



Research Paper

Hand hygiene product use by food employees in casual dining and quick-service restaurants

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ARTICLE INFO

Keywords:

FDA Food Code

Food handlers

Hand hygiene monitoring

Hand sanitizer

Hand soap

Restaurants

ABSTRACT

Hand hygiene product usage characteristics by food employees when hand sanitizers are made available are not well understood. To investigate hand hygiene product usage in casual dining and quick-service restaurants, we placed automated monitoring soap and sanitizer dispensers side-by-side at handwash sinks used by food employees in seven restaurants. Dispenses were monitored, and multiple dispenses that occurred within 60 s of each other were considered a single hand hygiene event. This resulted in 186,998 events during the study (149,779 soap only, 21 985 sanitizer only, and 15,234 regimen [defined as soap followed by sanitizer at the same sink within 60 s]) over 15,447 days of use. Soap was the most frequently used hand hygiene method by food employees in both restaurant types. Regimen use, despite being the preferred hand hygiene method by both restaurant chains, was the least used hand hygiene method. When pooled over restaurant types, the median daily usage for soap was statistically significantly highest of all methods at 23.5 dispenses per sink per day ($p < 0.0001$), the sanitizer median daily usage was 4.27 dispenses per sink per day, and regimen use was statistically significantly lowest of all methods at 4.02 dispenses per sink per day ($p < 0.0001$). When hand hygiene event types were pooled, casual dining restaurants had similar median hand hygiene event rates (11.4 dispenses per sink per day) compared to quick-service restaurants (11.9 dispenses per sink per day; $p = 0.890$). The number of events by sink location varied, with sinks located at a warewash station having the highest number of events (19.3 dispenses per sink per day; $p < 0.0001$), while sinks located by a ready-to-eat food preparation area had the lowest number of events (6.8 dispenses per sink per day; $p < 0.0001$). These data provide robust baseline benchmarks for future hand hygiene intervention studies in these settings.

The Centers for Disease Control and Prevention (CDC) identifies proper hand hygiene in food handling settings as a critical factor for reducing foodborne illness (Green et al., 2007). While proper hand hygiene is critical for reducing the risk of a foodborne illness outbreak, compliance with the United States Food and Drug Administration (FDA) recommendations for hand hygiene remains low in restaurants (Fraser et al., 2012). Using a direct observation study design on 321 restaurant workers, Green et al. observed a 27% compliance rate with Food Code recommendations on how to wash hands, noting an average of 8.6 activities per worker per hour requiring a handwash (Green et al., 2007). Although direct observational studies provide valuable insights into hand hygiene behaviors of restaurant workers, the Hawthorne effect (when an observed individual modifies their natural behavior since they are being observed) may bias results of the

study, thereby making it difficult to approximate real, natural hand hygiene behaviors (Sharman et al., 2020).

Observational research conducted in restaurants has shown employees should spend anywhere from 8 (Green et al., 2006) to 24 minutes per hour (Strohbehn et al., 2011) washing hands if in full compliance with FDA Food Code recommendations for “when” and “how” to wash hands. Compliance with FDA Food Code recommendations in the restaurant industry remains challenging, and many food employees have cited not having enough time to meet these hand hygiene expectations (Clayton et al., 2002; Green et al., 2005). Given these unrealistic time commitments, more convenient approaches for hand hygiene that are less time-consuming are needed (Boyce and Schaffner, 2021; Clayton et al., 2002). In 2002, the use of alcohol-based hand sanitizers was recommended by the CDC in healthcare settings as a primary means of hand hygiene when hands are not visibly

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soiled, in response to low hand hygiene compliance (Boyce and Pittet, 2002). Currently, the use of hand sanitizers is not considered an acceptable substitute for handwashing in the FDA Food Code (United States Food and Drug Administration, 2017). Hand sanitizers should only be used by a food handler immediately following a handwash with soap and water. The practice of applying a hand sanitizer to hands immediately after performing a handwash with soap and water is referred to as a hand hygiene “regimen” by FDA (United States Food and Drug Administration, 1999). Increased use of sanitizer instead of handwashing with soap and water when hand sanitizer is made available to food employees is sometimes cited as a reason for discouraging their use in food handling settings (United States Food and Drug Administration, 2020). Despite this, product usage characteristics (i.e., frequency of soap versus sanitizer versus soap followed by sanitizer) are not well understood in restaurant settings, with little to no published research on this topic to date.

