A Research Study to Investigate the Effectiveness of the INSTANT-OFF Faucet Control to Reduce Cross-Contamination During Hand Washing.

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CONCLUSIONS

There is evidence that touching faucet handles contributes to cross-contamination which is a serious health concern.

The results obtained in this study suggest that fingertips are more likely to contribute to cross-contamination than palms.

This study proved that the risk of cross-contamination caused by touching faucet handles (after hands were washed) was virtually eliminated when the INSTANT-OFF was used properly.

The INSTANT-OFF was found to be an effective device to reduce cross-contamination during hand washing.

The results of this study proved that no contamination of the actuator rod occurred from contaminated hands during hand washing.

The INSTANT-OFF offers a cost-effective alternative for anyone who is attempting to reduce the risk of cross-contamination at hand-wash sinks.

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INTRODUCTION

Foodborne illnesses is often caused from improper food preparation, inadequate disinfection and cross-contamination at hand-wash sinks in both domestic and commercial kitchens. Most food-borne illnesses in the United States are caused by bacteria, costing up to $17 billion annually (Wagner, Jr. 2009). Foodborne transmission of *Escherichia coli* 0157:H7 accounted for approximately 52% of *Escherichia coli* 0157:H7 outbreaks and 61% of outbreak-related cases in the United States from 1982-2002 (Rangel et al. 2005). In the 8,598 cases reviewed, 1,493 hospitalizations and 40 deaths were reported. Intentional contamination of restaurant salad bars and inadvertent contamination of food by employees were responsible for an outbreak of *Salmonella* Typhimurium in Oregon in 1980 (Torok et al. 1997) that resulted in 751 cases of illness with at least 45 hospitalizations and no deaths reported.

Chen et al. (2001) reported high variability in bacterial transfer rates for hands, foods, and surfaces in the kitchen. Previous studies have shown bacterial transfer efficiency is influenced by surface type, bacteria type, moisture and humidity levels, temperature, length of time on surface, and inoculum level (Montville and Schaffner 2003; Rusin et al. 2002; Sattar et al. 2001; Scott and Bloomfield 1990; Wilks et al. 2005). Efficient bacterial transfer increases the risk of cross-contamination and foodborne illness in the kitchen.

Bacterial survival on surfaces can also influence cross-contamination rates. Temperature, humidity, contamination level, the presence or absence of flagella, and the ability to form biofilms influence bacterial survival on surfaces (Poimenidou et al. 2009; Sinde and Carballo 2000; and Skandamis et al. 2009). Kusumaningrum et al. (2003) found *Staphylococcus aureus* and *Salmonella* Enteritidis can survive at room temperature on stainless steel for at least four days at high contamination levels. Lower contamination levels resulted in shorter survival times. Wilks et al. (2005) determined *E. coli* 0157:H7 could survive on stainless steel at room temperature (28°C) and refrigeration (4°C) for more than 28 days.

Hand washing and good kitchen hygiene are critical in reducing cross-contamination and foodborne illness. Hands can easily become contaminated and transfer pathogens from surface to surface; therefore regular hand washing with an appropriate antiseptic is important in reducing cross-contamination (Ansari 1989; Steere and Mallison 1975).

Chen et al. (2001) found that faucet handles may become significantly contaminated with *Enterobacter aerogenes* and contribute to cross-contamination. Non-hand - operated faucets, like foot-controlled faucets and automatic infra-red faucets are alternatives to reduce cross-contamination however, these devices are expensive and require professional installation. INSTANT-OFF provides a cost-effective alternative to touching faucet handles. INSTANT-OFF replaces the aerator on any faucet. Once installed, water is controlled by pushing the stainless steel rod with the back of your hand or thumb. With an INSTANT-OFF installed on a faucet you can access water without touching faucet handles.

In this study we set out to determine if the INSTANT-OFF could reduce cross-contamination during hand-washing, if using the INSTANT-OFF could effectively remove bacteria from hands and if any of the germs were transferred from contaminated hands to the actuator rod.

MATERIALS AND METHODS

Decontamination of Surfaces

A 10 percent household bleach solution was prepared and applied to the counter top, sink basin, the INSTANT-OFF actuator rod, and faucet handle of the experiment area before each replicate. Q swabs dipped in a 1X PBS with 10% glycerol solution were plated on Tryptic Soy Agar (TSA; REMEL Inc., Lenexa, Kansas) to confirm successful decontamination of all surfaces.

