Study to Assess the Prevention of Microbial Cross-Contamination From Tables to Utensils Using Flatware Rests

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Abstract **Restaurants serve more than 70 billion meals in the U.S. each year. Annually, approximately 48 million foodborne illnesses occur in the U.S., yet only over 800 foodborne disease outbreaks get reported. From 1998–2013, 56% of the 17,445 outbreaks reported were associated with restaurants. While scientifically validated cleaning and sanitation strategies are available, microbial cross-contamination from environmental surfaces remains an issue. For instance, previous research shows that the cleaning tool itself can become a source of contamination. The objective of this study was to test if a flatware rest provides a physical barrier between contaminated tabletop surfaces and eating utensils. Data confirmed that flatware rests prevented the contamination of utensils from microorganisms when compared with utensils placed directly on surfaces inoculated with *E. coli, Salmonella* Typhimurium, and MS2 bacteriophage (a surrogate for norovirus). This study demonstrates that flatware rests are a practical solution to prevent cross-contamination of foodborne pathogens from tabletop to utensil, and potentially are an added layer of consumer protection.**

Introduction

Restaurants serve more than 70 billion meals in the U.S. each year (Jones & Angulo, 2006). In 2014, food-away-from-home sales surpassed food-at-home sales, comprising over 50% of total food expenditures (Saksena et al., 2018). Overall, adults ages 18–54 years in the U.S. consume food away from home at least 5 times per week and in 2017, consumer units (e.g., families, single persons living alone, etc.) spent on average $3,365 on food away from home (Saksena et al., 2018; U.S. Bureau of Labor Statistics, 2019).

Unfortunately, foodborne disease causes approximately 48 million illnesses each year in the U.S., yet only over 800 foodborne disease outbreaks are reported annually to the Centers for Disease Control and Prevention (Scallan, Griffin, Angulo, Tauxe, & Hoekstra, 2011; Scallan, Hoekstra, et al., 2011). From 1998–2013, 56% of the 17,445 outbreaks reported were restaurant-associated, with the most common contributing factors being those related to food handling and preparation (61%) and food worker health and hygiene (47%) (Angelo, Nisler, Hall, Brown, & Gould, 2017). Within these broad categories, cross-contamination contributed to 32% of issues linked to food handling and preparation.

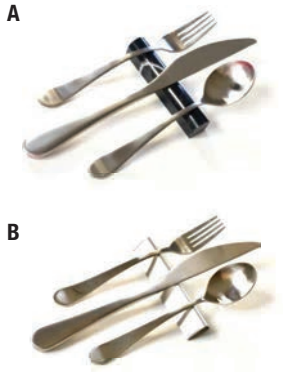
For prevention of cross-contamination from environmental surfaces, proper cleaning and sanitation are the primary tools available. Previous research, however, has shown that the cleaning tool itself can become the source of contamination (Hilton & Austin, 2000; Redmond, Griffith, Slader, & Humphrey, 2004; Scott & Bloomfield, 1990). Gibson and coauthors (2012) demonstrated that generic cotton terry towels—commonly used in food service establishments (FSEs)—can readily contaminate a surface if used previously to remove pathogens from a different surface. In addition, the sanitizing compounds most commonly used in FSEs (e.g., quaternary ammonium compounds) are ineffective against norovirus, which is the primary cause of foodborne disease in the U.S. (Feliciano, Li, Lee, & Pascall, 2012; Kingsley, Vincent, Meade, Watson, & Fan, 2014; Scallan, Hoekstra, et al., 2011).

Proper cleaning and sanitation to prevent the transmission of foodborne pathogens in FSEs should be an attainable goal, but additional approaches might be warranted for enhanced protection of public health. One option to enhance protection of public health is the addition of a physical barrier. In this study, the physical barrier is a flatware rest. While flatware rests likely had their beginnings in the late 17th century or even before, these items once again entered the marketplace in the 21st century as a tool to separate the flatware from the tabletop (Byer, 2016). Flatware rests are objects of different materials (e.g., stainless steel, marble, hard plastic) that are placed on the tabletop where the "head" or "neck" of the flatware is placed on the rest itself (Figure 1). The flatware rest provides a barrier between a tabletop and the eating utensil itself.

To our knowledge, there have not been any studies characterizing the efficacy of

FIGURE **1**

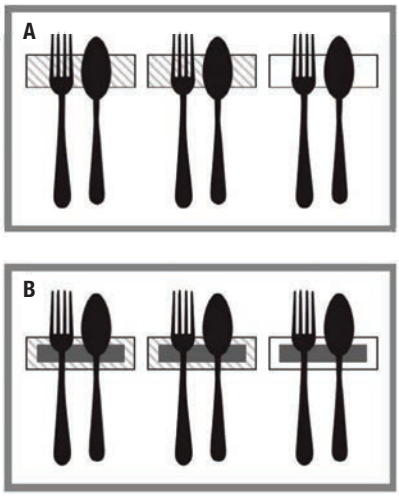
Example of Flatware Rests



A = marble flatware rest; B = stainless steel flatware rest.

