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Pediatrics 2008;121:e1555-e1562

DOI: 10.1542/peds.2007-2597

The online version of this article, along with updated information and services, is located on the World Wide Web at:

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Reducing Absenteeism From Gastrointestinal and Respiratory Illness in Elementary School Students: A Randomized, Controlled Trial of an Infection-Control Intervention

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Financial Disclosure: Drs Sandora and Goldmann received a consulting fee from The Clorox Company for their efforts in designing and conducting this study; Dr Shih has indicated she has no financial relationships relevant to this article to disclose.

What's Known on This Subject

Hand-hygiene interventions have reduced absenteeism in schools. Few data are available regarding the role of surface disinfection in reducing absenteeism.

What This Study Adds

This study shows that a school-based multifactorial intervention including using hand sanitizers and surface disinfection reduced absenteeism from gastrointestinal illness in elementary school students.

ABSTRACT

BACKGROUND. Students often miss school because of gastrointestinal and respiratory illnesses. We assessed the effectiveness of a multifactorial intervention, including alcohol-based hand-sanitizer and surface disinfection, in reducing absenteeism caused by gastrointestinal and respiratory illnesses in elementary school students.

METHODS. We performed a school-based cluster-randomized, controlled trial at a single elementary school. Eligible students in third to fifth grade were enrolled. Intervention classrooms received alcohol-based hand sanitizer to use at school and quaternary ammonium wipes to disinfect classroom surfaces daily for 8 weeks; control classrooms followed usual hand-washing and cleaning practices. Parents completed a preintervention demographic survey. Absences were recorded along with the reason for absence. Swabs of environmental surfaces were evaluated by bacterial culture and polymerase chain reaction for norovirus, respiratory syncytial virus, influenza, and parainfluenza 3. The primary outcomes were rates of absenteeism caused by gastrointestinal or respiratory illness. Days absent were modeled as correlated Poisson variables and compared between groups by using generalized estimating equations. Analyses were adjusted for family size, race, health status, and home sanitizer use. We also compared the presence of viruses and the total bacterial colony counts on several classroom surfaces.

RESULTS. A total of 285 students were randomly assigned; baseline demographics were similar in the 2 groups. The adjusted absenteeism rate for gastrointestinal illness was significantly lower in the intervention-group subjects compared with control subjects. The adjusted absenteeism rate for respiratory illness was not significantly different between groups. Norovirus was the only virus detected and was found less frequently on surfaces in intervention classrooms compared with control classrooms (9% vs 29%).

CONCLUSIONS. A multifactorial intervention including hand sanitizer and surface disinfection reduced absenteeism caused by gastrointestinal illness in elementary school students. Norovirus was found less often on classroom surfaces in the intervention group. Schools should consider adopting these practices to reduce days lost to common illnesses. *Pediatrics* 2008;121:e1555–e1562

www.pediatrics.org/cgi/doi/10.1542/peds.2007-2597

doi:10.1542/peds.2007-2597

This work was presented in part at the annual meeting of the Infectious Diseases Society of America; October 4–7, 2007; San Diego, CA.

This trial has been registered at www.clinicaltrials.gov (identifier NCT00514670).

Key Words

hand hygiene, hand sanitizer, disinfection, school, absenteeism, randomized, controlled trial

Abbreviations

CFU—colony-forming unit
RT-PCR—reverse-transcription polymerase chain reaction
CI—confidence interval

Accepted for publication Dec 5, 2007

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IN 2004, THERE were 36.4 million children of elementary school age (5–13 years) in the United States. Of these children, 31.1 million were enrolled in elementary school.¹ Children in this age group are at risk of developing respiratory and gastrointestinal infections, most commonly caused by exchange of secretions and inadequate hand hygiene.² School-aged children are often absent because of these common infectious diseases.³ These absences also result in lost time from work for parents and substantial costs related to physician visits and antibiotic prescriptions.⁴