Preparation of Bacteria

A pure culture of *Escherichia coli* K-12 (CBD 1242) was plated on TSA and incubated overnight at 35°C. One colony was removed from the TSA, transferred to 4 ml Tryptic Soy Broth (TSB; REMEL Inc., Lenexa, Kansas), and incubated for two hours or until turbidity was equivalent to McFarland standard 0.5 (approximately 1.5×10^8 CFU/ml). Ten-fold dilutions were prepared in 1X PBS with 10% glycerol (approximately 1.5×10^7 CFU/ml) in 2.0 ml microcentrifuge tubes (Fisher Scientific). After equilibration for 30 minutes, microcentrifuge tubes were stored at -84°C until use. Before use, vials were removed from storage, quick thawed at 35°C, and vortexed.

Contamination of Gloves

Three latex gloves per replicate were placed in a Class IIA Biological Safety Cabinet (BSC): one glove for the INSTANT-OFF replicate, one glove for the Faucet replicate, and one “Before” glove. A Sharpie marker was used to mark a 1 cm x 2 cm rectangle on each fingertip (including thumb) and a 6 cm x 5 cm rectangle on the palm area of each glove. Gloves were exposed to ultraviolet (UV) light for 20 minutes to sterilize and 20 µl of 1.5×10^7 CFU/ml *E. coli* K-12 was applied to each fingertip rectangle and 100 µl was applied to the palm rectangle. A disposable inoculating loop (BD) was used to spread the bacteria evenly across each rectangle. All gloves were allowed to dry for three hours in the BSC prior to use.

Swabbing and Plating

Q swabs (Puritan Medical Products Co. LLC) were autoclaved at 121°C for 15 minutes to ensure sterility prior to use. All swabs were moistened in 1X PBS with 10% glycerol prior to use. After contact with the sample site, swabs were spread on TSA plates and disposed of. Six swabs were performed for each INSTANT-OFF replicate: actuator rod before and after the simulation, fingertips before and after hand washing, and palm before and after hand washing. Eight swabs were performed for each Faucet replicate: faucet handle before and after the simulation, fingertips before and after hand washing, palm before and after hand washing, fingertips after handling the faucet handle, and palm after handling the faucet.

"Before" Replicates

Each latex glove designated for use as the "Before" glove served to confirm bacterial application to the glove was successful. Each fingertip rectangle was swabbed and then plated as above. The rectangle on the palm was swabbed separately and plated as above. All TSA plates were incubated at 35°C for 24 hours and then counted.

INSTANT-OFF Replicates

The latex glove to be used in each INSTANT-OFF replicate was removed from the hood using secondary containment and transported to the sink area. The INSTANT-OFF actuator rod was swabbed and plated as above prior to the hand washing simulation. The person wearing the gloves for testing put on one pair of nitrile gloves. A second nitrile glove was put on the left hand and the contaminated glove was put on the right hand. The back of the gloved right hand was used to press the INSTANT-OFF actuator rod and the gloves were rinsed for 20 seconds. The fingertips and palm of the latex glove were swabbed and plated as above. The outer layer of gloves were removed and disposed of. The INSTANT-OFF actuator rod was swabbed and plated as above after completion of the replicate. All TSA plates were incubated at 35°C for 24 hours and then counted.

Faucet Replicates

The latex glove to be used in each Faucet replicate was removed from the hood using secondary containment and transported to the sink area. The faucet handle was swabbed and plated as above prior to the hand washing simulation. The person wearing the gloves for testing put on one pair of nitrile gloves. A second nitrile glove was put on the left hand and the contaminated glove was put on the right hand. The faucet handle was rotated with the gloved right hand until the water was running. Gloves were rinsed for 20 seconds and the fingertips and palm of the latex glove were swabbed and plated as above. The faucet handle was rotated with the gloved right hand a second time to turn off the water. The fingertips and palm of the latex glove were swabbed again and plated as above. The outer layer of gloves were removed and disposed of. The faucet handle was swabbed and plated as above after completion of the replicate. All TSA plates were incubated at 35°C for 24 hours and then counted.