Automated hand hygiene monitoring systems are growing in interest and application in hospitals (Boyce, 2021). These systems leverage wireless signals (i.e., WiFi or Bluetooth), to transmit dispense data to a central storage site. Users of these systems can then quickly monitor dispenser usage over time by employees, which can help identify important trends. Using these automated monitoring equipped hand soap and hand sanitizer dispensers installed in seven real-world restaurants over multiple years, we sought to learn and to characterize the usage frequency of soap (alone) versus sanitizer (alone) versus soap followed by sanitizer (regimen) among restaurant workers, and determine the impact of restaurant type (casual dining versus quick service) and handwash sink location on hand hygiene product usage. We collected 186 998 hand hygiene events during this study over two years of data collection. Because of a large number of data points collected, results from this study are particularly robust as compared to direct in-person observation studies, making findings from this study excellent baseline benchmarks for future hand hygiene intervention studies in these settings.

Materials and methods

Study locations

Four casual dining and three quick-service restaurants were enrolled in this study. All casual dining restaurants belonged to the same national chain, and all quick-service restaurants belonged to the same national chain. All restaurants were in either California or Ohio. Data collection occurred between 10/15/2015 and 11/9/2017 for casual dining restaurants, and between 11/8/2019 and 3/14/2020 for quick-service restaurants. General characteristics and summary of data observations within each individual restaurant are listed in Table 1.

Data collection

PURELL® ES8 hand sanitizer and hand soap dispensers (GOJO Industries, Akron OH) were used in this study. Dispensers were fitted with SMARTLINK™ plug-in modules (GOJO Industries, Akron OH) which recorded and reported timestamped dispenses and dispenser type (e.g., soap or sanitizer). This technology has been previously used in healthcare settings to evaluate hand hygiene performance (Limper et al., 2017). Soap and sanitizer dispensers were installed immediately adjacent to one another at each handwashing sink, and throughout each restaurant (see Table 1 for locations). As indicated in Table 1, dispenser locations were categorized as either warewash (located immediately beside or in a dishwashing area), nonfood handling (not located immediately near an area where food handling occurs [e.g., back-of-house hallway]), raw food handling (located in an area where raw meat is handled and prepared), or ready-to-eat food

Table 1
General description of restaurants, dispenser locations, and dispense types monitored during study

Identifier	Zip Code	Restaurant Type	Locations of Handwash Sinks Monitored	Date Range of Data Collection	Number of Soap Events	Number of Sanitizer Events	Number of Soap followed by Sanitizer Events	Total Number of Hand Hygiene Events Recorded	Total Number of Days Analyzed
1	44512	Casual Dining	Bar, Salad Station, Dishwash Station, Grill Station	12/11/2015–11/9/2017	33,736	4608	3265	41,609	4899
2	44056	Casual Dining	Salad Station, Entrance to Kitchen, Ice Bin, Oven Sink	10/15/2015–11/7/2017	15,207	2471	205	17,883	2169
3	44333	Casual Dining	Bar, Dishwash Station, Fryer Station, Preparation Sink	12/18/2015–3/10/2017	41,561	4515	4725	50,801	3071
4	44070	Casual Dining	Bar, Dishwash Station, Preparation Sink	12/21/2015–11/8/2017	44,130	3164	1798	49,092	3182
5	92606	Quick Service	Wash Area, Kitchen Preparation Sink	11/8/2019–3/14/2020	6157	2077	2240	10,474	709
6	44056	Quick Service	Kitchen Preparation Sink, Drive Through Window Sink	11/11/2019–3/14/2020	3271	899	670	4840	658
7	92612	Quick Service	Wash Area, Sink Beside Office, Sink by Walk-in Refrigerator	11/8/2019–3/14/2020	5717	4251	2331	12,299	759

handling (located in an area where ready-to-eat foods are handled and assembled [e.g., salad preparation station]). Dispensers that also served guests (e.g., ordering kiosks, restrooms) were excluded from the analysis to ensure data collection focused only on restaurant food employee behavior.