FIGURE **2**

Experimental Setup for Evaluation of Flatware Rests



A = control setup with utensils (fork and spoon) placed directly on inoculated areas (gray diagonal stripes) or not inoculated area (white); B = treatment setup with the neck of the utensils (fork and spoon) oriented on the flatware rests (dark gray rectangle) with the flatware rests placed directly on inoculated areas (gray diagonal stripes) or not inoculated area (white).

flatware rests as a preventive control for microbial cross-contamination from surfaces. Therefore, the primary objective of this study was to evaluate the efficacy of flatware rests for the prevention of microbial cross-contamination from a contaminated tabletop to eating utensils.

Methods

Preparation of Microorganisms

E. coli C3000 (American Type Culture Collection [ATCC] 15507), *Salmonella* Typhimurium LT2 (ATCC 19585), and MS2 bacteriophage (ATCC 15597-B1)—a surrogate for norovirus—were used in the present study (Richards, 2012). Preparation of bacteria inoculum was done in accordance with AOAC International Official Method 920.09 and preparation of the MS2 bacteriophage was done as described previously (AOAC International, 2011; Gibson, Crandall, & Ricke, 2012). The tabletop surface was composed of a white, nonporous melamine material.

Experimental Setup

For each experiment, two 5 x 1.5-in. areas (12.7 x 3.81 cm) were inoculated with approximately 6 log colony forming units (CFUs) of each bacterial type or plaque forming units (PFUs) of MS2 and allowed to dry on the surface for 30 min. Two pieces of stainless steel flatware (spoon and fork) were placed on the contaminated areas with either the 1) head of the flatware resting directly in the contaminated area on the tabletop surface or 2) neck of the flatware placed on the marble or stainless steel flatware rest located on top of the contaminated area (Figure 2). The marble and stainless steel flatware rests measured 4 x 0.75 in. (10.16 x 1.91 cm) and 4.25 x 1 in. (10.8 x 2.53 cm), respectively. The utensils were left for 5 min followed by swabbing with calcium alginate-tipped swabs presoaked in 2.25 mL of buffered phosphate water. We also swabbed the bottom of the flatware rests that were in contact with the contaminated surfaces.

Recovery and Detection of Microorganisms

Swab samples were vortexed for 10 s, serially diluted in 0.1% peptone, and plated on 3M Petrifilm *E. coli*/Coliform Count Plates and XLT-4 agar plates for *E. coli* and *Salmonella* detection, respectively, or Tryptic Soy Agar using the double agar layer assay for MS2 detection as described previously (Almeida & Gibson, 2016; Conover & Gibson, 2016; Dusch & Altwegg, 1995). All plates were incubated for 18–24 hr at 37 °C. Following incubation, CFUs or PFUs were counted and recorded per milliliter.

Data Analysis

Concentrations of bacteria (CFU/mL) and bacteriophage (PFU/mL) were log-transformed for visual convenience without loss of generality in results (e.g., $\log_{10}$, CFU/mL, or PFU/mL + 1). All experiments were completed in duplicate with biological replicates, as well as positive and negative control samples for each type of microorganism.

Results

To determine the recovery efficiency of the microorganisms from the surface, we collected swabs from the inoculated areas on the tabletop after 5 min. Following the 5-min period, 4.56, 5.54, and 5.30 $\log_{10}$ (CFU/mL or PFU/mL + 1) were recovered from the tabletop surface for *E. coli*, *Salmonella*, and MS2, respectively. The transfer of microorganisms from the contaminated tabletop surface or flatware rests after a 5-min contact time is shown in Figure 3. On average, 3.82, 4.67, and 3.53 $\log_{10}$ (CFU/mL or PFU/mL + 1) were recovered from the utensils in direct contact with the contaminated surface for *E. coli, Salmonella*, and MS2, respectively. No microorganisms were recovered from the flatware placed on either the marble or stainless steel flatware rests.

We also swabbed flatware rests contacting the contaminated surfaces. For *E. coli*, *Salmonella*, and MS2, 4.50, 5.50, and 4.99 $\log_{10}$ (CFU/mL or PFU/mL + 1) were recovered from the bottom of the marble flatware rest, respectively. From the bottom of the stainless steel flatware rest, 3.75, 4.85, and 3.17 $\log_{10}$ (CFU/mL or PFU/mL + 1) of *E. coli*, *Salmonella*, and MS2 were recovered, respectively. No microorganisms were recovered from utensils or flatware rests placed in the control area (not inoculated; Figure 2).