RESULTS

Data were obtained for 15 replicates by counting the number of colonies that grew on TSA (Tables 1 and 2). No *E. coli* K-12 colony forming units (CFU) were found on the faucet handle or the INSTANT-OFF actuator rod prior to the start of the hand washing simulations. Swabs of the “Before” gloves consistently produced a lawn of bacteria that was statistically too numerous to count (greater than 300 CFU; Figures 1 and 2).

In most replicates, there was no *E. coli* K-12 growth on TSA after the hand washing simulation (before re-handling the faucet handle in Faucet replicates). A single *E. coli* K-12 CFU was recovered from one sample site in Faucet replicates 1, 7, and 11. In all but one INSTANT-OFF replicates, there was no *E. coli* K-12 colonies growth after the hand washing simulation (Figure 4). One *E. coli* K-12 CFU was recovered from the palm of the glove in replicate 1. One single CFU, however, is not a statistically significant count and is likely the result of human variability during the hand washing simulation.

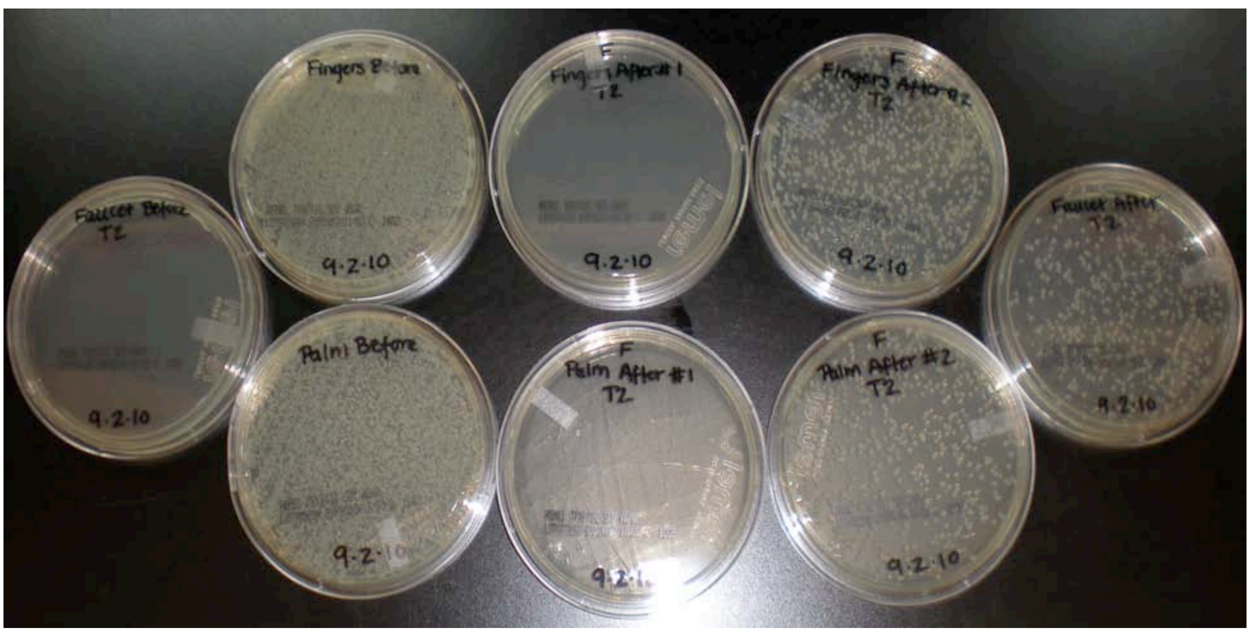

Figure 1. Faucet Replicates. From left to right: Faucet handle Before, Fingertips Before (top) and Palm Before, Fingertips After hand washing simulation (top) and Palm After hand washing simulation, Fingertips After handling faucet handle (top) and Palm After handling faucet handle, Faucet handle After. *E. coli* K-12 colony forming units were recovered from the fingertips, palm, and faucet handle in this replicate.