Data curation

Data along with timestamps were exported out of a Microsoft Azure SQL Data Warehouse as spreadsheets into Microsoft Excel (version 2102, Microsoft Corporation, Redmond, WA) for analysis. Given that people sometimes use multiple dispenses of the product during a single hand hygiene event, multiple dispenses from the same dispenser occurring within 60 s of each other were counted as a single hand hygiene event. Data were coded as one of three events: (1) soap dispense alone, (2) sanitizer dispense alone, or (3) “regimen” (defined as a soap dispense followed by a sanitizer dispense within 60 s of each other at the same handwashing sink). Regimen use was also the required hand hygiene procedure by both restaurant chains according to their hand hygiene policy.

Statistical analysis

Statistical analysis was performed on the annual number of events weighted by the number of days with a Poisson linear mixed effects model with random effects for Store and Year, and fixed effects for Event Type, Restaurant Type, and Dispenser Location, and the two-way interactions of the fixed effects. All analyses were implemented in R v4.0.4 (R Core Team, 2021). R package *lme4* was used to model the annual data (Bates et al., 2014), and package *multcomp* was used to maintain a family-wise confidence level of 95% for all pairwise com-

parisons associated with each fixed effect using the stepwise method (Hothorn et al., 2015). Unless otherwise noted, all hand hygiene rates are normalized as median dispenses per sink location per day.

Results

In this study, we report the hand hygiene product usage characteristics of restaurant food handlers based on a multiyear collection of over 186 998 data points from automated monitoring soap and hand sanitizer dispensers installed at handwashing sinks in the “back-of-house”. As shown in Table 1, we enrolled casual dining restaurants and quick-service restaurants from multiple locations in Ohio and California. Soap and hand sanitizer dispensers were placed at a wide variety of sink locations used by employees who handled food, including salad preparation stations, dishwashing stations, and grill stations. Total number of dispenser events recorded in each individual location during the study ranged from 4840 (location 6) to 50 801 (location 3). Data curation resulted in a total of 186 998 events being recorded, specifically composed of 149 779 soap events (alone), 21 985 sanitizer (alone), and 15 234 regimen (soap + sanitizer) events over 15 447 days of data collection. A detailed summary of observations within each individual restaurant is in Table 1.

When hand hygiene event types were pooled across all hand hygiene event types and across dispenser locations, casual dining restaurants had no statistically significant difference in median hand hygiene rates (11.4 dispenses per sink per day) compared to quick-service restaurants (11.9 dispenses per sink per day) ($p = 0.890$).

Overall median hand hygiene rates among event types are summarized in Table 2. When pooled across restaurant type and dispenser locations, soap (alone) was used over 5.5 times more often than either sanitizer (alone) or regimen (soap followed by hand sanitizer)

Table 2

Overall hand hygiene product usage rates across all restaurants and all sink locations

Hand Hygiene Event Type	Observed Median Hand Hygiene Rate Per Sink Per Day [95% CI]
Soap (alone)	23.5 ^a [17.7, 31.2]
Sanitizer (alone)	4.27 ^b [3.22, 5.68]
Regimen (soap followed by hand sanitizer)	4.02 ^c [3.03, 5.34]

Letters appearing beside the reported median daily rates indicate statistically significant groupings ($p < 0.0001$) observed between overall hand hygiene event types.

Table 3

Median hand hygiene rates among dispenser location types (pooled over restaurant and event type)

Dispenser Location Type	Median Rates Per Sink Per Day [95% CI]
Warewash	19.3 ^a [16.6, 22.5]
Nonfood handling	10.5 ^b [9.00, 12.2]
Food handling (raw)	7.4 ^c [6.37, 8.63]
Food handling (ready to eat)	6.8 ^d [5.84, 7.91]

Letters appearing beside the reported median daily rates indicate statistically significant groupings ($p < 0.001$) observed between overall hand hygiene event types.

