention (N = 28)	Expanded intervention (N = 29)
Median students, [IQR]	330 [190, 451]	294 [214, 581]	392 [217, 621]
Median 1st graders, [IQR]	34 [25, 53]	28 [21, 53]	43 [28, 74]
Median 1st grade classes, [IQR]	1 [1, 1]	1 [1, 1]	1 [1, 2]
Median 1st graders per class, [IQR]	32.5 [25, 40]	28 [20, 44]	37 [28, 43]
Median functional water taps per 100 1st graders, [IQR]	16.9 [8.3, 24]	15.7 [12.0, 22.6]	11.1 [7,1, 19.0]
Number with any soap at any sink, (%)	6 (20)	2 (7.1)	8 (30)
Number with any towels at any sink, (%)	0 (0)	1 (3.6)	0 (0)
Number with pit latrines, (%)	24 (80)	17 (61)	25 (89)
Median toilets or latrines per 100 1st graders, [IQR]	3.6 [1.3–53.9]	4.6 [0.3–9.1]	2.7 [0.6–6.7]
Number with toilet paper at toilet or latrine, (%)	1 (3.5)	1 (3.6)	0 (0)

* No significant differences between control and standard intervention schools or control and expanded intervention schools were found, $\alpha = 0.05$.

illness incidence did not. These differences were observed throughout the study period (Figure 2).

Although no significant differences in symptoms were found among in-class illnesses (Table 4), syndrome-specific absence incidence differed between groups (Table 5). Students in the standard intervention group were less likely than control students to be absent due to fever ($P = 0.049$), and students in the expanded intervention group were less likely to be absent due to headaches ($P = 0.04$) or stomachaches ($P = 0.03$) than were control students.

A high proportion of parents in both intervention groups reported receiving (standard intervention group median, 96%; expanded intervention group median, 100%) and using (standard intervention group median, 92%; expanded intervention group median, 94%) the student take-home packet.

DISCUSSION

Previous studies of the impact of handwashing on health have been limited to evaluations of handwashing programs delivered to at most a few thousand children.[4,8,10] Since 1999, more than 20 million primary school students in 550 cities across China have received the standard handwashing-promotion program evaluated in this study. During 5 months of observation, students who received the expanded handwashing intervention and soap experienced significantly fewer episodes and days of absence than students who did not. Rates of overall illness and absence and syndrome-specific illness and absence tended to be highest among children in control schools, intermediate among children in schools that received the handwashing-promotion program, and lowest among children in schools provided with the expanded handwashing-promotion program and soap.

Effective, at-scale delivery of handwashing promotion programs in less-developed countries is important for a number of reasons. These regions bear the greatest burden of respiratory and diarrheal morbidity and mortality, particularly among children. In 2000, > 10 million deaths occurred among children < 5 years of age.[2] In the countries with the highest child mortality burdens, ≈ 22% of these deaths resulted from diarrheal disease and 21% from pneumonia.[2] With appropriate handwashing interventions, it is possible that as many as one million of these lives could be saved.[5] Furthermore, hygiene interventions have been associated with fewer visits to health-care providers[8,12] and decreased use of antimicrobial medications.[12] Where health-care resources are limited, these effects may be especially important. Handwashing has also been recommended for prevention of diseases with pandemic potential, such as influenza and severe acute respiratory syndrome;[13] low-tech, inexpensive, widely available preventive

TABLE 4
In-class illness incidence rates, overall and by cause

Outcome	Control group (N = 15,539 student-weeks)	Standard intervention group (N = 16,294 student-weeks)			Expanded intervention group (N = 20,509 student-weeks)		
	Median episodes per 100 student-weeks	Median episodes per 100 student-weeks	P*	% Decline†	Median episodes per 100 student-weeks	P‡	% Decline§
Illness	0.65	0.45	#	35	0.19	0.18	71
Type of illness							
Headache	0	0	0.39	0	0	#	0
Headache only	0	0	#	0	0	#	0
Upper respiratory tract infection^	0.48	0.38	#	21	0	0.21	100
Rhinorrhea	0.17	0.19	#	−12**	0	0.30	100
Sore throat	0	0	#	0	0	#	0
Cough	0.08	0.08	#	0	0	0.25	100
Stomachache	0	0	#	0	0	#	0
Diarrhea	0	0	#	0	0	#	0
Fever	0	0	0.07	0	0	0.24	0

* Wilcoxon rank-sum comparing standard intervention group to control group.
† % decline between median rates in control and standard intervention group.
‡ Wilcoxon rank-sum comparing expanded intervention group to control group.
§ % decline between median rates in control and expanded intervention group.
^ Upper respiratory tract infection was defined as a student with conjunctivitis, otalgia, rhinorrhea, sore throat, or cough.
# $P > 0.4$.
** −12 represents a 12% increase.