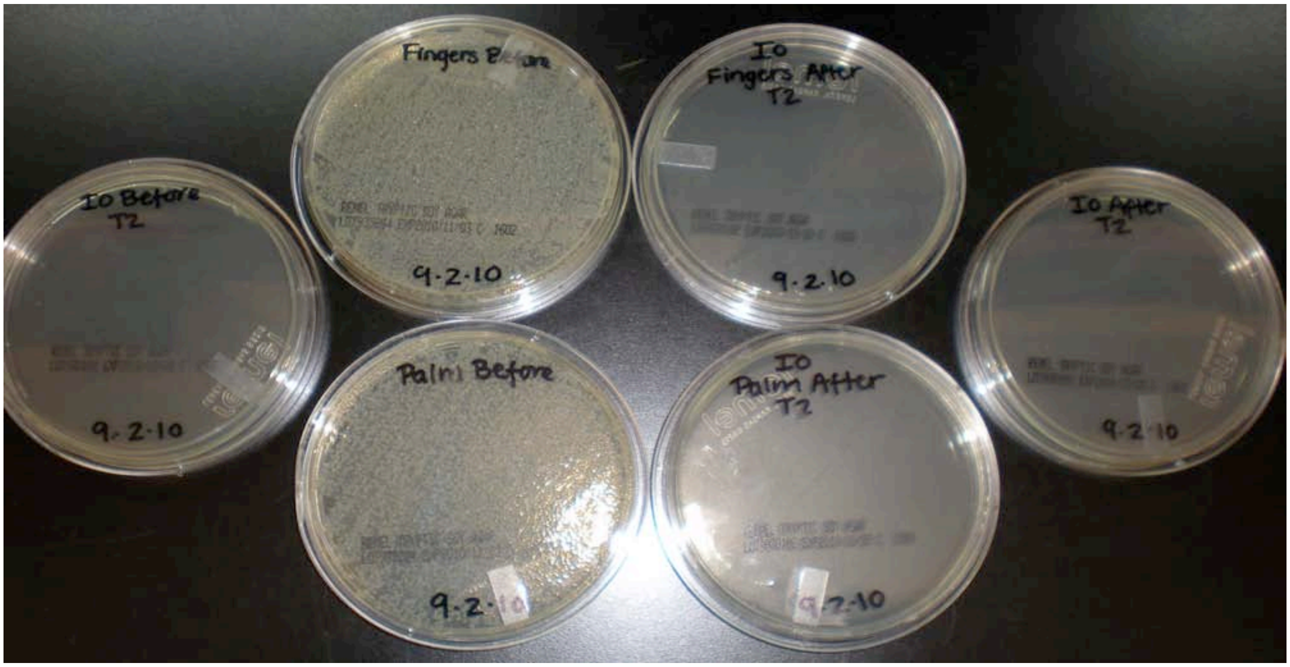

Figure 2. **INSTANT-OFF** Replicates. From left to right: **INSTANT-OFF** actuator rod Before, Fingertips Before (top) and Palm Before, Fingertips After hand washing simulation (top) and Palm After hand washing simulation, Instant-Off actuator rod After. No *E. coli* K-12 colony forming units were recovered after the hand washing simulation.

Table 1. Number of *E. coli* K-12 Colony Forming Units (CFU) recovered from TSA plates in Faucet replicates Before hand washing (HW), After hand washing (HW), and After handling the faucet handle (HF). TNTC[1]: Too Numerous To Count. TFTC[2]: Too Few To Count. Statistically significant counts should be between 30 and 300 CFU.