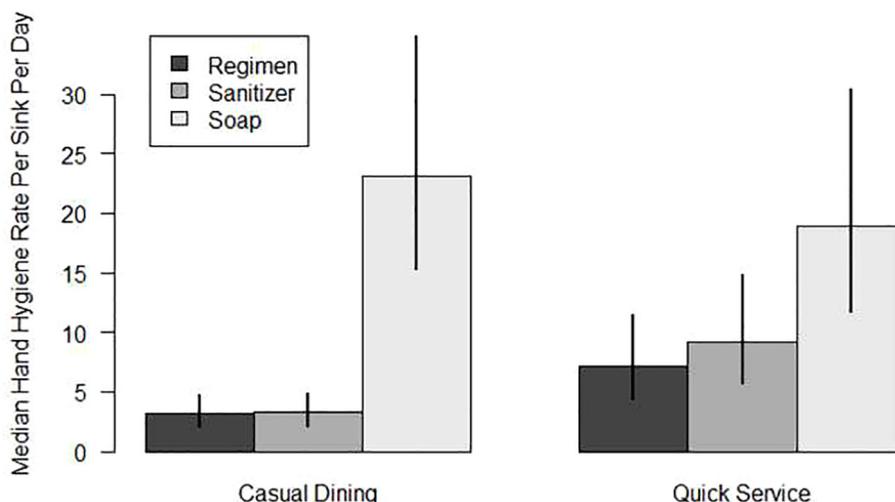


Figure 1. Daily median hand hygiene rates by restaurant type and hand hygiene event type. Error bars indicate 95% confidence intervals.

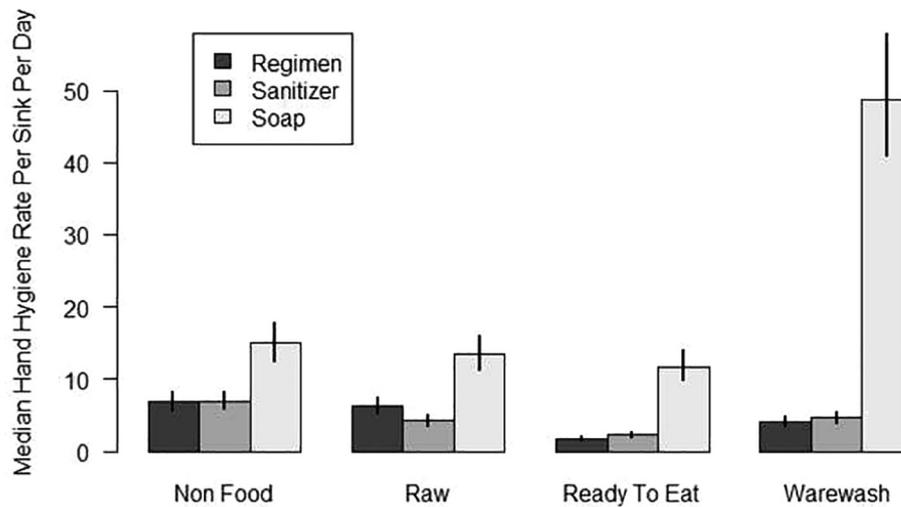


Figure 2. Daily median hand hygiene rates by handwashing sink location and event type. Error bars indicate 95% confidence intervals. Daily median hand hygiene rates between all handwashing sink locations and event types were statistically significantly different from one another ($p < 0.01$), except for two cases: (1) for all dispensers located at Nonfood preparation sinks, sanitizer use was not statistically significantly different than regimen use ($p = 1$), and (2) regimen use at Warewash sinks was not statistically significantly different than Sanitizer use at Raw food preparation sinks ($p = 0.727$).