TABLE 5
Rates of absence incidence, days of absence, and cause of absence

Outcome	Control group (N = 15,539 student-weeks) Median episodes per 100 student-weeks	Standard intervention group (N = 16,294 student-weeks) Median episodes per 100 student-weeks	P*	% Decline†	Expanded intervention group (N = 20,509 student-weeks) Median episodes per 100 student-weeks	P‡	% Decline§
Absence	2.04	1.15	0.08	44	1.19	0.03	42
Days of absence	2.58	1.86	0.14	27	1.19	0.03	54
Reason for absence							
Headache	0.73	0.40	0.08	45	0.54	0.04	26
Headache only	0.04	0	0.14	100	0	0.16	100
Upper respiratory tract infection^	0.70	0.43	0.34	39	0.48	0.33	31
Rhinorrhea	0.30	0.11	#	63	0.24	#	20
Sore throat	0	0	#	0	0	#	0
Cough	0.08	0.08	#	0	0	#	100
Stomachache	0.30	0.06	0.35	80	0	0.03	100
Diarrhea	0	0	#	0	0	#	0
Fever	0.68	0.11	0.049	84	0.38	#	44

* Wilcoxon rank-sum comparing standard intervention group to control group.
† % decline between median rates in control and standard intervention group.
‡ Wilcoxon rank-sum comparing expanded intervention group to control group.
§ % decline between median rates in control and expanded intervention group.
^ Upper respiratory tract infection was defined as a student with conjunctivitis, otalgia, rhinorrhea, sore throat, or cough.
# $P > 0.4$.

measures such as handwashing provide the greatest opportunity worldwide for both personal protection and pandemic prevention. Finally, because children have been recognized as important vectors for infectious illness in the community,[14,15] handwashing among this age group may have particularly important public-health implications.

Although school-aged children are at lower risk of death from diarrheal and respiratory illnesses than either younger children or the elderly, targeting hygiene behavior-change messages to schoolchildren has many advantages and could complement other efforts to reduce the under-five mortality. Even in communities that lack health services, schools are generally accessible.[16] Schools bring large numbers of children together, permitting efficient program delivery. Children in this age group may be particularly receptive to health education: although health-care workers tend not to sustain hygiene behavior changes following educational campaigns,[17] children are apt to integrate new health behaviors into their daily routines.[12,18] After preschool-based handwashing promotion, researchers measured substantial changes in child handwashing behavior.[19] Moreover, children can be important agents of health behavior change in the community. In previous studies, children have been shown to motivate classmates to alter their behavior,[16] to increase handwashing among parents and siblings,[20,21] and to affect health-related purchases for their households.[22] Schoolchildren exposed to handwashing promotion may be healthier and therefore less likely to expose family members and other close contacts to infectious agents,[8,23] a particular benefit for students' younger siblings or elderly relatives who are at higher risk for hospitalization and death due to infectious disease. Although siblings were rare among this study population because of fer-