	Before HW	After HW	After HF
Faucet Handle 1	0		293
Fingertips 1	TNTC[1]	0	TNTC[1]
Palm 1	TNTC[1]	TFTC[2] (1)	TFTC[2] (9)
Faucet Handle 2	0		0
Fingertips 2	TNTC[1]	0	TFTC[2] (1)
Palm 2	TNTC[1]	0	TFTC[2] (1)
Faucet Handle 3	0		0
Fingertips 3	TNTC[1]	0	193
Palm 3	TNTC[1]	0	0
Faucet Handle 4	0		0
Fingertips 4	TNTC[1]	0	106
Palm 4	TNTC[1]	0	0
Faucet Handle 5	0		0
Fingertips 5	TNTC[1]	0	0
Palm 5	TNTC[1]	0	0
Faucet Handle 6	0		0
Fingertips 6	TNTC[1]	0	0
Palm 6	TNTC[1]	0	0
Faucet Handle 7	0		0
Fingertips 7	TNTC[1]	TFTC[2] (1)	TFTC[2] (1)
Palm 7	TNTC[1]	0	0
Faucet Handle 8	0		TFTC[2] (23)
Fingertips 8	TNTC[1]	0	TNTC[1]
Palm 8	TNTC[1]	0	0
Faucet Handle 9	0		TFTC[2] (7)
Fingertips 9	TNTC[1]	0	46
Palm 9	TNTC[1]	0	0
Faucet Handle 10	0		163
Fingertips 10	TNTC[1]	0	273
Palm 10	TNTC[1]	0	0
Faucet Handle 11	0		TNTC[1]
Fingertips 11	TNTC[1]	TFTC[2] (1)	TNTC[1]
Palm 11	TNTC[1]	0	66
Faucet Handle 12	0		TNTC[1]
Fingertips 12	TNTC[1]	0	TNTC[1]
Palm 12	TNTC[1]	0	TNTC[1]
Faucet Handle 13	0		49
Fingertips 13	TNTC[1]	0	TNTC[1]
Palm 13	TNTC[1]	0	54
Faucet Handle 14	0		TNTC[1]
Fingertips 14	TNTC[1]	0	TNTC[1]
Palm 14	TNTC[1]	0	TFTC[2] (9)
Faucet Handle 15	0		33
Fingertips 15	TNTC[1]	0	TNTC[1]
Palm 15	TNTC[1]	0	0

Table 2. Number of *E. coli* K-12 Colony Forming Units (CFU) recovered from TSA plates in INSTANT-OFF replicates **Before hand washing (HW) and After hand washing (HW).** TNTC[1]: Too Numerous To Count. TFTC[2]: Too Few To Count. Statistically significant counts should be between 30 and 300 CFU.

	Before HW	After HW
Faucet Handle 1	0	0
Fingertips 1	TNTC[1]	0
Palm 1	TNTC[1]	TFTC[2] (1)
Faucet Handle 2	0	0
Fingertips 2	TNTC[1]	0
Palm 2	TNTC[1]	0
Faucet Handle 3	0	0
Fingertips 3	TNTC[1]	0
Palm 3	TNTC[1]	0
Faucet Handle 4	0	0
Fingertips 4	TNTC[1]	0
Palm 4	TNTC[1]	0
Faucet Handle 5	0	0
Fingertips 5	TNTC[1]	0
Palm 5	TNTC[1]	0
Faucet Handle 6	0	0
Fingertips 6	TNTC[1]	0
Palm 6	TNTC[1]	0
Faucet Handle 7	0	0
Fingertips 7	TNTC[1]	0
Palm 7	TNTC[1]	0
Faucet Handle 8	0	0
Fingertips 8	TNTC[1]	0
Palm 8	TNTC[1]	0
Faucet Handle 9	0	0
Fingertips 9	TNTC[1]	0
Palm 9	TNTC[1]	0
Faucet Handle 10	0	0
Fingertips 10	TNTC[1]	0
Palm 10	TNTC[1]	0
Faucet Handle 11	0	0
Fingertips 11	TNTC[1]	0
Palm 11	TNTC[1]	0
Faucet Handle 12	0	0
Fingertips 12	TNTC[1]	0
Palm 12	TNTC[1]	0
Faucet Handle 13	0	0
Fingertips 13	TNTC[1]	0
Palm 13	TNTC[1]	0
Faucet Handle 14	0	0
Fingertips 14	TNTC[1]	0
Palm 14	TNTC[1]	0
Faucet Handle 15	0	0
Fingertips 15	TNTC[1]	0
Palm 15	TNTC[1]	0

The number of *E. coli* K-12 CFU recovered from the fingertips and palm of the gloves after re-handling the faucet handle was highly variable (Table 1; Figure 3). *E. coli* K-12 CFU recovered from both the fingertips and the palm of the glove ranged from 0 to statistically too many to count. Subtle differences in the way the faucet handle was grasped and manipulated when turning the water on and off may account for this variability.

