Hand Washing Practices in a College Town Environment

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Abstract **Many people do not wash their hands when the behavior in which they engage would warrant it. Most research of hand washing practices to date has taken place in high-traffic environments such as airports and public attraction venues. These studies have established a persistent shortcoming and a gender difference in hand washing compliance. Using field observations of 3,749 people in a college town environment, the research described in this article replicates and extends earlier work while identifying potential environmental and demographic predictors of hand washing compliance. Additionally, the authors' research suggests that proper hand washing practices, as recommended by the Centers for Disease Control and Prevention, are not being practiced. Finally, the authors' research raises a question as to the accuracy of earlier measurements of "proper" hand washing practices, suggesting that compliance rates are inflated. The results can help increase hand washing rates for the general public and thus decrease the risk of transmitting disease.**

Introduction

Many individuals take hand washing for granted and do not consider how essential hand washing is in the prevention of infections and disease. Thus they often fail to wash their hands when they engage in activity that would warrant or require hand washing. Research has established that people generally overstate the degree to which they wash their hands; that women are much more likely to wash their hands than men; and that while hand washing compliance appears to have increased in recent years much room for growth still exists. According to the Centers for Disease Control and Prevention (CDC) (Mead et al., 1999), failing to wash or insufficiently washing hands contributes to almost 50% of all foodborne illness outbreaks. Additionally, Curtis and Cairncross (2003) performed a meta-analysis that suggests that hand washing with soap can reduce diarrheal disease risks by more than 40% and that hand washing interventions could save one million lives annually. Yet we do not know why people fail to wash their hands at recommended rates and in the proper fashion. Our research attempted to establish predictors of hand washing that can be used to induce higher rates of hand washing compliance.

Current Hand Washing Practices

Recent surveys establish that U.S. adults claim to wash their hands after using public restrooms at very high rates. In 2009, 94% (N = 2,516) suggested that they consistently wash their hands (QSR Magazine, 2009), while in 2010, 96% (N = 1,006) stated that they always wash their hands after using a public restroom (Harris Interactive, 2010). Self-reports of hand washing behavior have been criticized as unreliable as hand washing is a socially desirable activity (Judah, Aunger, Schmidt, Granger, & Curtis, 2009) and observational research suggests these high self-report rates are inflated (Harris Interactive, 2010).

The potential discrepancy aside, it is important to note that hand washing rates have trended upwards in recent years. The American Society for Microbiology and the American Cleaning Institute have studied hand washing practices since 1996. Most recently they reported on hand washing in restrooms at public attractions in five cities across the U.S. The restroom locations included Turner Field in Atlanta, the Museum of Science and Industry and Shedd Aquarium in Chicago, Penn Station and Grand Central Terminal in New York, and the Ferry Terminal Farmers Market in San Francisco (Harris Interactive, 2010). All locations experience high volumes daily, and at the composite level, the 2010 data (N = 6,028) establishes that 85% of the observed adults wash their hands after using a public restroom. This is an increase from 77% in 2007 (N = 6,076), which was somewhat lower than the 2005 rate of 83% (N = 6,336). With the exception of the Shedd Aquarium, which has seen a 3% dip in hand washing rates since 2005, all the venues saw a slight upward trend in observed hand washing rates (Harris Interactive, 2010). In 2003, hand washing rates were also observed across six North American airports, averaging 74% compliance (N = 4,046). The highest hand washing rates were obtained in Toronto with 95% while Chicago had the lowest rate at 62% (American Society for Microbiology, 2003).

The research consistently finds a gender bias in hand washing practices. Women wash their hands more frequently than men. In the 2003 study (American Society for Microbiology) it was observed that 83% of women washed their hands after using the restroom,

whereas only 74% of the men did so. In a multi-year study across public attractions, women consistently wash more than men across all years and venues (Harris Interactive, 2010). The average observed hand washing rates for women were 93% in 2010, 88% in 2007, and 90% in 2005. The equivalent rates for men were 77%, 66%, and 75%, respectively.

A study of 120 secondary school students (Guinan, McGuckin-Guinan, & Sevareid, 1997) found that 58% of female students and 48% of male students washed their hands after using the restroom, although only 28% of the female students and 8% of the male students used soap. In a university campus public restroom study (Johnson, Sholoscky, Gabello, Ragni, & Ogonosky, 2003), 61% of women and 37% of men (N = 175) were observed washing their hands, while the hand washing rate climbed to 97% for women and fell to 35% of men when a sign was introduced to encourage hand washing. Similarly, in a British 32-day study of highway service station restrooms (N = 198,000) that observed entry and soap use with electronic sensors, it was found that 65% of women and 32% of men washed their hands, but that the hand washing rate increased to as much as 71% for women and 35% for men when messages designed to encourage hand washing were displayed using electronic dot matrix screens (Judah et al., 2009).

A study of the hand washing practices of university students living in a dormitory found that women wash their hands after urinating 69% of the time and after bowel movements 84% of the time, whereas the corresponding figures for males were 43% and 78% (Thumma, Aiello, & Foxman, 2008). In a study of restaurant food workers (Green et al., 2006), food handlers washed their hands only 32% of the time when their behaviors made such hand washing required.

A review of the literature on foodborne disease outbreaks from 1975 to 1998 identified 81 foodborne disease outbreaks involving 14,712 people within which 93% of the foodborne outbreaks involved infected food workers transmitting pathogens to the food with their unwashed hands (Guzewich & Ross, 1999). An observation of 80 women in a bar bathroom (Hayes, 2002) found that only 40% washed their hands; when the researcher engaged the subject and modeled hand washing, the hand washing rate increased to 56%, while it dropped to 27% when the researcher appeared to be simply talking on her cell phone. This research also noted that the female subjects were less likely to wash their hands later in the night than earlier in the evening (r = -.44, p < .01).

It is evident from the reviewed research that room for improvement exists in hand washing practices. Additional research is needed to further understand how and why hand washing rates differ and if such rates can be influenced by environmental factors within the restroom. Gender is associated with marked differences in hand washing rates. Are other demographic variables such as age also associated with hand washing rates? Furthermore, evidence exists that environmental variables such as signage and posters influence hand washing rates and other health-related behaviors (Etter & Laszlo, 2005; Judah et al., 2009). Do other environmental variables, such as sink conditions and type of faucet impact hand washing rates? Does the hand washing rate on campus differ from the rate off campus?