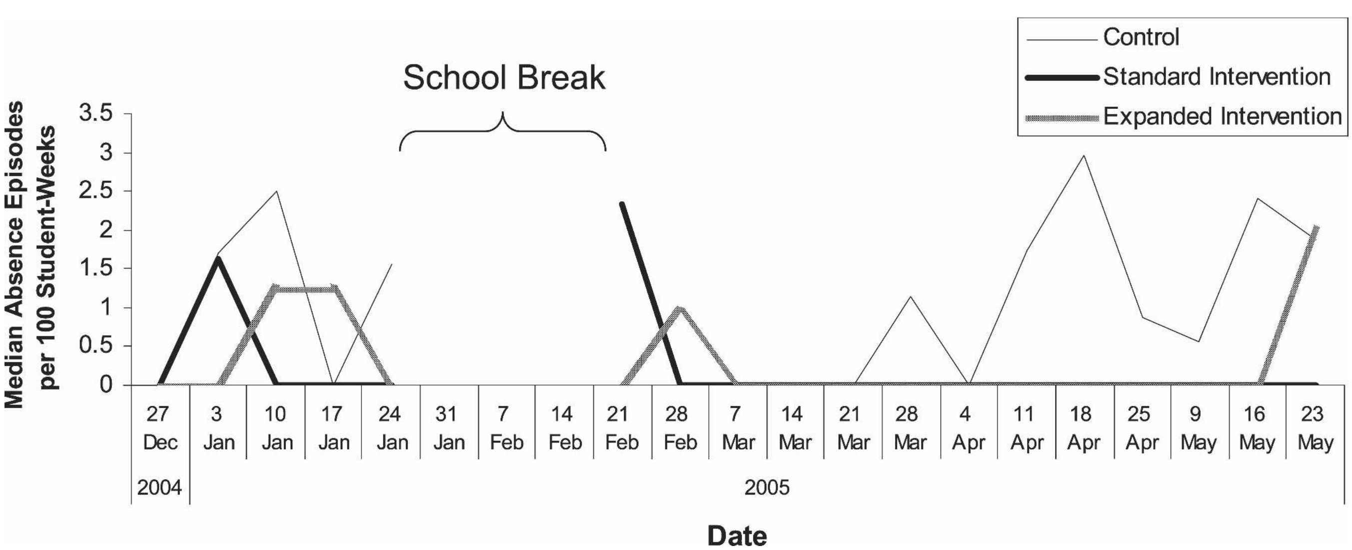

FIGURE 2. Median absence incidence by week and study group, week of December 27, 2004, through week or May 23, 2005, Fujian Province, China. Schools began and completed the winter break on different dates. Data points representing the weeks of January 24 and February 21 do not contain data from every school.

tility policies in China, children frequently lived with elderly grandparents. We were unable to assess health outcomes among students' family members in this study, but this outcome is important to include in future studies. Teachers in schools and childcare centers where handwashing promotion has occurred may also experience fewer illnesses.[12] Economic benefits may arise from fewer health-care encounters, less parental work income lost while caring for ill children, and decreased need for teachers to assist ill children with lessons they missed.[12] Finally, healthier students may exhibit improved academic performance and decreased absenteeism.[24,25] However, despite the possible advantages of school-based handwashing promotion, such programs require substantial commitment from school officials, teachers, and students, including coordinated training messages, funding, sufficient time for handwashing during the school day, and uninterrupted provision of appropriate handwashing infrastructure and soap.

The health surveillance system used in this study was subject to multiple limitations. The passive system was unlikely to be highly sensitive[26] and may have contributed to low reported illness rates. Illness information was also collected weekly rather than daily because of resource constraints; this may have further decreased illness surveillance sensitivity. In contrast, absence data were collected daily as part of the teachers' usual routine; therefore, each day of absence should have been captured, and calculated absence prevalence should closely reflect actual days of absence. However, an "absence incidence" was defined as 1 or more days of absence due to related causes within a single calendar week. This definition might overestimate absence incidence when, for example, diarrheal illness caused a student to be absent on a Friday and Monday and was recorded as two episodes of absence. Nonetheless, although the low reported illness and absence incidence rates reduced our power to detect significant differences between the study groups, we did measure significantly fewer episodes of absence and total days of absence among children exposed to handwashing promotion and soap. These health improvements were of similar magnitude as reports from smaller school-based interventions in industrialized countries.[10,11]

A second limitation is that, because teachers were not blinded, those in the intervention groups may have altered their illness reporting in an effort to please investigators. We were not able to compare reported rates of absenteeism during the intervention to rates from previous years. However, because local policies require teachers in this population to record student absences routinely, we expect absenteeism rates reported in this study to approximate actual absenteeism closely. Additionally, reports of isolated headache, which is not generally perceived as an infectious illness, were similar among all three study groups. Finally, the need for accurate, complete illness and absence information was highlighted repeatedly while teachers were trained to collect data.