Several approaches to reducing infections are plausible. Hand hygiene is generally accepted as the best means to prevent the transmission of infections. Hand-washing interventions have been shown to reduce absenteeism among elementary school students.⁵ Alcohol-based hand sanitizers are an effective alternative to hand-washing and have the advantages that they do not require access to a sink, are rapidly bactericidal as well as virucidal for most respiratory and gastrointestinal pathogens, and are faster to use and gentler on hands. Hand sanitizer use in school settings has been shown to reduce absenteeism.⁶⁻⁸ Environmental disinfection is another approach to reducing exposure to infections in school settings, because the etiologic agents of some infectious diseases survive on environmental surfaces for hours. Many available disinfectants contain ingredients that rapidly kill bacteria and viruses. A preschool-based intervention focused on environmental cleaning and disinfection resulted in a decrease in the total number of illnesses.⁹ Combining school disinfection programs with a hand hygiene component may further reduce absenteeism caused by common illnesses.

METHODS

Design

We performed a cluster-randomized, controlled trial to assess the effectiveness of a multifactorial infection-control intervention, including alcohol-based hand sanitizer and surface disinfection, in reducing absenteeism caused by gastrointestinal and respiratory illnesses among elementary school students. We also sought to describe the viral and bacterial contamination of common surfaces in a typical elementary school classroom and to assess the impact of an environmental disinfectant on the presence of selected viruses and bacteria on these surfaces. We hypothesized that combining school disinfection programs with a hand hygiene component would significantly reduce absenteeism caused by gastrointestinal and respiratory illness. The study was reviewed and approved by the Children's Hospital Boston Institutional Review Board.

Participants

This study took place over an 8-week period (March to May 2006) in a single elementary school system (classrooms located in 2 buildings) located in Avon, Ohio. These schools serve the same geographic area and were selected based on an interest in participating and a classroom arrangement that supported our interventional study design. Eight third-grade classrooms located in 1 building (split into 4 teams of 2 classrooms each; each classroom within a team rotates through a specified set of rooms for that team during the school day), and 4 fourth-grade classrooms (1 team of 4 classes) and 3 fifth-grade classrooms (1 team of 3 classes) located in another building participated in the study. To be eligible for the study, a student had to be a member of 1 of these classrooms. A written recruitment letter that was cosigned by the classroom teacher was distributed through the school to all of the

families of eligible students. A student's parent or guardian either provided written consent to participate or declined participation by means of an opt-out postcard. If neither the opt-out card nor the consent form was received, the child's teacher or study personnel called the parent or guardian to remind them to respond. Students also provided written assent to participate. Teachers provided a separate written consent to participate in the study. No eligible students who expressed interest in participating were excluded.

Intervention

Clustered randomization was used to assign classrooms to intervention or control groups, with the team as the unit of randomization. This randomization scheme was selected because classes in each team share classroom space within the school, and students on a given team were, therefore, likely to be correlated. Randomization was also stratified by team size; because the 2 teams representing the fourth and fifth grades were larger than the 4 third-grade teams, we ensured that each group would contain 1 larger team and 2 smaller teams. The allocation sequence was generated by computer, and teams were assigned to study groups by a study investigator (Dr Shih).

In each intervention classroom, teachers were given a container of disinfecting wipes (Clorox Disinfecting Wipes [The Clorox Company, Oakland, CA]; active ingredient, 0.29% quaternary ammonium chloride compound) to disinfect the students' desks once daily (after lunch). The individual containers of wipes were labeled by assigned classroom. All of the disinfecting wipes containers were placed on a shelf in the classroom. Teachers were instructed by the research team on how to use the wipes properly. The individually labeled empty containers were collected once every 3 weeks from the classroom to assess adherence. In addition, each intervention classroom was provided with pre-labeled 1.7-oz containers of alcohol-based hand sanitizer (AeroFirst nonaerosol alcohol-based foaming hand sanitizer [DEB SBS Inc, Stanley, NC, for The Clorox Company]; active ingredient, 70% ethyl alcohol). Students were instructed by study personnel on proper hand-hygiene techniques using the sanitizer. Students were asked to use the hand sanitizer before and after lunch, after use of the restroom (on return to the classroom; hand hygiene with soap and water occurred in the restroom, because sanitizers were not placed there), and after any contact with potentially infectious secretions (eg, after exposure to other ill children or shared toys that had been mouthed). A receptacle was placed in each classroom to collect empty bottles of hand sanitizer, and new hand sanitizer was distributed at the beginning of each week. Teachers in the intervention classrooms were responsible for encouraging the use of the disinfecting wipes and hand sanitizer according to study protocol. Teachers were also responsible for proper collection of empty product containers and distribution of new product. In control classrooms, the usual baseline cleaning procedures and hand hygiene practices were

followed; disinfecting wipes were not used in these classrooms, and the students in these classrooms did not use alcohol-based hand sanitizer at school.