($p < 0.0001$), with regimen used least frequently ($p < 0.0001$) (Table 2). When these data were examined by restaurant type, the same general pattern of hand hygiene treatment usage characteristics remained (i.e., highest rates observed with soap use, lowest rates observed for regimen use), regardless of restaurant type (Fig. 1). No statistically significant difference in soap use between casual dining restaurants (23.1 dispenses per sink per day) and quick-service restaurants (18.9 dispenses per sink per day) ($p = 0.966$) was observed. On the other hand, the quick-service restaurants had higher sanitizer and regimen use (9.16 and 7.12 dispenses per sink per day, respectively) as compared to sanitizer and regimen use in the casual dining restaurants (3.25 and 3.16 dispenses per sink per day, respectively) ($p \leq 0.023$).

Median hand hygiene rates among dispenser locations are shown in Table 3. Hand hygiene events occurred most frequently at handwash sinks located in the warewash area of the restaurant (19.3 dispenses per sink per day; $p < 0.0001$) and occurred least frequently at handwash sinks located in food handling areas focused on ready-to-eat products (6.80 dispenses per sink per day; $p < 0.0001$). As shown in Figure 2, warewashing area hand hygiene rates were largely driven by high levels of soap use compared to sanitizer and regimen use ($p < 0.001$). Daily median rates of regimen use were lowest in ready-to-eat and warewash sink locations ($p < 0.001$), with sanitizer use lowest in raw food handling sink locations ($p < 0.001$, Fig. 2).

Our analyses allowed an assessment of the similarity of annual hand hygiene rates from the same store and/or from the same year. Hand hygiene rates (on the ln-scale) from the different years from the same store were moderately correlated ($r = 0.57$), but very little correlation was observed from the same year in different stores ($r = 0.01$).

Discussion

In this study, we observed a preference for soap use among food handlers when given both soap and sanitizer as an option at handwashing sinks (Table 2). Food handlers from these locations clearly do not see hand sanitizer as a preferential option over soap. Additionally, we observed a limited use of a hand hygiene regimen despite this hand hygiene procedure being the required hand hygiene protocol for food employees of both restaurant chains. Regimen use has been shown to be more effective than handwashing with soap and water alone (Edmonds et al., 2012), which is the primary reason why both

chains had this method adopted as their required hand hygiene protocol for food employees. One reason the regimen may not be used as frequently by food service employees is that there is limited time to complete hand hygiene and the regimen takes longer than handwashing with soap alone (Todd et al., 2010). Time is often cited as a major barrier to hand hygiene in food preparation (and in many other settings, such as for healthcare personnel) (Voss and Widmer, 1997). In one study, employees were asked why they did not follow hand hygiene protocols in food handling settings and the primary reason was lack of time available to them to complete hand hygiene (Green et al., 2006). To help alleviate time as a barrier to hand hygiene compliance, employers should assess the layout of the food handling areas to ensure food employees have easy access to sinks. Additionally, sinks need to be in good working condition and stocked with the necessary supplies to properly execute a hand hygiene protocol (clean paper towels, hand soap, etc.). Another reason the regimen may not have been used as frequently is that the superior antimicrobial efficacy benefit of the regimen compared with soap alone (Edmonds et al., 2012) may not have been clear or not seen as valuable to food employees. Therefore, the employees may simply use the option most familiar and convenient to them.

Soap (alone) was the most frequently used hand hygiene method, with a daily median rate of 23.5 dispenses per sink per day (Table 2). This is over five times the observed usage rate of hand sanitizer (alone), which we observed to be 4.3 dispenses per sink per day (Table 2). This observation dispels the notion that introduction of a hand sanitizer near a handwashing sink located in a food handling area will lead to food employees using hand sanitizer preferentially over soap and water. According to FDA Food Code, hand sanitizer cannot be used in lieu of handwashing with soap and water (United States Food and Drug Administration, 2017). Food employee training should cover this, which is likely the main reason why soap use is over five times that of hand sanitizer in this study. Additionally, while performing hand hygiene with a hand sanitizer is faster and more convenient than using soap and water, a single-use application of hand sanitizer does not have the soil removal capabilities of soap and water (Prince-Guerra et al., 2020; Strohhahn et al., 2008). During a shift, the hands of food employees may become frequently soiled, leading the employee to choose soap over sanitizer for purposes of cleaning their hands. This may partially explain why soap use was significantly higher than that of sanitizer use in this study. Recent research using farm workers has shown that a two-step application of an alcohol-