In this study as in many handwashing studies, we did not measure handwashing behavior directly because of the inherent challenges that poses.[27,28] Self-reported handwashing behavior has been shown to correlate poorly with observed behavior,[29] but observing behavior directly is resource-intensive and can be subject to the Hawthorne effect.[30] Consequently, we did not attempt to measure handwashing behavior through self-report or structured observation but rather used health parameters as alternative outcome measures.

The health outcomes we measured might have been influenced by imbalances in randomization. Although we stratified schools by county before randomizing to intervention group, we were unable to do this during the ultimate selection of control schools, and some differences among household characteristics were found between the groups. Children in control schools were less likely than children in intervention schools to have piped sanitary facilities in their homes. However, it is unlikely that this factor alone contributed to the health differences we measured. Toilet facilities are most likely to be associated with gastrointestinal illness, yet diarrhea incidence was similarly low among all three groups. Other socioeconomic indicators, including income and household access to piped water, were similar across groups. Exposure to second-hand smoke, which may predispose children to respiratory symptoms, was also similar.

Health differences were sustained through 5 months of observation and persisted after a prolonged school break. Handwashing behavior change of similar duration was reported following handwashing promotion among preschool students in Israel; however, no differences in absenteeism were measured during that study.[19] Although the in-school handwashing lesson in China required only one class period, the take-home handwashing literature and game were frequently used in students' homes, especially among students enrolled in the expanded intervention schools. This exposure to hygiene concepts in the home and the presence of peer handwashing champions at the expanded intervention schools likely provided on-going reinforcement for handwashing behaviors in multiple settings and might explain the sustained health differences we observed. It is unclear whether these trends will continue after the study is concluded.

Finally, whether similar health impacts could be measured following a comparable intervention in settings with fewer resources requires clarification. This study did not include the poorest communities in China; further, we enrolled only schools with a piped water supply. However, schools cannot exist in complete absence of water, and inexpensive, low-tech handwashing stations without piped water supplies are known to be acceptable and effective for handwashing.[31,32] A study in Turkey also reported adequate handwashing procedures among students even when handwashing infrastructure was suboptimal.[33] Semistructured interviews with representatives from 15% of schools following completion of this study revealed that students in the standard intervention group enthusiastically engaged in the hygiene lessons and some began to carry bar soap to school each day for personal use. Although this may explain why health impacts were observed in this group, it is unclear how sustainable this practice is, whether students' parents altered their hygiene behaviors and purchases in reaction to the program, whether other populations might adopt similar behaviors, or whether handwashing promotion programs can affect health in the absence of soap. Furthermore, bar soap was supplied as needed to school sinks in the expanded intervention group, and school officials reported restocking soap at school sinks more frequently than expected. This suggests that soap intended for use on school grounds was sometimes instead used within homes of students from expanded intervention schools and could have amplified the illness reductions among students in this group. Similar illness impact might not be observed if unauthorized soap removal is aggressively prohibited during other handwashing-promotion programs. Even so, on-going commitment from government and school officials to provide appropriate water infrastructure and soap at schools may improve sustainability of behavior change and health impact because handwashing is more frequent if facilities are readily available,[30,34] and handwashing with soap and water more effectively removes microbes than handwashing with water alone.[35] Conducting similar investigations in other populations would help address these questions.

We report significantly fewer episodes and days of absence among schoolchildren provided with soap and a simple handwashing promotion program that has been delivered to millions of children. Although provision of the handwashing-promotion program without soap was associated with marginally significant decreases in episodes and days of absence, in-class illness incidence did not differ significantly from the control group. Further, it is unclear whether provision of soap to schools is replicable or sustainable. Nonetheless, these data are the first to describe health impacts after handwashing promotion among schoolchildren in the developing world and to suggest health impacts after a handwashing-promotion program delivered at scale. Unlike many other health interventions, appropriate handwashing technologies are simple, cost-effective, widely available, and could be used universally.[12,27,36] Although we were unable to assess the sustainability of student hygiene behavior change, the impact on hygiene practices and health of family members, and the capacity to impact health in the absence of soap, this simple, easily replicable handwashing promotion model may be useful for improving handwashing behaviors in both industrialized and less developed communities and has the potential to profoundly reduce diarrheal and respiratory disease burdens if implemented worldwide. Additional study could improve our understanding of the factors required for effective, large-scale delivery of handwashing programs to improve the health of the world's most vulnerable populations.

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