Students whose families declined to participate were not asked to use hand sanitizer and were not questioned regarding family characteristics or illnesses (and their absences recorded as part of usual school procedure were excluded from analysis). Classroom cleaning, disinfection, and microorganism sampling occurred as planned in the designated classrooms.

Data Collection and Illness Definitions

Existing school policy requires that a parent or guardian call to report absences for their children. All of the student absences were recorded in the usual fashion by the school employee who normally answers this dedicated telephone line. This employee was blinded to the group assignment of the child. In addition to recording the name of the child and the date of the absence, this individual recorded the reason for the absence on a standardized form, from which the absence was classified as respiratory or gastrointestinal illness related (or not illness related) according to protocol-specified definitions. A respiratory illness was defined as an acute illness that included ≥ 1 of the following symptoms: runny nose, stuffy or blocked nose, cough, fever or chills, sore throat, or sneezing. A gastrointestinal illness was defined as an acute illness that included ≥ 2 watery or much looser-than-normal bowel movements and stools over a 24-hour period and/or vomiting. These definitions were adapted from those used in previously published studies of respiratory and gastrointestinal illness transmission.^{10,11}

Swabs for bacteria and viruses from 3 types of classroom surfaces (desktops, computer mice, and water fountains) were obtained once per week during the first 5 study weeks. Four desktops from each classroom were selected at random and sampled each week. In addition, 1 water fountain and 2 computer mice in each classroom were also sampled once weekly. All of the samples were collected by the teachers, who received training from study personnel on sample collection. Surface samples were obtained by swabbing each individual surface with a sterile polyester fiber-tipped transport system collection swab moistened in transport medium (BBL Culture-swabs [Becton Dickinson and Company, Sparks, MD]). All of the samples were delivered overnight to the University of Arizona laboratory on ice and frozen at -80°C until assayed. The laboratory used for this study was chosen because it has experience processing swabs from environmental surfaces for viral pathogens in previous research studies.¹²

Outcomes

The primary outcome was the absenteeism rate caused by respiratory or gastrointestinal illness during the study period. The absenteeism rate was measured as the number of school days missed during the study period specifically caused by reported respiratory or gastrointestinal illness, divided by the total number of

school days eligible during the study period. Secondary outcomes included bacterial colony counts and the presence of selected viruses on designated classroom surfaces.

Bacterial count was measured as the median total heterotrophic bacterial count in colony-forming units (CFUs) per milliliter on the described surfaces. Standard microbiologic culture techniques were used to identify bacteria. Specific organisms of interest were also assessed, including *Staphylococcus aureus* (both methicillin-susceptible and methicillin-resistant strains).

