Research Note

Effect of Hand Wash Agents on Controlling the Transmission of Pathogenic Bacteria from Hands to Food

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ABSTRACT

The goals of this study were to evaluate the effectiveness of two hand wash regimens in reducing transient bacteria on the skin following a single hand wash and the subsequent transfer of the bacteria to a ready-to-eat food item, freshly cut cantaloupe melon. The number of bacteria recovered from hands and the quantity transferred to the melon were significantly less following the use of an antibacterial soap compared with plain soap. The antimicrobial soap achieved >3-log reductions versus Escherichia coli and 3.31- and 2.83-log reductions versus Shigella flexneri. The plain soap failed to achieve a 2-log reduction against either organism. The bacteria recovered from the melon handled by hands washed with antimicrobial hand soap averaged 2 log. Melon handled following hand washing with plain soap had >3 log bacteria in the experiments. Based on previously published feeding studies, an infection rate in the range of approximately 15 to 25% would be expected after ingesting melon containing 2 log CFU compared with ingesting greater than the 3 log transferred from hands washed with plain soap, which would result in a higher infection attack rate of 50 to 80%. The data thus demonstrate there is a greater potential to reduce the transmission and acquisition of disease through the use of an antimicrobial hand wash than through the use of plain soap.

The spread of transient bacteria by hands plays a significant role in the direct and indirect transmission of disease (36). There is a need to reduce the numbers of bacteria that can be transferred to shared inanimate objects, food, or other people. A single source of infection can transfer that infection to other people through direct or indirect contact. For example, one study found that up to 50% of family members become infected when a child contracts Shigella sonnei dysentery (9). Another study looking at the spread of Salmonella from one sick family member to others found that the chance of another family member acquiring the infection was as high as 60% (26). There is a high probability that these secondary infections can be attributed to both direct and indirect cross-contamination in the home.

Several studies have linked outbreaks of shigellosis to food handling practices, particularly lack of proper hand washing (17, 19, 23, 25). A number of studies have demonstrated the potential for hand transfer of either naturally occurring or seeded bacteria from contaminated food products (7, 13, 18). A review of foodborne illness outbreaks in Wales attributed 39% of them to cross-contamination in the kitchen (13). Many experts believe that food prepared and eaten in the home is responsible for the majority of foodborne illnesses (1, 14, 24, 29, 31). Combined, these studies imply that proactive risk management steps can be taken in commercial and noncommercial settings to help interrupt the transmission of potentially pathogenic microorganisms to oneself, to others, and to inanimate objects that can act as fomites. Hand washing with soap and water is recommended to reduce the number of bacteria on the skin (6, 36) and has been shown to reduce the risk of disease transmission (3). Although most experts agree that nonmedicated soaps and hand washes help remove some pathogenic microorganisms from the skin, there is still debate on the specific contribution of antimicrobial hand washes. Well-controlled studies in non–health care settings that directly compare the effect of washing with an antimicrobial hand wash product or a nonmedicated product on a specific infection or disease have not been published. Hand washing with antimicrobial hand wash products has previously been shown to provide greater bacterial reductions than washing with plain soap (30). Questions remain whether this additional bacterial reduction translates into a meaningful reduction in the transfer of potentially pathogenic microorganisms and the subsequent acquisition of disease.

Published data on the dose-response of bacteria-causing foodborne illnesses suggest that a health benefit can be achieved by lowering bacterial counts on hands, thereby reducing the risk of infection. For example, Shigella species and enterohemorrhagic Escherichia coli have been reported to cause infection at relatively low numbers (8, 12, 32, 35). While as few as 180 cells of Shigella flexneri were enough to cause infection in approximately 15 to 25% of volunteers.
in a controlled setting, significantly higher attack rates of 50 to 80% were found at levels in the range of 1,000 (3 log) or more organisms (10, 11, 34).

In the present study, our goals were twofold: (i) to evaluate the effectiveness of a commercially available antimicrobial hand wash (antimicrobial hand soap) containing triclosan (0.46%, wt/wt) as the active antimicrobial ingredient and a plain nonmedicated hand wash (plain soap) at reducing bacteria on hands following a 15- or 30-s hand wash and (ii) to look at the subsequent transfer of the surviving E. coli and S. flexneri from the washed hands to a ready-to-eat food item, freshly cut cantaloupe melon balls.