It is unclear from the reviewed literature whether the various reported rates of hand washing reflect hand washing with soap as recommended by the CDC or if the rates incorporate practices somewhat inconsistent with the established recommendations. As such, our study used three measures of hand washing, defined as 1) no washing—leaving the restroom without washing or rinsing hands, 2) attempted washing—wetting hands but not applying soap, and 3) washing hands with soap, in addition to measuring the duration of washing. This added distinction is important because Burton and co-authors (2011) reported that washing with soap and water is more effective at removing fecal bacteria from hands than washing with water alone.

Methods

Participants and Procedures

Direct observations of hand washing behaviors were conducted by 12 research assistants in restrooms located across a college town. Observers were instructed to be unobtrusive and disguise their observation of hand washing behaviors. To ensure this and ensure accurate measurement and coding consistency, each of the observers met researchers individually for training and attended training meetings as a group.

All observations were recorded according to a standard coding form. The coding form consisted of the subject ID, date, subject's age group, observation time, gender, hand washing behaviors, the type and availability of drying mechanisms (i.e., not available, hot air, paper towel, or both), location of restrooms (off campus versus on campus), type of faucet (standard faucet versus motion detection), the cleanliness of sink conditions, and availability of hand washing signage.

Washing behaviors were recorded into three categories: no washing (leaving the restroom without washing or rinsing their hands), attempted hand washing (wetting hands without using soap), and washing hands with soap. Observers also discreetly measured the total length of time in terms of the number of seconds subjects' hands were placed under running water during washing, lathering, and rinsing. The time of observation was collected and nominal time categories were formed for the purpose of analyses. Due to the unobtrusive nature of our observations, the subject's age group was estimated using the trained observers' subjective evaluations and the subject was placed into one of two groups: college age or younger and older than college age. The cleanliness of sink conditions had three categories including dirty, reasonable, and clean, which was also based on the subjective evaluation of observers. The presence of a hand washing sign was added to the coding form later based on observer feedback.

Statistical Analysis

Descriptive data were compiled and further analyzed using Chi-square analysis and ANOVA. Specifically, Chi-square analysis was used to identify statistically significant differences in subjects' demographic variables, environmental variables in the restrooms, and among hand washing behaviors. ANOVA was used to establish mean differences in the length of time hands were placed under running water across the above specified variables. Kappa and paired t-test statistics were calculated, using a subsample (n = 90) to evaluate inter-rater reliability.

Results

Inter-Rater Reliability

Evaluation of inter-rater agreement is an important step in ensuring reliability in observa-

tional studies, especially when studies involve multiple observers. We selected four different restrooms (n = 44, located in two off-campus restrooms; and n = 46, located in two on-campus restrooms) to determine the inter-rater reliability among observers. The observers agreed 100% on the environmental variables. For the two dependent variables, the time spent washing time and other washing behaviors, paired-samples t-tests (Fleiss, 1981), and Cohen's Kappa (Cohen, 1960) were used. A Kappa statistic of more than .8, more than .6, and more than .4 is considered to have "almost perfect," "substantial," and "moderate" agreement, respectively (Landis & Koch, 1971). Excellent inter-rater reliability was demonstrated as indicated by nonsignificant paired t-test result in estimating washing time (p > .01) and Kappa of .89 in evaluating washing behaviors.

Characteristics of Sample and Overall Findings

Table 1 presents characteristics of the sample and observation settings. Of the 3,749 subjects observed, approximately 54% of observations took place in restrooms located off campus. Sixty-two percent of observations took place in the afternoon, followed by evening/night (23.6%) and morning (14.4%). Of all subjects, 60.5% of the observed subjects were women. About 62% (61.6%) of the subjects were estimated as college age or younger, with the remainder estimated to be older than college. Nearly all restrooms had a mechanism for drying hands (98.7%). About 64% of the restrooms in the study contained signs encouraging hand washing. Seventy-seven percent of the restrooms were equipped with a standard faucet while 22.9% had motion detection faucets.

Overall, 66.9% of the subjects used soap when washing their hands. Of these, 1.2% did not dry their hands, but left the restrooms with wet hands. About 23% attempted to wash their hands, that is, they wet their hands but did not use soap. A total of 10.3% did not wash their hands *at all* after using the restroom. CDC (2012) recommends that people should rub their soaped hands for 15 to 20 seconds before rinsing thoroughly. Our measure of duration included the length of time placed under running water while subjects were washing, rubbing, and rinsing their hands. Nonetheless, as shown in Table 2, only 5% or so spent more than 15 seconds in combined washing, rubbing, and rinsing of their hands.

TABLE **1**

Characteristics of Sample and Restroom Settings (*N* = 3,749)

Variables	*n*	%
Observation time		
Morning	538	14.4
Afternoon	2,326	62.0
Evening/night	885	23.6
Gender		
Male	1,479	39.5
Female	2,270	60.5
Age		
College group and younger than college group	2,310	61.6
Older than college group	1,439	38.4
Drying		
Not available	47	1.3
Only paper	2,799	74.7
Only air dryer	331	8.8
Both paper and air dryer	572	15.3
Faucet		
Standard faucet	2,889	77.1
Motion detection	860	22.9
Sink condition		
Dirty	219	5.9
Reasonable	1,779	47.5
Clean	1,750	46.7
Location		
On campus	1,755	46.8
Off campus	1,994	53.2
Sign		
Sign	1,548	63.7
No sign	882	36.3

Results From Chi-Square Analysis

The Chi-square analysis revealed statistically significant differences in hand washing behaviors across time of observation, gender, age, sink condition, and hand washing signage (Table 3). For example, 12.4% observed during evenings did not wash their hands while the morning and afternoon rates of leaving the restroom without attempting to wash were 8.6% and 9.4%, respectively. Subjects washed their hands significantly more with soap during mornings (70.6%) than during afternoons (66.4%) and evenings (67%). The gender difference was confirmed with women using soap and engaging in proper hand washing behavior significantly more (77.9%) than men (50.3%). About 7% of the women and 14.6% of the men did not wash their hands at all, while 15.1% of the women and 35.1% of the men simply wet their hands with water. Those estimated to be older than college (70.3%) washed their hands with soap significantly more than the college age and younger group (64.8%).