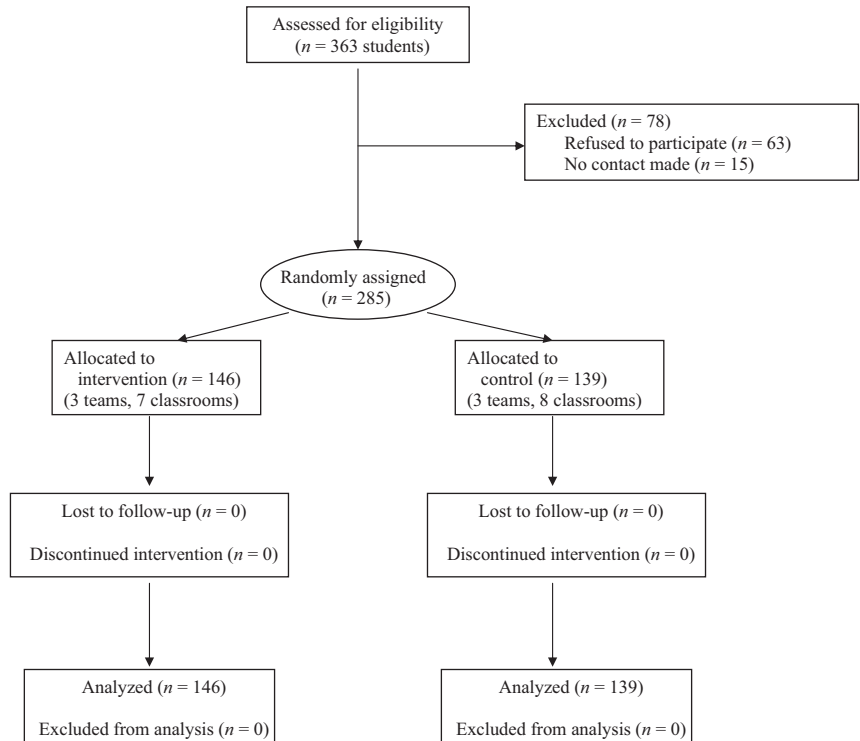
The frequency of viral contamination of surfaces was measured as the presence of 4 viruses (parainfluenza virus 3, influenza A, respiratory syncytial virus, and norovirus) on the described surfaces as detected by reverse-transcription polymerase chain reaction (RT-PCR). Samples were extracted from the collection swabs and homogenized using a vortex mixer followed by viral RNA extraction. Viral RNA was then isolated using nested RT-PCR or multiplex heminested RT-PCR.

Statistical Analysis

Absenteeism rates (number of ill days per student) were modeled as Poisson variables. Generalized estimating equations were used to compare absenteeism rates between intervention and control groups, accounting for potential correlations among students on the same team. This comparison was performed first in an unadjusted analysis and was then adjusted (using multivariable regression models) for potential confounders, including gender, race, health status, family size, and hand sanitizer use in the home. Bacterial counts on classroom surfaces were compared between intervention and control groups using Wilcoxon rank-sum tests. The presence of virus on classroom surfaces was compared between intervention and control groups using Fisher's exact test. Statistical analyses were performed by using SAS 9.1 (SAS Institute, Inc, Cary, NC). Two-sided *P* values of $<.05$ indicated statistical significance.

Sample size was fixed based on the number of students available in the participating classrooms. Power was then calculated based on this sample size. Four teams of 2 classes each from third grade, 1 team of 4 classes from fourth grade, and 1 team of 3 classes from fifth grade participated in the study. Three teams total (2 third-grade teams plus 1 of the larger teams [either fourth or fifth grade]) were randomly assigned to each study group (intervention or control). Assuming that there were, on average, 25 students per class, the team size was $25 \times 2 = 50$ for the third grade, $25 \times 4 = 100$ for the fourth grade, and $25 \times 3 = 75$ for the fifth grade; therefore, there were $\sim 50 + 50 + 80 = 180$ students in each group. Based on previous unpublished studies, the absenteeism rate in the control group was anticipated to be 2%. Assuming that there were 40 eligible days per student during the study period (5 days per week over 8 weeks) and that the correlation of illness burden among students in the same team was 0.01,¹³ using the average team size of 60, this study with 3 teams per treatment group would have had 97% power to detect a 50%

FIGURE 1
Participant flow diagram.



decrease in absenteeism and 86% power to detect a 40% decrease.

RESULTS

A total of 363 students in 15 different classrooms were eligible to participate and received letters about the

study. A total of 285 of these students provided written informed consent and were randomly assigned (Fig 1). No students were lost to follow-up or discontinued the intervention during the study period.

Baseline demographic characteristics were similar in the intervention and control groups (Table 1). Most families were white and non-Hispanic and in excellent or very good health at baseline. The most common family size was 4 to 5 household members. Alcohol-based hand sanitizers were currently being used in the homes of approximately half of the families in each group.