MATERIALS AND METHODS

The method used in these studies was a modification of the standard American Society for Testing and Materials test method E1174 evaluation of health care personnel handwash formulations (2). Modifications include an improved hand contamination procedure and an evaluation of the transfer of bacteria to food following hand washing. A series of four experiments were performed (A through D). Seven to 13 subjects >18 years of age were randomly assigned to receive a single hand washing treatment with either a currently marketed antimicrobial hand soap (0.46% triclosan, Dial Complete Antibacterial Foaming Hand Wash) or a plain soap (Kiss My Face Self Foaming Liquid Soap) following hand contamination with S. flexneri or E. coli. The same two hand soaps were used in all four experiments. Informed consent was obtained, and the experiments were conducted in accordance with Good Clinical Practice Regulations. In each of the experiments, subjects were asked to refrain from using any antimicrobial products for at least 4 days prior to test day. On test day, subjects performed a conditioning wash to remove dirt and bacteria from their hands and to familiarize themselves with the hand wash procedure. Subjects were asked to pass their hands under running tap water tempered to 40 ± 2°C. Two pumps (~3 g) of plain soap (Johnson’s head-to-toe baby wash) were dispensed into the cupped palm of one hand, and the soap was spread over the entire surface of the hands and to the lower one-third of the forearms. Subjects washed for 15 ± 2 s in a vigorous fashion. Hands were rinsed under running tap water that had been tempered to 40 ± 2°C for 30 s. The subjects’ hands were dried thoroughly with disposable paper towels (Brawny Light-Duty, Georgia Pacific), and the hands and wrists were subsequently soaked with 70% isopropyl alcohol for 30 s. The hands were allowed to air dry completely. Hands were then challenged with bacteria by a modification of the standard method (American Society for Testing and Materials E1174) in which only the palmar surfaces of the hands were contaminated. In the modified method, two single-ply paper towels (Brawny Light-Duty) were folded together into a rectangle of approximately 12.7 by 21.6 cm. The towels were placed inside an aluminum foil pouch and sterilized by autoclaving. Just prior to subject contamination, one pouch for each hand was opened, exposing the paper towel. A 30-ml bacterial suspension was poured evenly onto the towels, allowing complete absorption of the suspension. The subjects’ hands were placed directly above the individual towels and then pressed down firmly for 5 ± 1 s, ensuring that the entire palm, fingers, and finger pads were in contact with the saturated towel. The hands were then air dried for 90 ± 5 s. In experiments A and B, the subjects’ hands were contaminated with E. coli, and in experiments C and D, their hands were contaminated with S. flexneri. In all experiments, a baseline sampling was taken following the first hand contamination step. This was done to determine the total number of organisms contaminating the hands. Hands were sampled by placing plastic bags (Gladd food storage bags or equivalent, 29.2 by 31.8 cm) on the subjects’ right and left hands. Aliquots of 75 ± 2 ml of sterile neutralizing stripping solution (0.075 M phosphate buffer with 0.1% Triton X-100) were poured into each bag. The bag was secured at the wrist, and the hands were massaged for 1 min in a uniform manner. A 1-ml aliquot was obtained from the bagged hands within 1 min of completing the massage and placed into a sterile tube for further dilution and plating. Following baseline sampling, the subjects performed a second conditioning wash and then a repetition of the hand contamination step. They were then instructed to perform a hand washing treatment specific to each type of hand soap tested. The soap was dispensed into the subjects’ cupped dry palm of one hand and then spread over the entire surface of the hands, including the backs of the hands, and between the fingers and the lower one-third of the forearm. For the antimicrobial hand soap, two pumps (3 g) of soap were dispensed, and four pumps (3 g) were used for the plain soap. In experiments A and B, the soap was lathered vigorously over the hands for 15 ± 2 s, and in experiments C and D, the soap was lathered for 30 ± 2 s. After the timed wash, hands were rinsed under running tap water tempered to 40 ± 2°C for 30 s. Following hand treatment with the prescribed test material, the subjects were asked to handle the food: cantaloupe melon balls that had been prepared prior to test day. Fresh cantaloupe was purchased at a local store. The outside of the melon was cleaned with 70% isopropyl alcohol to reduce the potential of cross-contamination to the inside of the melon during slicing and melon ball preparation. Four 2.2-cm melon balls per subject were prepared with a sterile melon ball scoop (melon ball, ~5 g). The four melon balls were placed into a sterile specimen cup (120-ml capacity) and refrigerated at 5°C until test day. The melon balls were brought to room temperature (25 ± 5°C) prior to use. The melon balls were dispensed into the subjects’ dominant hand. Subjects rolled the balls for 15 ± 2 s in their palms with the thumb and fingers. After 15 s, the melon balls were placed directly into a sterile stomacher bag. Twenty milliliters of bacterial neutralizing stripping solution was added to the bag, and the melon balls were pulverized for 1 min at 260 rpm with a stomacher. Immediately after handling the food, the subjects’ nondominant hand was sampled by the previously described sampling method. Bacterial enumeration was performed by standard microbiological plating methods. Effectiveness was determined by evaluating the difference between the baseline and postwash bacteria recovery counts, and the difference in the transfer of bacteria to food was calculated with the number of bacteria per 20 g of melon (about four melon balls) recovered.