When restrooms contained hand washing signs, subjects used soap more (68.5%) than subjects in restrooms that had no such signs (60.5%). Sink cleanliness influenced hand washing behaviors as well. When sinks were clean, 73.9% washed their hands using soap, while the rate for reasonably clean and dirty sinks was 61.2% and 59.4%, respectively. No

TABLE **2**

Overall Hand Washing Behavior and Length of Hand Washing Time (*N* = 3,749)

Variables	*n*	%
Washing behavior		
Not washing	384	10.3
Wetting hands without soap	856	22.8
Washing hands with soap	2,509	66.9
Length of hand washing time		
0 seconds	384	10.3
1–4 second(s)	824	22.0
5–8 seconds	1,432	38.2
9–14 seconds	911	24.2
15 seconds or longer	198	5.3

TABLE **3**

Chi-Square Test: Comparison of Hand Washing Behavior by Sample Demographics and Restroom Settings (*N* = 3,749)

Variables	Not Washing	Wetting Hands Without Soap	Washing With Soap	χ^2
	10.3% (*n* = 384)	22.8% (*n* = 856)	66.9% (*n* = 2,509)	
	%	%	%	
Observation time				13.2*
Morning	8.6	20.8	70.6	
Afternoon	9.4	24.2	66.4	
Evening/night	12.4	20.6	67.0	
Gender				311.3*
Male	14.6	35.1	50.3	
Female	7.1	15.1	77.9	
Age				12.9*
College group and younger than college group	10.6	24.6	64.8	
Older than college group	9.7	20.0	70.3	
Faucet				0.8
Standard faucet	9.8	22.9	67.3	
Motion detection	10.8	23.0	66.2	
Sink condition				91.2*
Dirty	19.6	21.0	59.4	
Reasonable	10.7	28.1	61.2	
Clean	8.1	17.9	73.9	
Location				4.8
On campus	10.3	24.3	65.4	
Off campus	9.7	21.6	68.6	
Sign				17.4*
Sign	9.7	21.7	68.5	
No sign	10.7	28.8	60.5	

*$p < .01$.

statistically significant differences in subjects' hand washing behavior were found across faucet type (standard faucet versus motion detection) or restroom location (on campus versus off campus).

Results From ANOVA

Multi-way ANOVA was conducted to evaluate the mean differences among identified factors in terms that may influence the length of washing time (Table 4). Statistically significant differences were found for gender, age group, type of faucet, sink condition, and hand washing signage. The average washing time for men and women, although short for both, was 6.27 seconds for men and 7.07 seconds for women. The gender effect persists. The age group older than college spent significantly more time washing their hands (mean = 6.93 seconds) than did college group and younger than college group (mean = 6.48 seconds). The presence of a sign also influenced washing time; the mean score in the presence of a sign was 7.08 seconds and 6.50 seconds without. Subjects spent significantly more time washing their hands when the sink condition was clean (mean = 7.20 seconds), compared to when the sink appeared reasonably clean (mean = 6.36 seconds) or dirty (mean = 6.16 seconds). No significant differences in hand washing time were found across time of observation or restroom locations.

Discussion

Hand washing is the most effective thing one can do to reduce the spread of infectious diseases according to CDC (CDC, 2012; Mead et al., 1999). Our study provided detailed information about how long and in what environments different groups engaged in various hand washing behaviors. While earlier research reported that not all wash their hands, prior studies have not identified factors associated with proper hand washing behaviors. Additionally, previous studies did not clearly distinguish between washing with and without soap. Our study recognizes the importance of environmental factors that promote proper hand washing behaviors. To our knowledge, our study was one of the first studies to focus on hand washing behaviors and the length of time spent washing while incorporating environmental factors and the time of observation.

The observed hand washing behaviors and the length of time washing hands relate differently to different factors. Our study supports earlier work in observing that men need more encouragement than women to engage in proper hand washing behaviors, although most men and women do wash their hands using soap. Nonetheless, the percentages who simply wet their hands was significantly higher for men (35.1%) than for women (15.1%).

While our study was not specifically designed to test for the intervention effect of a hand washing sign, the study did find that the presence of a sign influenced both hand washing behaviors and the length of washing time. This is an important finding as a high percentage of people fail to wash their hands properly, and signs that include messages highlighting correct hand washing or reminders to use soap may increase compliance. It appears that this kind of explicit reminder may be particularly useful in men's restrooms, given that more than one-third of men simply wet their hands without using soap.

In previous studies the automated and sequenced phases of the device/sink resulted in significant improvement in hand washing practices (Larson, Bryan, Adler, Lee & Blane, 1997; Larson, McGeer, & Quiaishi, 1991). Our study showed that the type of faucet itself (standard faucet versus motion detection) did not impact hand washing behaviors. Care must be taken in the interpretation of washing time, as it is possible to equate washing time with the motion-detected dispensing of water, much as our study did in terms of manual water flow.

More importantly, the findings of our study showed that it is important to maintain clean sink conditions, as clean sinks promoted proper hand washing procedures as well as increased length of time washing hands. When sinks are dirty, some may choose not to wash their hands, despite knowing they should. Studying the effect of time of day on hand washing behavior, a relatively new research focus, showed that hand washing generally decreased as the evening progressed.

The most important findings of our research relate to the distinctions among hand washing behaviors and the length of time hands were washed. Specifically, less than 6% of the sample approached the recommended hand washing duration. Furthermore, our study identified that a large proportion of subjects engaged in hand washing behavior that did not involve the use of soap. It is interesting to note that if the proportion of people who were observed using soap when washing their hands were combined with those who only used water, the hand washing rates reach the higher levels reported in other studies. This raises the question of whether hand washing compliance rates have been inflated by way of definition in earlier work.

TABLE **4**

Multi-Way ANOVA: Hand Washing Time by Demographics and Restroom Settings (*N* = 3,749)

Variables	Hand Washing Time Mean (Seconds)	*F*	η^2
Observation time		.92	.022
Morning	6.50		
Afternoon	6.81		
Evening/night	6.77		
Gender		25.21*	.082
Male	6.27		
Female	7.07		
Age		8.14*	.058
College group and younger than college group	6.48		
Older than college group	6.93		
Faucet		49.29*	.114
Standard faucet	6.45		
Motion detection	7.74		
Sink condition		15.76*	.091
Dirty	6.16		
Reasonable	6.36		
Clean	7.20		
Location		2.23	.024
On campus	6.63		
Off campus	6.86		
Sign		7.97*	.057
Sign	7.08		
No sign	6.50		

Note. Total mean = 6.75 (*SD* = 4.76), mean = 7.52 (*SD* = 4.41).
*$p < .01$.

Limitations and Future Research

While the data from our study are informative, it should be noted that observations only took place in one college town environment. Care should be therefore taken in generalizing the findings.

As an alternative to the self-reporting method, direct and unobtrusive observations of hand washing were used as a way to enhance reliability and validity. It should be recognized, however, that even an apparent unobtrusive observation may influence hand washing behaviors, as the simple presence of others in a restroom may lead to increased compliance (Bittner, Rich, Turner, & Arnold, 2002; Drankiewicz & Dundes, 2003; Edwards et al., 2002; Nalbone, Lee, Suroviak, & Lannon, 2005).