Table 2 displays the number of absences for gastrointestinal and respiratory illness during the study period. Twenty-four percent of the students in the control group missed ≥ 1 day because of a gastrointestinal illness, compared with 16% of the students in the intervention

TABLE 1 Baseline Demographic Characteristics

Demographic Variable	Control (N = 144 Families) ^a	Intervention (N = 146 Families) ^a	<i>p</i> ^b
Gender, <i>n</i> (%)			.64
Male	70 (49)	65 (45)	
Female	74 (51)	79 (55)	
Race, <i>n</i> (%)			.47
White	125 (87)	130 (90)	
Black	4 (3)	1 (1)	
Other	13 (9)	10 (7)	
No. of people currently living in home, <i>n</i> (%)			.83
≤ 3	22 (15)	17 (12)	
4–5	96 (67)	109 (75)	
≥ 6	26 (18)	19 (13)	
Household member health status, <i>n</i> (%)			.09
Excellent	80 (56)	97 (67)	
Very good	55 (38)	40 (28)	
Good	8 (6)	8 (6)	
Fair	1 (1)	0 (0)	
Poor	0 (0)	0 (0)	
Current hand-sanitizer use in home, <i>n</i> (%)			.81
Yes	68 (47)	70 (49)	
No	76 (53)	73 (51)	

^a Numbers may not sum to group totals for all of the variables because of missing responses.

^b Data are from the Fisher's exact test or Cochran-Armitage trend test.

TABLE 2 Absences for Gastrointestinal and Respiratory Illness

No. of Absences for Specified Illness	Control Students (N = 139), <i>n</i> (%)	Intervention Students (N = 146), <i>n</i> (%)
Gastrointestinal illness		
0	105 (76)	123 (84)
1	21 (15)	15 (10)
2	9 (6)	5 (3)
3	3 (2)	2 (1)
5	0 (0)	1 (1)
7	1 (1)	0 (0)
Respiratory illness		
0	104 (75)	106 (73)
1	19 (14)	22 (15)
2	10 (7)	10 (7)
3	5 (4)	5 (3)
4	1 (1)	3 (2)

TABLE 3 Predictors of Absenteeism

Covariate ^a	Absenteeism for Gastrointestinal Illness, Rate Ratio (95% CI)	<i>P</i>	Absenteeism for Respiratory Illness, Rate Ratio (95% CI)	<i>P</i>
Study arm				
Intervention	0.91 (0.87–0.94)	<.01	1.10 (0.97–1.24)	.12
Control	1.00 ^b	NA	1.00	NA
Race				
White	1.06 (0.74–1.51)	.75	0.79 (0.52–1.18)	.24
Other	1.00	NA	1.00	NA
Health status				
Excellent	0.93 (0.79–1.11)	.43	0.75 (0.64–0.87)	<.01
Other	1.00	NA	1.00	NA
Family size				
≤3	1.00	NA	1.00	NA
4–5	1.10 (0.92–1.32)	.30	1.10 (0.81–1.50)	.55
≥6	1.13 (0.93–1.38)	.20	0.89 (0.67–1.19)	.44
Current hand-sanitizer use in home				
Yes	0.96 (0.85–1.10)	.56	0.87 (0.74–1.02)	.08
No	1.00	NA	1.00	NA

NA indicates not applicable.

^a Analyses were adjusted for race (white versus other), health status (excellent health versus other), family size (≤3 vs 4–5 versus ≥6), and current sanitizer use in home (yes versus no).

^b Reference groups for calculating rate ratios are indicated by a rate ratio of 1.00.

group. The number of days absent because of gastrointestinal illness during the 8-week study period ranged from 0 to 7 days (median: 0 days) per student in the control group and 0 to 5 days (median: 0 days) per student in the intervention group. Twenty-five percent and 27% of students in the control and intervention groups, respectively, missed ≥1 day because of a respiratory illness. The number of days absent because of respiratory illness during the study period ranged from 0 to 4 days (median: 0 days) per student in each group.

Compared with the control group, the unadjusted absenteeism rate for gastrointestinal illness was significantly lower in the intervention group (rate ratio: 0.86 [95% confidence interval (CI): 0.79–0.94]; *P* < .01). The unadjusted absenteeism rate for respiratory illness was not different between the groups; the intervention to control group rate ratio was 1.07 (95% CI: 0.92–1.24; *P* = .39). Predictors of absenteeism included in the multivariable models are shown in Table 3. After adjusting for race, health status, family size, and current hand-sanitizer use in the home, the absenteeism rate for gastrointestinal illness remained significantly lower in the intervention group compared with the control group (rate ratio: 0.91 [95% CI: 0.87–0.94]; *P* < .01). The adjusted absenteeism rate for respiratory illness was not different between the groups; the rate ratio was 1.10 (95% CI: 0.97–1.24; *P* = .12).