General laboratory procedures. Bacterial strains used in these studies were obtained from the American Type Culture Collection (ATCC) in Manassas, Va., and were propagated according to ATCC recommendations. Stock cultures were maintained with the Microbank Bacterial Preservation System (Pro-Lab Diagnostics, Richmond Hill, Ontario, Canada) and stored at −80°C. S. flexneri ATCC 700930 and E. coli ATCC 11229 were grown in tryptic soy broth (TSB) at 35°C for 24 h. A 24-h broth culture was streaked onto Trypticase soy agar (TSA) and incubated for 24 h at 35°C. A study challenge pool was made by transferring at least three isolated colonies from the TSA plate to a sterile vessel of TSB. A series of at least three but no more than five 24-h broth transfers were made in 10 ml of TSB. On test day, an appropriate amount of TSB broth culture was diluted into a suitable volume of sterile 0.85% physiological saline to obtain a titer of approximately 1.0 × 10^7 to 1.0 × 10^8 CFU/ml. Thirty milliliters of challenge pool was dispensed into sterile 50-ml centrifuge
Table 1. Mean log reduction of bacteria following a single hand wash treatment

<table>
<thead>
<tr>
<th></th>
<th>Escherichia coli ATCC 11229²</th>
<th>Shigella flexneri ATCC 70093³</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>AMd</td>
<td>3.84e</td>
<td>1.66</td>
</tr>
<tr>
<td>AM</td>
<td>3.29e</td>
<td>1.91</td>
</tr>
<tr>
<td>Plain</td>
<td>3.31e</td>
<td>1.55</td>
</tr>
<tr>
<td>D</td>
<td>2.83e</td>
<td>1.42</td>
</tr>
</tbody>
</table>

Values are expressed as log CFU per hand.

Wash time, 15 s.

Wash time, 30 s.

AM, antimicrobial soap.

P < 0.001, two-tailed (antimicrobial hand soap versus plain soap).

Bacterial recovery method. Serial 10-fold dilutions were performed in Butterfield’s phosphate-buffered water with the initial 1-ml aliquot from the bagged hands. Dilution aliquots were plated on Hektoen Enteric agar for S. flexneri and MacConkey agar for E. coli by standard plate count procedures (33). All plates were incubated at 35°C for 36 to 48 h. Plates yielding colonies were counted by standard plate counting procedures. The number of bacteria recovered per hand was calculated by multiplying the CFU by 75, the volume in milliliters of stripping solution used in the bag. Bacteria counts (CFU per hand) were converted to log counts. The right and left hand bacteria log counts were averaged, and comparisons were made between baseline, wash treatment, and transfer counts. Log bacteria reduction was calculated by the mean average baseline minus the mean average recovery from the treatment group. The number of bacteria transferred to the melon balls was calculated by multiplying the CFU per milliliter by 40 to obtain the total bacteria count per 20 g or four melon balls (5 g per ball). If a subject dropped one of the melon balls, an adjustment was made to the multiplier. The CFU per 20 g of melon balls was converted to log counts, and the mean average log recovered bacteria count was calculated. Paired two-tailed statistical analysis was performed on the wash treatment and transfer counts.