based hand sanitizer may be effective at removing soil and bacteria from hands (Prince-Guerra et al., 2020). Given the time constraints frequently encountered by food employees, the use of this two-step method for performing hand hygiene should be further investigated in the future studies focusing on real-world settings. Additionally, future studies are needed to evaluate the frequency and level of hand soiling experienced by food employees during a normal workload, and the impact of this soiling on hand hygiene product usage characteristics and preferences.

The daily median rates for hand hygiene observed in this study are very low, but similar to several previously published in-person observational studies focused on how often food service employees should be washing their hands (Green et al., 2005; Green et al., 2006; Strohbehn et al., 2011). This is especially concerning given that our study design only allowed for monitoring hand hygiene rates at the sink level. In other words, the observed hand hygiene rates are not at the individual food employee level. In one study by Strohbehn et al., researchers suggest that 29 hand washing events per hour are to be expected in a restaurant if food employees are fully compliant with FDA Food Code recommendations, but only observed employees attempting handwashes an average of 2.03 times per hour over a sixty-hour observation window (Strohbehn et al., 2008). In the current study, we observed a median of 23.5 hand hygiene events on a daily basis. When adjusted for hourly total hand hygiene events, this median becomes 2.07 and 2.84 per hour for the quick-service restaurant and casual restaurant, respectively, similar to the findings of Strohbehn et al. (2008). One reason employees may not wash their hands frequently is due to employee time constraints, which is often cited as a barrier to hand hygiene (Green et al., 2006). Additionally, our study involved observations through passive technology (dispenser-mounted wireless actuation counters) rather than direct in-person observation. In-person observation studies may potentially inflate hand hygiene rates due to bias from the observer (the so-called “Hawthorne Effect”) (Sharman et al., 2020). Given that our study design introduced no observer bias, it is reasonable to expect these observed hand hygiene rates to be lower than similar studies using an in-person observation design. Finally, our observed low rate of hand hygiene may also be affected by the motivational factors proposed through each restaurant chain’s corporate culture (Arendt et al., 2015; Ellis et al., 2010). Recent research has linked the presence of a food safety management system within a restaurant as having a positive impact on hand hygiene compliance rates (Verrill et al., 2021). As our study was not designed to assess the impact of food safety management systems and food safety culture on hand hygiene compliance, these are topics for future research efforts. Clearly, more efforts investigating innovative means to improve hand hygiene frequency within restaurants are needed.

We observed similar rates of overall hand hygiene in a quick-service restaurant chain (median rate 11.9 dispenses per sink per day) compared to a casual dining restaurant chain (11.4 dispenses per sink per day). The quick-service restaurants did have higher sanitizer and regimen use (9.16 and 7.12 dispenses per sink per day, respectively) as compared to sanitizer and regimen use in the casual dining restaurants (3.25 and 3.16 dispenses per sink per day, respectively) ($p \leq 0.023$). Previous studies have observed that quick-service restaurants tend to have higher hand hygiene compliance scores compared to full-service restaurants (Verrill et al., 2021). While we are not able to ascertain the reason behind our observation that the quick-service restaurants had higher rates of sanitizer and regimen use, it is reasonable to speculate that corporate culture, restaurant-to-restaurant variability, and differences in the amount of time available to each employee to perform hand hygiene may have been key factors contributing to these findings. Corporate mandates or encouragement (e.g., by the manager in charge) can help employees focus more time on health and safety aspects that ultimately impact customers and provide guidance on mak-

ing the restaurant experience more appealing to customers. Although it is controversial whether additional training leads to improved handwashing compliance (Todd et al., 2010), recent research has clearly shown that the presence of a food safety management system (which is reflective of a food safety-focused corporate culture) is linked to improved hand hygiene compliance (Verrill et al., 2021). In healthcare settings, it has been shown that a multimodal strategy is necessary to drive sustained hand hygiene improvement (Lotfinejad et al., 2021). This finding may be translatable to foodservice settings (Fraser et al., 2012), with the caveat that healthcare has adopted hand sanitizer as an alternative to handwashing when hands are not visibly soiled. Employers who seek to improve employee hand hygiene frequency are encouraged to adopt a food safety culture at all levels of the business, since this can lead to improved hand hygiene compliance, and an overall reduction in risk for pathogen transmission and for foodborne illness outbreaks.