While our study attempted to investigate the role that a hand washing sign would have on hand washing behavior, the subjects were not asked whether they recalled seeing the sign or whether they could recall the messages. Future research should consider sign content, design, and placement.

In our study the act of drying was measured. Approximately 2% of subjects who

attempted to wash their hands (i.e., wetting hands without soap) or washed hands with soap did not dry their hands at all, but we do not know if those who attempted to dry their hands achieved dry hands. This would be good to include in future studies as studies have demonstrated that the transfer of microorganisms is more likely to occur from wet skin than from dry skin (Mackintosh, & Hoffman, 1984; Merry, Millder, Findon, Webster, & Neff, 2001; Patrick, Miller, & Findon, 1997).

Conclusion

Our study replicated and extended earlier work on hand washing practices. While past studies have focused on high-traffic venues such as transportation hubs and stadiums, our study focused on hand washing behaviors in a college town environment. Field observations by trained observers in a variety of restrooms provided a sample of 3,739 people who were unobtrusively watched to note their hand washing behaviors.

The findings were consistent with earlier research in that a significant gender bias was found. Women wash their hands significantly more often, use soap more often, and wash their hands somewhat longer than men. Both men and women fell far short, however, of CDC-recommended hand washing durations, averaging 6.27 and 7.07 seconds, respectively. Only 5.3% of the sample washed their hands for 15 seconds or more. Considering the definition of hand washing and the careful training of observers, this particular finding raises the specter of significant inflation in earlier reported hand washing compliance rates. Future studies need to measure hand washing compliance carefully.

Additionally, our study established that restroom environmental conditions and signage are important. Specifically, hand washing compliance was greater when restroom sinks were clean and when signs encouraging hand washing were posted.

Hand washing compliance and practices as reported in this and previous studies fall short of the ideal. The public needs to be continuously encouraged to engage in proper hand washing practices. In addition, careful attention to restroom environmental conditions and signage may help increase compliance. Given the established gender bias, consideration should be given to the content of the messages targeting men and women. Perhaps men and women would respond differently to gender-targeted messages.

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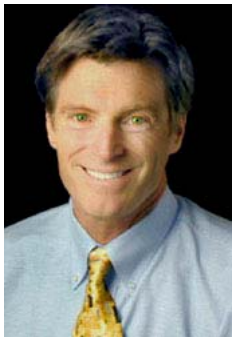
11 HAND WASHING FACTS

Could singing Yankee Doodle save your life?



By Jay Hardy, CLS, SM (ASCP)

Jay Hardy is the founder and president of Hardy Diagnostics.

After studying microbiology at California State Universities at Fullerton and Long Beach, he completed his Medical Technology internship at Santa Barbara Cottage Hospital.

The company began in 1980, shortly after Hardy served as a Medical Technologist and microbiologist at Goleta Valley Hospital in California.

1.

80% of all infectious diseases are transmitted by touch.

According to experts, without a vaccine, the single most important thing you can do to prevent getting the flu is to wash your hands.

2.

The Solution to Pollution is Dilution.

While soap may not kill all viruses, thorough hand washing will decrease the viral counts to a point below the infectious threshold.

3.

Caught in the act (or lack of).

95% of the population says that they wash their hands after using a public toilet. However when 8,000 people were monitored across five large cities in the US, they found the actual number to be more like 67%.

Chicago topped the list at 83%. New York was the worst at less than half.

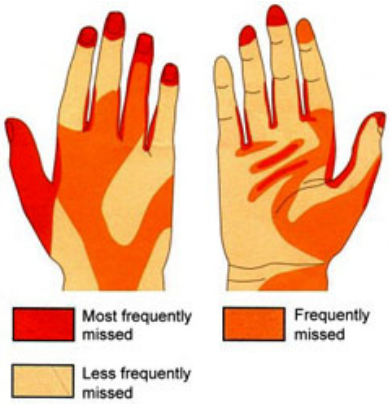
4.

Do as I say, not as I do…

A poll of pediatric ICU physicians showed that they ***claimed*** their rate of hand washing between patients was 73%, but when followed and observed, the hand washing rate was found to be less than 10%. Listen carefully and you can hear Dr. Semmelweis rolling over in his grave. The top excuses for not hand washing among doctors? Too busy and dry skin.

5.

Where's the dirt?



CDC studies show that the number of bacteria per square centimeter on the human body are as follows:

- ☐ Scalp – 1,000,000
- ☐ Forearm – 10,000
- ☐ Arm pit – 500,000
- ☐ Abdomen – 40,000
- ☐ Hands of medical personnel – 40,000 to 500,000

When it comes to hands, fingernails and the surrounding areas harbor the most microorganisms.

6.

Who has it?

A recent study showed that 21% of the health care workers in ICU had varying counts of *Staphylococcus aureus* on their hands.

7.

Too busy?

One study demonstrated that hand washing guidelines were followed 25% of the time during times when the floor was overcrowded and understaffed. Compliance rose to 70% when the floor was properly staffed and not overcrowded with patients.

8.

And the winner is…

Many studies have shown that alcohol rubs are more effective than plain or even antimicrobial soaps, unless the hands are heavily soiled. However we can't get overconfident with alcohol rubs. Despite its effectiveness against many organisms, alcohols have very poor activity against bacterial spores, protozoan oocysts, and certain non-enveloped (nonlipophilic) viruses. In addition, alcohol has no residual effect as some antimicrobial soaps do.

9.

How long is enough?

The CDC recommends at least 15 seconds. However, studies show that the reduction of skin bacteria is nearly ten times greater by washing with soap for 30 seconds rather than 15. Even so, remember that alcohol gels are even more effective than soap.

The average wash time for health care workers? 9 seconds.

Children (and why not adults?) are taught to sing “Yankee Doodle Dandy” start to finish before rinsing. This takes about 15 seconds. If you don’t know the words to Yankee Doodle, the Happy Birthday song sung twice will suffice.

10.

Some like it hot.

But if they do, hot water can increase the chance of dermatitis. Hot or warm water has not been proven to increase the effectiveness of hand washing. Cold water, though not as comfortable, produces less skin damage from detergents especially with repeated washings.

11.

The two layers of bacteria.

The outer layer of bacteria found on your hands is termed “**Transient Flora**”. This layer is potentially the most dangerous for transmitting disease from one person to another. Fortunately, it is also the most easily eliminated by hand washing. The deeper layer is called “**Resident Flora**”. This bacterial population is more likely to be made up of innocuous bacteria such as *Staphylococcus epidermidis* and *Corynebacteria* spp. (diptheroids); and is more resistant to washing, since they occupy the deeper layers of skin cells.