Swabs of the faucet handle after completion of each replicate also produced highly variable results. The number of *E. coli* K-12 CFU recovered ranged from 0 to statistically too many to count (Table 1). **No *E. coli* K-12 CFU were recovered from the INSTANT-OFF actuator rod after the hand washing simulations were complete (Figure 4, Table 2).**

DISCUSSION

This study successfully showed that *E. coli* K-12 from contaminated gloves could transfer to the faucet handle and back to a clean glove (Table 1, Figures 1 and 3).
In both Faucet and INSTANT-OFF replicates, surface decontamination and glove contamination were consistently successful.

The INSTANT-OFF replicates successfully showed removal of *E. coli* K-12 from the gloves without contamination of the actuator rod (Table 2, Figures 2 and 4).

The Faucet replicates, however, were much less predictable. A statistically significant number of CFUs were recovered from the faucet handle in four of the fifteen replicates (Replicates 1, 10, 13, and 15; 26.67%). Statistically significant counts of CFUs were recovered in four of the fifteen fingertip replicates (Replicates 3, 4, 9, and 10; 26.67%) and two of the fifteen palm area replicates (Replicates 11 and 13; 13.33%). All other replicates provided results that were outside of the statistically significant 30-300 CFU range. The lack of statistically significant data is likely due to the high level of *E. coli* K-12 (1.5×10^7 CFU/ml) used to contaminate the gloves. Additional replicates performed with lower levels of *E. coli* K-12 did not provide statistically significant results either (data not shown). Human elements, such as swabbing and differences in faucet grasping technique, may also have contributed to the variability observed (Tables 1 & 2).

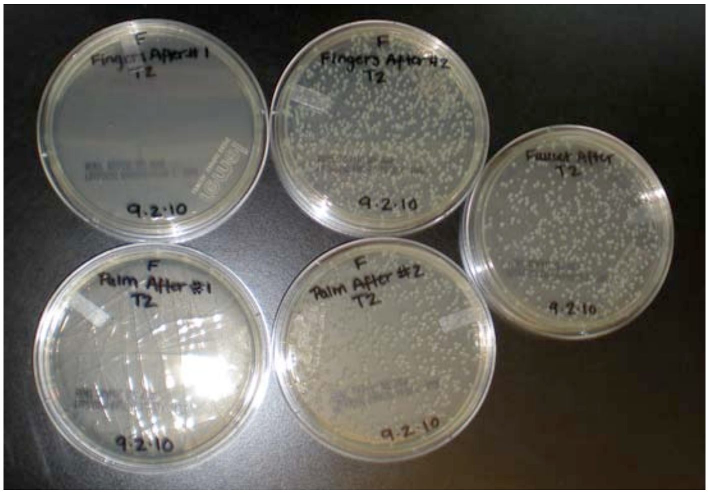

Figure 3. Hands after washing- Close up of Faucet replicates after the hand washing simulation and after handling the faucet handle. From left to right: Fingertips (top) and Palm (bottom) After hand washing simulation. **On right – Hands after touching contaminated faucet handles** Fingertips top) and Palm After handling the faucet handle, Faucet handle After. *E. coli* K-12 colony forming units were recovered from the fingertips, palm, and faucet handle in this replicate.

Figure 4. Close up of INSTANT-OFF replicates after the hand washing simulation. From left to right: Fingertips (top) and Palm, Instant-Off actuator rod. No *E. coli* K-12 colony forming units were recovered.

STUDY CONCLUSIONS

There is evidence that touching faucet handles contributes to cross-contamination, which can cause food-borne illness, a serious health concern.

The results obtained in this study suggest that fingertips are more likely to contribute to cross-contamination than palms.

This study proved that the risk of cross-contamination caused by touching faucet handles (after hands were washed) was virtually eliminated when the INSTANT-OFF was used properly.

The INSTANT-OFF was found to be an effective device to reduce cross-contamination at faucets. In addition, there was no contamination on the actuator rod from contaminated hands during hand washing.

The INSTANT-OFF offers a cost-effective alternative for businesses who are attempting to reduce the risk of cross-contamination at hand-wash sinks.

FUTURE STUDIES

A future study should involve human participants who handle contaminated food rather than wearing latex gloves. A lower level of bacteria should also be considered in order to obtain statistically significant results.

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