We analyzed hand hygiene rates by dispenser locations to gain a better understanding of how handwashing sink location and the type of food handling task impact hand hygiene frequency. To our knowledge, no previous study has examined hand hygiene rates by handwashing sink location. As shown in Table 3, when all hand hygiene event types were aggregated, handwashing sinks located in warewash areas had higher usage rates compared to all other locations, with 19.3 hand hygiene dispenses occurring per sink per day ($p < 0.0001$). This finding is supported by anecdotal evidence from routine field observations suggesting that handwashing sinks located in warewashing areas had the highest level of usage within restaurants (Otto, 2021). The high usage in these areas may be since the hands of food employees in these areas are frequently soiled from handling dirty dishes and other wares (i.e., the feeling of dirtiness and the presence of visible soil motivate them to wash their hands). We observed that handwashing sinks located in food handling (raw) and food handling (ready to eat) preparation areas had the lowest rates of hand hygiene, at 7.4 and 6.8 dispenses per sink per day, respectively (Table 3). This is particularly alarming given that these are sinks closest to food preparation areas in active use. We hypothesize that employees working in these areas are extremely limited on time available to them to wash hands, or it could be that employees are not changing tasks as frequently as other food employees. Future studies investigating hand hygiene rates specifically by the food preparation task, the foodborne illness risk, and food handling employee role are needed.

While this study benefits from a large dataset of observations, it is not without limitations. First, since an in-person observation study design was not used, we cannot be sure that hand hygiene events counted in this study were fully compliant with FDA recommendations on how to wash hands. Second, to make the dataset more manageable, we were forced to define criteria to curate the dataset by counting multiple dispenses during the same 60-second window as a single hand hygiene “event”. While this helps to control for multiple dispenses of the product during a single hand hygiene attempt, it does not allow us to capture multiple hand hygiene attempts by separate individuals within a 60-second window. Therefore, true hand hygiene rates may be slightly higher than what we observed, although relative rates across product type, restaurant type, and handwashing sink location are likely not impacted. An additional limitation is that only one chain of casual dining and one chain of quick service were enrolled in the study. If other chain (or nonchain) restaurants were enrolled, it is possible that our results would be different. Also, our study design made it impossible to assess hand hygiene usage at the employee level. It is entirely possible that diligent employees who wash their hands frequently could be skewing some of the results we observed in our study. Finally, glove usage was not able to be monitored using this study design. Therefore, how glove usage may have impacted the hand hygiene results is unknown and is another opportunity for future research.

In this study, we utilized automated monitoring hand hygiene dispensers to explore hand hygiene product usage characteristics over time in two types of restaurants (casual dining or quick service). It is unique in the large amount of data collected over a relatively long period of time. Several key insights were observed, including confirming the preference for soap use among food employees when presented with hand sanitizer as an option. Given that this study design introduces no observer bias, hand hygiene rates identified in this study are valuable benchmarks for future intervention studies. Future research will focus on elucidating the reasons behind the observed lower hand hygiene rates at handwashing sinks located in food preparation areas, as well as determining the impact on food safety culture and restaurant type with the goal of increasing hand hygiene rates.

Disclosures/Conflict of Interest Statement

GOJO Industries provided funding to A. Parker and D. Walker for technical writing assistance and statistical consulting for this study. J. Arbogast, G. Robbins, J. Slater, and C. Manuel are scientists employed by GOJO Industries. GOJO Industries is the manufacturer of the soap and hand sanitizer dispensers utilized in this study.

Acknowledgments

Mia DeFino, MS, ELS provided technical writing assistance.

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