Jay Hardy
HARDY DIAGNOSTICS

World Health Organization
REGIONAL OFFICE FOR Africa

Division of Prevention and Control of Non-Communicable Diseases
Food Safety and Nutrition

Fact Sheet 2º

Hand Washing and Food Safety

A bulk of the foodborne disease outbreaks are attributable to poor hygienic practices and improper handling of food. Undoubtedly, adequate personal hygiene practices are essential in reducing the risks of a foodborne illness. Hand washing is one of the most effective and cheapest measures against infections and foodborne diseases.

FAST FACTS

- Many foodborne diseases and pathogenic microorganisms are spread by contaminated hands.
- Foodborne pathogens, such as *salmonellosis, shigellosis, hepatitis A, giardiasis* and *campylobacteriosis* are transmitted via the faecal-oral route. These account for a substantial number of disease outbreaks in developing countries.
- Good quality drinking-water and good personal hygiene in food preparation and handling are therefore of utmost importance in preventing the spread of disease.[1]

Foodborne disease

Many foodborne diseases and pathogenic microorganisms are spread by contaminated hands. Many of these illnesses occur unnecessarily, since the faecal-oral routes of disease transmission are easily prevented.[1]

WHO reports that 90% of the annual deaths from diarrhoea are among children particularly in developing countries. A significant number of the deaths could be attributed to shigella, which causes dysentery or bloody diarrhoea. [2]

A study on the microbial quality of street foods in Accra, Ghana showed among others the significance of proper hand-washing practices, use of soap and environmental hygiene. Among the reported risk factors for street food contamination were cooking of food well in advance of consumption, exposure of food to flies, and working with food at ground level and by *hand*.[3]

Significance of proper hand washing to food safety

Judicious washing of hands can significantly reduce bacterial contamination and risk of foodborne illness.

Reports indicate that the simple act of washing hands with soap and water reduces incidents of diarrhoea from *shigella* and other causes by up to 35 percent. [2]

Proper hand washing

Hands should ideally be washed, with soap or ash, under running water. Rubbing hands vigorously 15-20 seconds until a soapy lather

[1] Healthy Villages – A guide for communities and community health workers. WHO. 2003.
[2] Water for Health: Taking Charge. WHO. 2001.
[3] Mensah *et al.* Street Foods in Accra, Ghana: How Safe Are They? Bulletin of the World Health Organization. 2002.



appears, and scrubbing between fingers and fingernails.

Where there is no system, running water can be organized by using a water butt with a tap. If there is a shortage of water, using soap with a small quantity of water in a bowl is adequate.[4]

Washing of hands should be particularly be done:

- Before food preparation;
- Before eating;
- Before serving food;
- During food preparation to avoid cross-contamination;
- Before and after handling raw meat, poultry and fish products;
- After changing diapers;
- After blowing nose/sneezing;
- After using the toilet, not just after defecation, since the pathogens can also be picked up from previous users of toilets via door handles, taps and drying towels.[5]
- After handling unsanitary objects such as waste/garbage containers;
- After contact with toxic substances or chemicals;
- After touching/handling livestock or pets

In all these activities hands may become contaminated with pathogens or toxic chemical residues that can be transferred to food.[5]

Health education in food safety

Experience has shown that well designed and implemented educational programmes, is a feasible and cost-effective means of improving health status.[6]

Adequate food safety and hygiene education/promotion particularly in schools with the provision of adequate sanitary and hand-washing facilities are essential.

WHO technical support and actions in food safety education

A special focus is being made at collaborating with education authorities to promote food safety education in primary and secondary level, among both students and parents. Work is also underway on the promotion of participatory community-based food safety education and awareness-raising strategies.

For More Information on Food Safety and Nutrition please contact Division of Prevention and Control of Non-communicable Diseases (DNC). B.P. 6 Congo Brazzaville.

[4] Food, Environment and Health: A Guide for Primary School Teachers. WHO. 1990

[5] Basic Food Safety for Health Workers. Adams M and Mortarjemi Y. WHO. Geneva. 1999

[6] Foodborne disease: a focus for health education. WHO. 2000

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Factors Related to Food Worker Hand Hygiene Practices†

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ABSTRACT

To identify factors related to food worker hand hygiene practices, we collected (i) observational data on food worker (n = 321) hand hygiene practices (hand washing and glove use) and (ii) observational and interview data on factors related to hygiene behavior, such as worker activity, restaurant characteristics, worker food safety training, and the physical and social environment. Results indicated that hand washing and glove use were more likely to occur in conjunction with food preparation than with other activities (e.g., handling dirty equipment) and when workers were not busy. Hand washing was more likely to occur in restaurants whose food workers received food safety training, with more than one hand sink, and with a hand sink in the observed worker's sight. Glove use was more likely to occur in chain restaurants and in restaurants with glove supplies in food preparation areas. Hand washing and glove use were also related to each other—hand washing was less likely to occur with activities in which gloves were worn. These findings indicate that a number of factors are related to hand hygiene practices and support suggestions that food worker hand hygiene improvement requires more than food safety education. Instead, improvement programs must be multidimensional and address factors such as those examined in this study.

Many reported foodborne illness outbreaks originate in food service establishments *(25),* and sporadic foodborne illnesses have been associated with having eaten outside the home *(11, 19).* Additionally, food workers' poor personal hygiene is an important contributor to foodborne illness outbreaks *(15, 25).* For example, Olsen et al. *(25)* found that annually from 1993 to 1997, poor personal hygiene of food workers was a contributing factor in 27 to 38% of foodborne illness outbreaks, and Guzewich and Ross *(15)* found that in 89% of outbreaks caused by food contaminated by food workers, pathogens were transferred to food by workers' hands.