Discussion

Cross-contamination events within FSEs are prevalent and can occur at numerous stages in the food preparation process. Previous researchers have determined that food preparation and food-adjacent surfaces (e.g., cutting boards, microwave oven controls, faucet handles on sinks, various handles, and ingredient lids) that were perceived to

be clean by visual assessment were contaminated with microorganisms (Sharp & Walker, 2003; Tebbutt, Bell, & Aislabie, 2007). It has been indicated that pathogens can multiply on these surfaces and even after drying, some microorganisms can remain viable for weeks, resulting in cross-contamination of foods (Holtby, Tebbutt, Grunert, Lyle, & Stenson, 1997; Wilks, Michels, & Keevil, 2005). Even restaurant menus can become contaminated with pathogens and should be sanitized regularly to prevent the transmission of foodborne pathogens (Sirsat, Choi, Almanza, & Neal, 2013). Furthermore, as previously mentioned, cleaning tools such as towels and cloths can become the source of contamination. Two primary factors should be considered when determining the risk of foodborne disease associated with cross-contamination: 1) level of contamination on the surfaces and 2) prospect of the transfer of contamination to the food and ultimately, to the consumer (Bloomfield & Scott, 1997).

In a study conducted by Sirsat and coauthors (2013), researchers sampled surfaces of restaurant menus and concluded that there was 1 to 2 $\log_{10}$ CFU/cm^2 of aerobic microorganisms present on the laminated menus. Another investigation focusing on the microbial load of surfaces within communal kitchens revealed an average of 1.0 x 10^3 to 4.3 x 10^7 CFU/mL of total coliforms depending on the surface type and location (Sharp & Walker, 2003). During an investigation of microbial loads on food contact surfaces in schools, Illés and coauthors (2018) found that 70.3% of kitchen tables presented unsatisfactory (>2.40 $\log_{10}$ CFU/100 cm^2) mesophilic aerobic bacterial counts with a mean of 3.49 $\log_{10}$ CFU/100 cm^2.

While none of the aforementioned studies report on pathogens recovered from kitchens and FSEs, it is important to note the recovered microbial load in relation to the infectious dose of common foodborne pathogens. Human enteric viruses such as norovirus cause the most foodborne-related illnesses worldwide due to their ease of transmission and low infectious dose (Siebenga et al., 2009). The ingestion of as few as 18 to 1,000 viral particles on average can lead to illness (Kambhampati, Koopmans, & Lopman, 2015).

Another important group of pathogens, nontyphoidal salmonellae, are responsible for 11% of the estimated foodborne illnesses in the U.S. annually and are the second-most common foodborne disease agent (Scallan, Hoekstra, et al., 2011). The infective dose of salmonellae can vary depending on the immune status of the individual, the strain, and the food product. Data thoroughly reviewed by Blaser and Newman (1982) from outbreaks of salmonellae suggest that infections can be caused by the ingestion of <10^3 cells, but more commonly, higher doses are needed to overcome stomach acidity.

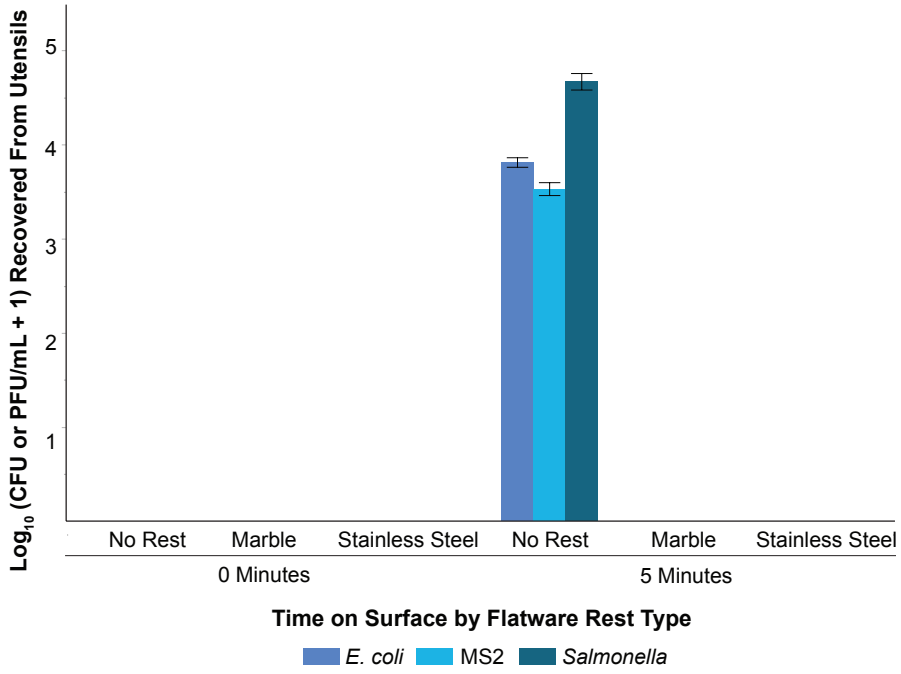
Numerous other bacterial pathogens can be transmitted via direct food handler contamination or cross-contamination in FSE environments, including enterotoxigenic *E. coli*, *Campylobacter* spp., *Shigella* spp., and group A *Streptococcus* (Todd, Greig, Bartleson, & Michaels, 2007), although these are not nearly as prevalent as the previously discussed norovirus and nontyphoidal *Salmonella*. In general, these pathogens are of fecal origin—with the exception of group A *Streptococcus*—and have a range of reported infectious doses (e.g., approximately 100 to >10^6 cells) (Todd, Greig, Bartleson, & Michaels, 2008).