Complete microbiologic sampling data were available for 3 of the planned 5 sampling weeks (weeks 1, 2, and 4; in weeks 3 and 5, the samples were picked up late for shipping and could not be processed by the laboratory). Norovirus was the only virus detected on classroom surfaces during the study (Table 4). In comparing all of the samples across the entire study period, norovirus

TABLE 4 Norovirus Detection on Classroom Surfaces

Week	Surface	No. (%) of Samples in Which Norovirus Was Detected		<i>P</i> ^a
		Control	Intervention	
Total for study	All samples ^b	47 (29)	12 (9)	<.01
Week 1	All samples	28 (51)	2 (4)	<.01
	Computer mouse	10 (63)	0 (0)	<.01
	Desks	14 (45)	1 (4)	<.01
Week 2	Water fountains	4 (50)	1 (14)	.28
	All samples	0 (0)	0 (0)	NA
	Computer mouse	0 (0)	0 (0)	NA
	Desks	0 (0)	0 (0)	NA
Week 4	Water fountains	0 (0)	0 (0)	NA
	All samples	19 (39)	10 (28)	.36
	Computer mouse	5 (36)	1 (10)	.34
	Desks	10 (36)	6 (30)	.76
	Water fountains	4 (57)	3 (50)	.99

NA indicates not applicable.

^a Data are from Fisher's exact test.

^b Total number of samples for the study are 160 for the control group and 134 for the intervention group.

was detected on significantly fewer surfaces in intervention classrooms when compared with controls (9% of intervention classroom samples were positive vs 29% of control samples; *P* < .01). When comparing specific surfaces tested, norovirus was significantly less frequent on computer mice and desks in week 1. A similar trend was also seen for water fountains during week 1, but the difference was not statistically significant; the number of water fountain samples was smaller than other surface samples because each classroom only contained a single water fountain.

The results of the bacterial sampling are displayed in Table 5. Overall, the median colony count on classroom surfaces was 60 CFU/mL in the control group and 50 CFU/mL in the intervention group (*P* = .11). In weeks 1 and 2, the bacterial colony count was

TABLE 5 Bacterial Colony Counts on Classroom Surfaces

Week	Surface	Median HPC in CFU/mL		<i>P</i> ^a
		Control	Intervention	
Total for study	All samples ^b	60	50	.11
Week 1	All samples	180	90	.01
	Computer mouse	225	100	.04
	Desks	220	90	.01
	Water fountains	40	70	.22
Week 2	All samples	30	10	.03
	Computer mouse	30	40	.68
	Desks	30	0	.01
	Water fountains	10	10	.68
Week 4	All samples	65	135	.30
	Computer mouse	160	55	.58
	Desks	60	140	.14
	Water fountains	20	190	.99

HPC indicates heterotrophic plate count.

^a Data are from the Wilcoxon rank-sum test.

^b The total numbers of samples for the study were 147 for the control group and 153 for the intervention group.

significantly lower in the intervention group when compared with controls; no difference was seen in week 4. Colony counts on desks were significantly lower in the intervention group in weeks 1 and 2, and colony counts on computer mice in the intervention group were lower during week 1. Bacterial counts were never significantly higher in the intervention group during any week or for any surface examined. We also looked specifically for *S aureus* in cultures; during the study, 6 samples grew *S aureus* (3 each from the control and intervention groups); only 1 of these isolates was methicillin resistant.

Over the course of the study, 7175 disinfecting wipes (205 canisters of 35 wipes each) and 70 bottles of hand sanitizer were used. With 8 study weeks and 7 intervention classrooms, the product usage averaged 897 wipes used per week (128 wipes per classroom per week) and 8.75 bottles of hand sanitizer used per week (1.25 bottles per classroom per week). No adverse events were reported during the study.