The U.S. Food and Drug Administration's (FDA) Food Code for retail establishments includes guidelines on prevention of food contamination by workers' hands *(15, 29).* Hand washing is one of the FDA's recommended prevention methods, for it can significantly reduce transmission of pathogens from hands to food and other objects *(15, 22, 24).* The Food Code indicates that proper hand washing should take at least 20 s and include running warm water, soap, friction between the hands for 10 to 15 s, rinsing, and drying with clean towels or hot air. In addition, the Food Code specifies situations in which hands should be washed, such as before food preparation and after handling raw meat or poultry. The FDA also recommends that bare-hand contact should be prevented when working with ready-to-eat (RTE; i.e., safe to eat without further cooking) food and minimized when working with non-RTE food, because hand washing may not always be sufficient to prevent the transmission of pathogens from hands to other items, such as food *(3, 9, 22).* The Food Code suggests that barriers, such as deli tissue, tongs, and disposable gloves, be used for this purpose. Gloves are commonly used as barriers in food service establishments, and anecdotal evidence suggests that glove use for this purpose may be increasing. Proper glove use can decrease the transfer of pathogens from hands to food *(22, 23),* but some researchers and practitioners have argued that glove use may lead to less safe hand washing practices *(10, 15, 21).*

Research on the prevalence of hand washing and glove use in food-service establishments indicates that these hand hygiene practices do not occur as often as they should. For example, food workers have reported that they sometimes or often do not wash their hands and/or wear gloves when they should, do not always wash their hands after touching raw meat, and do not always change their gloves after touching raw meat *(6, 13).* Additionally, observational studies have found low rates of hand hygiene practices. For example, the FDA observed improper hand washing in 73% of restaurants and failure to prevent bare-hand contact with RTE foods in 57% of restaurants *(28).* Additionally, both Clayton and Griffith *(5)* and Green et al. *(14)* found that observed food workers washed their hands in only a third of the instances in which they should have washed them.

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† The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

TABLE 1. *Observed activities for which hand washing is recommended*

When hand washing should occur	Activity	Description
Before the activity	Food preparation	Engaging in food preparation, including working with exposed food, clean equipment and utensils, and unwrapped single-use articles
	Putting on gloves for food preparation	Putting on gloves in order to engage in food preparation (see above)
After the activity and before beginning another activity	Preparing raw animal product	Preparing raw animal product (animal products that have not been cooked or processed; uncooked eggs, meat, poultry, and fish)
	Eating, drinking, tobacco use	Eating, drinking, or using tobacco (unless from a closed beverage container handled to prevent hand contamination)
	Coughing, sneezing, tissue use	Coughing, sneezing, or using a handkerchief or disposable tissues
	Handling dirty equipment	Handling dirty equipment, utensils, or cloths
	Touching body	Touching human body parts other than clean hands and clean, unexposed arms

These findings, along with evidence that poor personal hygiene frequently contributes to foodborne-illness outbreaks, indicate that improvement of food workers' hygiene practices is needed. Researchers and practitioners contend that a range of personal, social, and environmental factors influence food worker practices and that these factors need to be addressed to successfully change food workers' behavior *(8, 26, 27).* Thus, the purpose of this study was to identify factors related to food worker hand hygiene practices.

This article is the second one based on a study we conducted on food worker hand hygiene practices. For this study, we observed food workers for an extended period and recorded specific information on their work activities and the hygiene practices associated with those activities. We also collected data on possible factors related to hygiene behavior through interviews with restaurant managers and observations of restaurant environments. In the first article on this study, we presented descriptive data on food worker hand washing and glove-use practices across different work activities *(14).* In this article, we present data on the relationships between hand washing and glove use and factors proposed to be related to hygiene behavior. These factors include worker activity (e.g., worker busyness), restaurant characteristics (e.g., ownership: chain versus independent), worker training, physical environment (e.g., number of sinks), and the social environment and management (e.g., management encouragement of hand hygiene). These factors were chosen because existing theories or data suggest that they may affect hygiene behavior (*1, 6–8, 12, 13, 16–18, 20, 26*).

MATERIALS AND METHODS

Restaurants. This study was conducted by environmental health specialists (specialists) affiliated with the Environmental Health Specialists Network (EHS-Net), a collaborative project of the Centers for Disease Control and Prevention (CDC), the FDA, the U.S. Department of Agriculture, and 9 states (California, Connecticut, New York, Georgia, Iowa, Minnesota, Oregon, Rhode Island, Tennessee; Colorado participated until 2005). EHS-Net is focused on the investigation of environmental antecedents of foodborne illness, including food preparation and hygiene practices.

The study comprised randomly selected restaurants located in designated geographical areas in six of the 2004 EHS-Net states (Colorado, Connecticut, Georgia, Minnesota, Oregon, Tennessee; see Green et al. *(14)* for more information on the sample). While there is variability in these states' adoption of the FDA Food Code, all had similar hand washing guidelines and none prohibited bare-hand food contact at the time of the study.

Data collection. The study was conducted over 3 months in the fall of 2004. Before the start of the study, the study protocol was reviewed and approved by CDC's Institutional Review Board (IRB) and the appropriate IRBs in the participating states. Additionally, all specialists participated in training designed to increase data collection consistency. (See Green et al. *(14)* for more information.)

In each restaurant, a specialist first interviewed the restaurant manager, owner, or other employee to collect data on restaurant characteristics, food preparation training and policies, manager certification, food preparation processes, and hand washing encouragement. The specialist then conducted a 10- to 15-min observation of the kitchen to collect information on the environment, such as the number of hand sinks with warm water, soap, and towels or hot-air drying methods. Then, using an observation method similar to the one designed by Clayton and Griffith *(5),* the specialist conducted a 45- to 50-min observation of one worker who was preparing food. Workers were chosen on the basis of the specialist's ability to observe them relatively unobtrusively (e.g., without interfering with their work). To limit the influence of the specialist's presence on worker behavior, the specialist observed the worker for 10 to 15 min before beginning the 45- to 50-min data collection period to allow the worker time to adjust to the specialist's presence. Additionally, workers were not made aware of precisely which aspects of their behavior were being recorded during the observations.

During this observation, the specialist recorded data on specific activities that required hand washing (according to the Food Code; see Table 1) and the hand hygiene behaviors associated with those activities. For the activities of food preparation and putting on disposable gloves for food preparation, hand washing should occur before each activity. For the remaining activities (preparing

TABLE 2. *Variables used in logistic regression models of appropriate hand washing and glove use*