In addition to the low infectious dose of many pathogens and the risk of cross-contamination from surfaces, common chemicals for cleaning and sanitation do not effectively destroy all pathogens. For example, Joseph and coauthors (2001) reported no resistance in planktonic *Salmonella* Weltevreden cells to iodine and chlorine; however, biofilms of *S.* Weltevreden demonstrated resistance to similar treatments. Therefore, improper cleaning and "leftover" salmonellae could be a potential source of contamination. Moreover, chlorine, chlorine dioxide, peroxyacetic acid, hydrogen peroxide, and trisodium phosphate were all tested for the inactivation of norovirus (Kinglsey et al., 2014).

While some chemicals (e.g., trisodium phosphate) showed reduction of norovirus over a period of time, others (e.g., hydrogen peroxide) had no impact on the virus, provid-

FIGURE **3**

Microbial Recovery From Utensils Based on Treatment



MS2 = bacteriophage that is used as a surrogate for norovirus.

Note. Bars indicate the mean value of microorganisms recovered from the utensils (fork and spoon) for each treatment (no rest, marble rest, or stainless steel rest) by time (0 and 5 min). Zero minutes represent the microbial status of the utensils prior to being placed on the contaminated surface or flatware rest. Error bars were constructed using one standard deviation from the mean.

ing further evidence that chlorine remains the most effective sanitizer for the inactivation of norovirus (Kinglsey et al., 2014). Another study, conducted by Feliciano and coauthors (2012), determined that quaternary ammonium compounds used regularly in FSEs to inactivate bacteria were unable to reduce the same level of murine norovirus—a norovirus surrogate—under similar conditions. This lack of virus reduction by many traditional sanitizers might be linked to the limited guidance measures for human enteric viruses within the food industry, as thoroughly reviewed by Bosch and coauthors (2018).

There are a few limitations related to the present study. First, a higher concentration of microorganisms (i.e., compared with naturally occurring levels) was inoculated onto the tabletop surface in order to demonstrate the potential magnitude of cross-contamination that can occur between the tabletop and eating utensils. This situation might be considered not representative of a real-world scenario. Based on the number of microorganisms transferred to the eating utensil from the tabletop surface (2–18% of original inoculum), however, one could speculate that even a low-level contamination event (10^2 CFU or PFU) could result in transference of a sufficient infectious dose to the utensil. Second, the flatware rest itself has its own limitation. More specifically, the flatware rest is introducing an additional surface that has the potential to become contaminated and will need to be sanitized properly. Unlike an entire tabletop surface, though, the flatware rests can be placed in a mechanical warewasher for microbe inactivation on the surface as specified in the Food and Drug Administration's *Food Code*, *Sanitization of Equipment and Utensils* (U.S. Department of Health and Human Services, 2017).

Conclusion

The results of this study show that flatware rests can prevent cross-contamination of microorganisms from tabletops to utensils, and thus might provide an added layer of protection to consumers. FSEs—and the hospitality industry in general—should consider physical barriers to microbial contamination as an additional preventive control for foodborne pathogens. FSEs must still ensure, however, that cleaning and sanitizing regulations established by state food codes are strictly adhered to in order to maintain an effective barrier (Food and Drug Administration, 2019). Thus, future studies should validate the cleaning and sanitation protocols applied to flatware rests if their use is implemented as a preventive control measure.

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