DISCUSSION

We found that a multidisciplinary infection-control intervention, consisting of surface disinfection plus alcohol-based hand-sanitizer use, reduced the absenteeism rate for gastrointestinal illness in elementary school classrooms. The absenteeism rate for respiratory illness was not reduced by this intervention.

Gastrointestinal illnesses are extremely common and have important consequences. It has been estimated that the number of intestinal infectious diseases in the United States may approach 100 million cases annually, and these illnesses cost \$23 billion per year in health care expenditures and lost productivity.¹⁴ Any intervention that can reduce these infections will, therefore, have substantial impact on both public health and resource use. School-aged children frequently have exposures to peers with gastrointestinal illnesses, and inadequate hand-hygiene practices place them at risk of acquiring these infections. A 10% to 15% reduction in absenteeism, the effect size seen in our study, would correspond with a substantial number of additional days in school that are currently being lost to these illnesses.

Waterless hand-hygiene agents, including alcohol-based hand rubs, reduce the time required to perform hand hygiene and provide a convenient alternative to hand-washing with soap and water when immediate access to a sink is not available.¹⁵⁻¹⁷ These agents are rapidly bactericidal and virucidal for the pathogens that most frequently cause respiratory and gastrointestinal illnesses in school-aged children, and several studies have suggested that these products can reduce illnesses in school settings.^{6,7,18,19}

There are fewer published data regarding surface disinfection in group settings for children. A study of an infection-control program, including environmental cleaning and disinfection, was performed in a specialized preschool for children with Down syndrome; parents reported that their children had fewer total illnesses during the intervention year as compared with a preintervention year.⁹ Kotch et al²⁰ performed a cluster-ran-

domized trial of a multicomponent hygienic intervention in child care centers. The intervention included training about disinfection of toilet and diapering areas, toys, sinks, and floors (in addition to hand-washing, laundering of linens and clothing, and hygienic food preparation techniques). The program was effective in reducing the most severe episodes of diarrhea but did not reduce respiratory illnesses.

We found that norovirus was detected less frequently on classroom surfaces in the intervention group compared with the control group. Norovirus is transmitted by hands through the fecal-oral route, directly from person to person, or through contaminated food or water. Experience from outbreak settings suggests that environmental contamination also plays a major role in norovirus infection.²¹⁻²³ Until recently it has been difficult to study the activity of antiseptics and disinfectants against norovirus because of the inability to cultivate the virus in cell lines.²⁴ Evidence of efficacy of various products usually has been based on activity against feline calicivirus, which is used as a surrogate for norovirus, but it remains unclear how well these efficacy data apply to human norovirus. Recently, a group of researchers created a new cell culture model that supports the infectivity and replication of human norovirus²⁵; this breakthrough holds promise for providing insight on the molecular biology of this organism.

The Centers for Disease Control and Prevention currently recommends that chlorine bleach (at a concentration of ≥ 1000 ppm) be used to disinfect environmental surfaces in the setting of norovirus infections.²⁶ Most quaternary ammonium products are believed not to have significant activity against norovirus,²⁷⁻³² because the virus is nonenveloped. However, a recent study of a quaternary ammonium compound showed it to have equivalent virucidal effectiveness against feline calicivirus (\log_{10} reduction: 6.6) as a sodium hypochlorite solution at a concentration of 1000 ppm.³³ In laboratory testing, the wipes used in our study achieved a 1.58-log reduction against feline calicivirus (E. Shaheen, PhD, The Clorox Company, written communication, 2007), suggesting that the product does have some activity (although not enough to achieve complete inactivation, which is the requirement of the Environmental Protection Agency for a disinfectant to be granted a claim against an organism).

Studies using feline calicivirus also suggest that norovirus may be killed less efficiently by alcohol than by routine hand washing.³⁴ We cannot prove that the demonstrated reduction in norovirus exposure was the cause of the decrease in absenteeism from gastrointestinal illness in our study; it is possible that other gastrointestinal pathogens (such as rotavirus, which is known to be killed reliably by alcohol^{35,36}) were contributors to a reduction in days lost to gastrointestinal illness. However, reducing exposure to norovirus in the classroom would still be a potentially valuable outcome given the propensity of norovirus to be spread via environmental surfaces.