Variable	Variable values	Hand washing model	Glove use model
Worker activity			
Actity type	Food preparation; putting on gloves for food preparation; preparing raw animal product; eating, drinking, using tobacco/coughing, sneezing, using tissue; handling dirty equipment; touching the body	✓	✓
Worker busyness	Yes (worker engaged in ≥8.6 [median] activities) vs no (worker engaged in <8.6 activities)	✓	✓
Hands washed appropriately with activity	Yes vs no		✓
Gloves worn during activity	Yes vs no	✓	
Restaurant characteristics			
Restaurant ownership—chain	Yes vs no	✓	✓
Complex food preparation processes	Yes vs no	✓	✓
Worker training			
Hand hygiene taught to workers	Yes vs no	✓	✓
Workers provided with food safety training	Yes vs no	✓	✓
Management certification required	Yes vs no	✓	✓
Physical environment			
Multiple hand sinks	Yes (>1 sink) vs no	✓	
Hand sink close to worker	Yes (<10 ft from sink) vs no (≥10 ft from sink)	✓	
Hand sink in worker's sight	Yes vs no	✓	
Hand washing supplies at hand sinks	Yes (all hand sinks had warm water, soap, and recommended drying methods) vs no	✓	
Glove supplies in food preparation areas	Yes vs no		✓
Social environment/management			
Worker visibility to manager	Yes (manager could see worker some/most of the observation) vs no	✓	✓
Worker visibility to customers	Yes (worker somewhat/fully visible) vs no	✓	✓
Management encouragement of hand washing	Yes (respondents said hand washing was encouraged) vs no	✓	

raw animal products; eating, drinking, or using tobacco; coughing, sneezing, or using tissues; handling dirty equipment or utensils; and touching human body parts other than clean hands and arms), hand washing should occur after each activity and before beginning another activity. Data were also collected on the activity of preparing raw produce. However, because of inconsistencies in the way specialists identified raw produce, these data were excluded from analysis.

The specialist also collected data on hand hygiene behaviors in which the worker engaged along with each of the observed activities. The specialist recorded whether the worker placed his or her hands under running water, whether the worker used soap, whether and how the worker dried his or her hands (e.g., paper towel, cloth towel, clothes), and whether the worker wore and removed his or her gloves. Data were also recorded on whether hand sanitizer was used, but those data are not discussed here. Finally, the specialist recorded data on the physical environment during the observation, such as proximity of the observed worker to the nearest sink.

Data analysis. We used multivariate logistic regression models to determine the combination of factors that best explained hand hygiene practices. Stepwise regression procedures were used to guide the determination of the explanatory variables included in the final models. A model was conducted for appropriate hand washing, which entailed (i) removing gloves, if worn; (ii) placing hands under running water; (iii) using soap; and (iv) drying hands with paper towels, cloth towels, or hot air. A model was also conducted for glove use, which entailed wearing gloves during work activities. For these models, the level of analysis was activity; thus, the outcome variables were dichotomous and indicated whether the hygiene practice (hand washing or glove use, depending on the model) occurred with each observed activity for which hand washing is recommended. Because the observed worker in each restaurant engaged in multiple activities during the observation, activity was treated as a repeated measure in all analyses. The state in which data collection took place was included as a control variable in both regression models. Preliminary forward stepwise regression analyses were conducted with the SAS software package (SAS, Cary, N.C.); all other regression analyses were conducted with the SUDAAN software package (RTI International, Research Triangle Park, N.C.) to account for the repeated measures aspect of these data.

Table 2 describes the explanatory variables included in the regression models. These fell into the categories of worker activity

(activity type, worker busyness, hands washed, gloves worn), restaurant characteristics (ownership: chain versus independent, complex food preparation processes [i.e., holding, cooling, reheating or freezing of foods]), worker training (hand hygiene taught to food workers, food safety training provided to food workers, management certification required), physical environment (multiple hand sinks, hand sink closeness to worker, hand sink in worker's sight, hand washing supplies at hand sinks, glove supplies in food preparation areas), and social environment and management (worker visibility to manager, worker visibility to customers, management encouragement of hand washing). All explanatory variables were included in the initial regression model of appropriate hand washing. All explanatory variables, except those expected to only be related to hand washing (multiple hand sinks, hand sink closeness to worker, hand sink in worker's sight, hand washing supplies at hand sinks, and management encouragement of hand washing) were included in the glove-use model. Additionally, whether gloves were worn in conjunction with the activity was included as an explanatory variable in the hand washing model and whether hands were washed appropriately in conjunction with the activity was included as an explanatory variable in the glove-use model. Odds ratios (ratios above 1 indicate that the hygiene behavior was more likely to occur with the activity; ratios below 1 indicate that the hygiene behavior was less likely to occur with the activity) and Wald *F* test probability values (values at 0.05 or lower are considered significant) are provided for each explanatory variable included in the final regression models.

RESULTS

Descriptive analyses. Of the 1,073 establishments we contacted, 808 were eligible to participate (i.e., met our definition of a restaurant, were open for business, and did not belong to a chain with an already participating restaurant). Of these, 333 agreed to participate, yielding a response rate of 41%. Because of missing information, data are reported on only 321 restaurants. Sixty-one percent (196) of the restaurants were independently owned, 38% (121) were chains or franchises, and 1% (4) had missing data concerning ownership.

The median duration of individual worker observations was 48 min (25% quartile = 45; 75% quartile = 48). Observed workers engaged in a total of 2,195 activities falling into one of the defined activity categories. The estimated median number of activities observed per hour per worker was 8.6 (25% quartile = 5; 75% quartile = 12.3). The most frequent activity, accounting for 36% of all activities (786 activities), was handling dirty equipment, followed by food preparation (23%; 514 activities); preparing raw animal product (17%; 384 activities); putting on gloves for food preparation (10%; 224 activities); touching the body (9%; 197 activities); eating, drinking, or using tobacco (3%; 77 activities); and coughing, sneezing, or using tissue (1%; 13 activities). Because of the low frequency of the last two groups of activities, they were combined into one category called ''eating/coughing'' for the remaining analyses.

Workers washed their hands appropriately (i.e., removed gloves, if worn; placed their hands under running water; used soap; and dried their hands with paper or cloth towels or hot air) in conjunction with 27% (588 of 2,195 activities) of all activities. They wore gloves during 28% (608 of 2,195 activities) of all work activities. More detailed descriptive data on these hand hygiene activities can be found in Green et al. *(14).*

TABLE 3. *Logistic regression model of appropriate hand washing (*n *= 2,149)*

Hand washing	Odds ratio[a]	Lower 95% CI[b]	Upper 95% CI
Worker activity			
Activity type			
Food preparation (reference)	—	—	—
Putting on gloves for food preparation	0.64	0.34	1.22
Preparing raw animal product	0.44*[c]	0.31	0.61
Eating/coughing	0.48*	0.31	0.74
Handling dirty equipment	0.13*	0.07	0.23
Touching body	0.39**	0.20	0.74
Worker was busy	0.45*	0.30	0.66
Worker wore gloves during the activity	0.41*	0.26	0.67
Worker training			
Workers provided with food safety training	1.81***	1.06	3.12
Physical environment			
Multiple hand sinks	1.63***	1.07	2.47
Hand sink in worker's sight	1.93**	1.15	3.23

[a] Odds ratios above 1 indicate that hand washing was more likely to occur with the activity; odds ratios below 1 indicate that hand washing was less likely to occur with the activity.
[b] CI, confidence interval.
[c] Wald *F* test probability values: * $P < 0.001$, ** $P < 0.01$, *** $P < 0.05$.