RESULTS AND DISCUSSION

In all four experiments, the antimicrobial hand soap was significantly better than plain soap and water at eliminating bacteria on hands and subsequently at reducing the transfer of bacteria from hands to food. The antimicrobial soap achieved 3.84- and 3.29-log reductions versus E. coli after a 15-s wash and 3.31- and 2.83-log reductions versus S. flexneri after a 30-s wash, whereas the plain soap failed to achieve a 2-log reduction against either organism, regardless of the wash time (Table 1). Although experts agree that reduction of bacteria on the hands is beneficial, numerous studies have sought to evaluate the contribution of hand washing or hand antisepsis in reducing the risk of infection or disease in health care settings, and the results have been inconclusive and somewhat contradictory (3–5, 20, 21). The evaluation and effectiveness of hygienic hand washing practices outside the clinical setting pose additional complications that include confounding factors, such as product use patterns, hand washing compliance, and unintentional interventions during the studies, which have limited the investigator’s ability to properly assess success or failure in reducing infections directly to a hand washing regimen (22, 27). Importantly, direct comparisons between formulations that contain active ingredients and those that do not have also been hindered by these complications.

To begin addressing some of these issues, we developed the bacterial transfer model presented in the article, which controls for some of the complicating factors in previous studies, such as product use and compliance. This model could be used to evaluate the effectiveness of hand washing regimens in general. The method examines not only the reduction of bacteria on the hands but also the subsequent transfer of the remaining bacteria to an object, in this case, a ready-to-eat food (cantaloupe melon balls), which, if contaminated with bacteria from the hands and then eaten, would have the potential to cause illness. We found that significantly fewer bacteria were transferred to the melon balls from hands washed with antimicrobial soap than from hands washed with plain soap, as shown in Table 2. The average log bacteria recovery from the melon balls handled by hands treated with antimicrobial hand soap was 2.00, 2.36, 1.97, and 2.27 log (Table 2). Melon balls handled with plain soap–treated hands had >3 log bacteria in all four experiments. This was a statistically significant difference (P < 0.001, two-tailed) of more than 1.25 log compared with the antimicrobial hand wash–handled melons.

The number of bacteria that were transferred to the melon balls following hand washing for both 15 and 30 s with the antimicrobial soap was not only statistically less than plain soap and water, but more importantly, this 2- to 2.2-log dose obtained for the antimicrobial soap is at the lower end of the dose-response range for S. flexneri and would be anticipated to result in significantly fewer cases of infection than the 3-log dose obtained for the plain soap (10, 12, 34). Similar dose-response ranges have been determined for E. coli (32). The current study used initial contamination levels representative of a worst-case scenario and consistent with what could be expected on the hands following the handling of contaminated food or on the hands of someone ill with diarrhea (15, 16, 28).

The studies presented here demonstrate that under specific, but not uncommon, circumstances, hand washing with an efficacious antimicrobial soap provides a greater benefit in reducing disease acquisition than washing with plain soap and water. The significant reduction of bacteria on hands results in fewer bacteria transferred to objects such as food. Washing with plain soap and water after handling raw meat or poultry or after activities such as handling diapers contaminated with Shigella or other enteric bacteria with similar dose-response patterns, such as enterohemorrhagic E. coli, and then preparing other food, such as making a fruit salad, could result in significant infections due to cross-contamination. Additional research should be done to examine the attack rates following the ingestion of food handled under these test conditions. If warranted, well-controlled human clinical studies could be conducted to pro-
TABLE 2. Mean log recovery of bacteria on hands and cantaloupe following treatment with antimicrobial hand soap or plain soap

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<thead>
<tr>
<th></th>
<th>Escherichia coli ATCC 11229</th>
<th>Shigella flexneri ATCC 700930</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>AM&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Plain (n = 7)</td>
</tr>
<tr>
<td>Baseline</td>
<td>6.13 ± 0.45</td>
<td>6.46 ± 0.14</td>
</tr>
<tr>
<td>Single wash</td>
<td>2.46 ± 0.55</td>
<td>4.64 ± 0.17</td>
</tr>
<tr>
<td>Melon balls</td>
<td>2.00 ± 0.45</td>
<td>3.48 ± 0.44</td>
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</tbody>
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<sup>a</sup> Values are expressed as log CFU per hand ± standard deviation.
<sup>b</sup> AM, antimicrobial soap.
<sup>c</sup> Means are significantly different (P < 0.05).
<sup>d</sup> P < 0.001, two-tailed (antimicrobial hand soap versus plain soap).

vide definitive proof of the hypothesis that a significant reduction in the dose of a pathogenic microorganism through hand washing reduces the rate or severity of specific infections.

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REFERENCES


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