The lack of significant effect against respiratory illness in this study is similar to the pattern seen in a

previous study on the effectiveness of hand sanitizer use in reducing illness transmission in the homes of families with children enrolled in out-of-home child care.¹¹ There are several possible explanations why these types of interventions have failed to prevent respiratory illness. It is possible that any contribution of droplet transmission might have reduced our ability to show an impact of hand hygiene and surface disinfection. However, most common respiratory viruses are transmitted primarily by contact via the hands,^{37–40} making this explanation less plausible. A more likely explanation is the difference in the frequency and types of events during which transmission of gastrointestinal or respiratory infections is likely to occur. Gastrointestinal illness is caused by episodic exposure around defecation and subsequent lack of hand hygiene, whereas respiratory virus exposure is virtually constant and requires more fastidious and generalized attention to hand hygiene, which is difficult for most individuals to sustain during the course of a busy day. Because we did not directly monitor timing or frequency of hand sanitizer use by individuals in this study, we cannot determine whether this hypothesis was truly the reason for our inability to reduce absenteeism from respiratory illness. Although our product usage data verify that hand sanitizer was being used in the intervention classrooms, the amount of use may not have been high enough to prevent transmission of respiratory infections.

Any school-based intervention requires time and resources, and this intervention is no exception. Hand sanitizers and surface disinfectants are readily available commercially at a reasonable price and could easily be obtained by school officials. The more critical requirement for a successful intervention is the time commitment of teachers and school administrators. In our experience, school staff members are very invested in education about hand hygiene and illness prevention for young children. Incorporating further infection control education (such as teaching about surface disinfection) into such preexisting education is likely to be the most efficient way to expand such learning opportunities.

This study has several limitations. Because our study design was not factorial, we are not able to determine the relative contributions of hand hygiene and surface disinfection to achieving a reduction in absenteeism from gastrointestinal illness. However, previous studies have shown each approach to be effective individually,^{6–9} and combined interventions could be more effective based on the ability to interrupt transmission through different mechanisms. We believe that multifaceted interventions such as ours are feasible and are frequently more appealing than isolated interventions to those who implement such programs outside of research settings (eg, in schools or other group settings for children). Because illness definitions were symptom based instead of microbiologically confirmed, the possibility for misclassification exists. We made no attempt to verify parental reporting of reason for absence, but we have no reason to believe that misclassification would have been differ-

ent between the 2 groups, and the individual recording absences for the study was blinded to group assignment. In addition, because we did not perform diagnostic tests on ill children, we cannot definitively state that the observed reduction in absenteeism is linked to the observed reduction in environmental pathogens. However, unknown confounders that might otherwise have contributed to the reduced absenteeism should have been distributed equally in the 2 groups by our randomized design. Although we did track overall usage of hand sanitizer and disinfecting wipes, we did not directly observe usage patterns, so we cannot address timing of usage in relation to specific exposures. Finally, because this study took place in a single school system, the results may not be generalizable to other schools where demographics or infrastructure are substantially different.

CONCLUSIONS

We have shown that a multifaceted intervention that included alcohol-based hand sanitizer use and disinfection of common classroom surfaces reduced absenteeism from gastrointestinal illness among elementary school students. The intervention did not impact absenteeism from respiratory illness. In addition, norovirus was detected less frequently on classroom surfaces in the group receiving the intervention. Schools should consider incorporating these simple infection-control interventions in the classroom to reduce the number of days lost caused by common illnesses.

ACKNOWLEDGMENTS

Study funds, hand sanitizer, and disinfecting wipes were provided by The Clorox Company (Oakland, CA). The sponsor did not participate in data analysis or article preparation and did not have approval rights over the publication.

We are indebted to Charles P. Gerba, PhD, Stephanie A. Boone, PhD, and Sonia Frankem at the University of Arizona for processing our specimens. We gratefully acknowledge the students and families who participated in the study and the teachers and administration at the Avon Heritage North and South Elementary Schools. We also thank Sharon Wong of the Clinical Research Program at Children's Hospital Boston for help with creation of our database.

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Pediatrics 2008;121:e1555-e1562

DOI: 10.1542/peds.2007-2597

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