Appropriate hand washing. The final regression model for appropriate hand washing was comprised of the variables that best accounted for the variance in appropriate hand washing ($R^2 = 0.142$). Those included activity type, worker busyness, glove use, food safety training provided to food workers, multiple sinks, and hand sink in worker's sight (Table 3). Appropriate hand washing was more likely to occur with food preparation activities than with all other activities except putting on gloves. Appropriate hand washing was also more likely to occur in restaurants where food workers received food safety training, where there were multiple hand sinks, and where a hand sink was in the observed worker's sight. Appropriate hand washing was less likely to occur when workers were busy and when gloves were worn at the point at which hand washing should occur.

Glove use. The activities of food preparation and putting on gloves for food preparation were combined for these analyses. Specifically, all activities categorized as putting on gloves for food preparation were recategorized as food preparation activities in which gloves were worn. The final regression model for glove use was composed of the variables that best accounted for the variance in glove use ($R^2 = 0.235$). Those included activity type, worker busyness, hand washing, restaurant ownership, and glove supplies in food preparation areas (Table 4). Glove use was more likely

TABLE 4. *Logistic regression model of glove use (*n *= 2,160)*

Glove use	Odds ratio[a]	Lower 95% CI[b]	Upper 95% CI
Worker activity			
Activity type			
Food preparation (reference)[c]	—	—	—
Preparing raw animal product	0.69	0.41	1.18
Eating/coughing	0.17**[d]	0.05	0.62
Handling dirty equipment	0.42*	0.27	0.67
Touching body	0.52*	0.30	0.92
Worker was busy	0.51**	0.31	0.83
Worker washed hands along with activity	0.37*	0.23	0.58
Restaurant characteristics			
Restaurant ownership—chain	3.41*	1.91	6.09
Physical environment			
Glove supplies in food preparation areas	5.47*	2.88	10.38

[a] Odds ratios above 1 indicate that glove use was more likely to occur with the activity; odds ratios below 1 indicate that glove use was less liketly to occur with the activity.

[b] CI, confidence interval.

[c] The activities of food preparation and putting on gloves for food preparation were combined for this analysis.

[d] Wald F test probability values: * $P < 0.001$, ** $P < 0.01$, *** $P < 0.05$.

to occur during food preparation activities than during activities involving eating/coughing, handling dirty equipment, and touching the body. Glove use was also more likely to occur in chain restaurants and in restaurants with glove supplies in the food preparation areas. Glove use was less likely to occur when workers were busy and during activities with which workers washed their hands appropriately.

DISCUSSION

Both appropriate hand washing and glove use were related to activity type—workers were more likely to wash their hands appropriately and wear gloves with food preparation than with most other activities. This finding is encouraging, for it suggests that at least some workers understand the need to protect food from hand contamination. Appropriate hand washing and glove use were also related to worker busyness—these hand hygiene behaviors were less likely to occur when workers were busy (i.e., engaged in relatively larger numbers of activities needing hand washing). Because food workers have identified time pressure as a barrier to engaging in safe food preparation practices *(6, 12, 20),* these results are perhaps not surprising. However, given that time pressure is also inherent to the food service industry, these results are troubling. We have previously suggested that restaurant managers ensure adequate staffing for the workload and emphasize the importance of food safety over speed to combat the effects of time pressure on safe food preparation practices *(12).* Clayton and Griffith *(5)* have proposed that restaurants evaluate their food preparation activities in light of the frequency with which hand washing is needed. A reduction in the number of needed hand washings may lessen time pressure and thereby increase the likelihood that food workers will engage in the remaining needed hand washings and don gloves when appropriate.

Hand washing and glove use were related to each other—appropriate hand washing was less likely to occur with activities in which gloves were worn than with activities in which gloves were not worn. These results suggest that workers who wear gloves do not remove them and wash their hands as they should. Although some researchers and practitioners have contended that glove use can promote poor hand washing practices *(10, 15, 21),* little data exists on this issue. More research is needed to understand the relationship between glove use and hand washing.

Appropriate hand washing was positively related to two factors associated with restaurants' hand sinks: multiple hand sinks and a hand sink in the worker's sight. These factors contribute to sink accessibility, which likely promotes hand washing. Appropriate hand washing was also more likely to occur in restaurants in which the manager reported that food workers received food safety training. This finding is consistent with other findings of an association between knowledge and training and safe food preparation practices *(4).*

Glove use was related to restaurant ownership—workers were more likely to wear gloves in chain restaurants than in independent restaurants. This finding suggests that glove use may be determined, at least in part, by restaurant management. Some types of restaurants, such as chains, may be more likely to require and institutionalize glove use. Gloves were also worn more often when glove supplies were accessible in food preparation areas. As with sinks and hand washing, glove accessibility likely promotes glove use.

The findings of this study indicate that a number of factors are related to hand hygiene practices and support those who have suggested that food worker hand hygiene improvement requires more than the provision of food safety education. Instead, improvement programs must be multidimensional and address additional factors *(8, 26, 27).* These factors may include, but are certainly not limited to, those found to be significant in this study: activity type, worker busyness, number and location of hand sinks, availability of supplies (e.g., gloves, soap, towels), restaurant ownership, and the relationship between prevention methods (i.e., glove use and hand washing).

The FDA recommends that barriers such as gloves be used to prevent hand contact specifically with RTE food. Although we examined glove use during food preparation, we did not distinguish between RTE food and non-RTE food (other than raw meat or poultry). Explanatory variables for glove use with RTE food may differ from those identified in our study. Additionally, because of concerns about data collection complexity, we did not collect data on some hand hygiene behaviors that are considered important by the FDA *(29).* For example, we did not measure how long workers washed their hands or whether they cre-

ated friction between their hands. The inclusion of such factors may have affected our findings.

There are a number of factors that may impact hand hygiene behavior that we did not examine in this study. For example, we did not measure individual characteristics of the observed food workers, such as age, gender, and food safety knowledge, attitudes, and beliefs. Evidence suggests that such individual characteristics influence food safety behavior *(2, 13)*. This study also does not allow us to make causal inferences about the relationships among variables. For example, the relationship between hand washing and the presence of a hand sink in the observed worker's sight was significant and positive. However, we cannot determine if the presence of a sink in sight causes workers to wash their hands more frequently or if there is some other explanation for the relationship (e.g., workers choose to work close to a sink because they plan to wash their hands frequently). Thus, although our data indicate that there are significant relationships between a number of factors and hand hygiene behavior, more research is needed to determine the causal nature of those relationships.

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