



Finger licking good? An observational study of hand hygiene practices of fast food restaurant employees and consumers

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Abstract

Purpose: Appropriate hand hygiene technique is a simple and effective method to reduce cross contamination and transmission of foodborne pathogens. This study aims to investigate the frequency of hand hygiene activities among food handlers and consumers in fast food restaurants.

Methodology: Twenty-five fast food restaurants and cafes were visited between May – August 2017 in North West England. A hand hygiene observational tool was adapted and modified from previous studies. The observational tool was designed to record 30 sequential hand activities of consumers and employees. Each transaction consisted of an observed action (e.g. touch with bare hands), object (e.g. exposed ready-to-eat foods) and observed hand hygiene practice (e.g. handwashing or cleaning with wipes or sanitisers). Adenosine triphosphate (ATP) swabs of hand-contact surfaces of restaurants' restrooms were carried out.

Findings: Findings revealed that both food handlers and consumers have low hand hygiene compliance rate in fast food restaurants. Consumers were more likely to clean their hands with napkins after handling exposed ready-to-eat (RTE) food. Food handlers were observed to change into new gloves without washing their hands before handling exposed RTE food. The mean results for all hand-contact surfaces in restrooms were higher than 30 Relative Light Units (RLUs) indicating unhygienic surfaces. Male restroom exit doors' adenosine triphosphate (ATP) levels were significantly higher than females.

Originality: This study revealed the lack of hand hygiene practices among food handlers and consumers at fast food restaurants and cafes. Restroom hand-contact surfaces revealed high ATP level indicating unhygienic surfaces. This can potentially re-contaminate washed hands upon touching unhygienic surface (e.g. exit door panel/handle) when leaving the restroom.

Keywords: behaviour; food handlers; food safety; handwashing; sanitation

Introduction

The World Health Organization (WHO) estimated that 31 foodborne hazards resulted in 600 million foodborne illnesses and more than 400,000 deaths in 2010 (WHO, 2015). In the UK, it is estimated that about a million people are affected by foodborne illnesses annually, leading to 20,000 hospitalisation and 500 deaths. It costs the UK about £1.5 billion and places a significant burden on the productivity and socio-economic development of the country (FSA, 2011).

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3 39 Eating out is becoming more prevalent as consumers spent more than £1.47 trillion worldwide while
4 40 UK consumers spent a total of £77 billion eating out in restaurants and cafes in 2015 (Edwards, 2013;
5 41 Statista, 2017). However, restaurants have been linked to foodborne illnesses such as the multistate
6 42 outbreaks of Shiga toxin producing *Escherichia coli* O26 in Chipotle Mexican Grill (CDC, 2016),
7 43 community outbreak of *Salmonella enterica* serotype Typhimurium in two local restaurants (Holman,
8 44 et al., 2014) and norovirus outbreaks among diners at restaurants (Smith et al., 2012; Westrell et al.,
9 45 2010).

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14 47 Although no single food item or ingredient ~~were-was~~ implicated in the *E. coli* O26 outbreak, it is likely
15 48 that a common meal item or ingredient served at the restaurants in different states ~~were-was~~ the
16 49 likely source of outbreaks (CDC, 2016). Meanwhile the *Salmonella* outbreak was traced to an
17 50 asymptomatic chef who worked at both restaurants (Holman et al., 2014). The norovirus outbreak
18 51 ~~were-was~~ potentially caused by consumption of raw oysters, transmission from infected food
19 52 handlers or due to the restaurant environment (Smith et al., 2012; Westrell et al., 2010). Food
20 53 handlers represent the critical, final stage of food production, where meals are prepared and
21 54 delivered. This group is also a reservoir of pathogens, and may not always be aware if they are
22 55 transmitting pathogens (Todd et al., 2008). Food workers who do not adhere to safe and hygienic
23 56 practices can potentially transmit pathogens to food and food contact surfaces. However, in addition
24 57 to food workers, consumers may sometimes be the source of outbreaks (Todd et al., 2007). For
25 58 example, in a restaurant setting where food from a common shared platter was eaten with fingers, it
26 59 is likely that guests or staff introduced the norovirus into the shared dish causing three successive
27 60 gastroenteritis outbreaks (Marshall et al., 2001).

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35 62 Previous studies on food safety knowledge, attitude and practices among employees and consumers
36 63 (Samapundo et al., 2016; Tomaszewska et al., 2018; Zanin et al., 2017) were based on self-reported
37 64 practices. Zanin et al. (2017) identified 36 studies that addressed food safety knowledge, attitudes
38 65 and practices of food handlers but most ~~still~~ a lack of translation of knowledge/attitudes into
39 66 practices. Studies on observation of food safety practices had been carried out using cameras (Evans
40 67 and Redmond, 2018; Masson et al., 2017), direct observation (Her et al., 2017; Ovca et al., 2018)
41 68 and discrete observation (Trafialek et al., 2017). Hand hygiene is an effective method to reduce cross
42 69 contamination and transmission of foodborne pathogens (Ali et al., 2014). However, previous studies
43 70 have shown that adherence to hand hygiene by food handlers is poor (Clark et al., 2018; do Prado *et*
44 71 *al.*, 2015; Robertson et al., 2013) whilst hand hygiene studies among consumers are still lacking.
45 72 Similarly, a number of Adenosine Triphosphate (ATP) hygiene monitorings had been carried out in
46 73 hospitals (Alfa et al., 2015; Amodio and Dino, 2014), kitchen (Aycicek et al., 2006) and food
47 74 production facilities (Lau et al., 2016). But there is still a paucity of research on the hygienic status of
48 75 hand-contact surfaces in restrooms. There was one ~~published~~ study on ATP swabs of restroom sinks
49 76 and stall doors ~~was~~ conducted by Shaughnessy et al. (2013). Thus, it is the aim of this study to

77 observe hand hygiene practices of both consumers and employees and to determine the ATP level of
78 hand-touch surfaces of restroom facilities in fast food restaurants.

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80 **Methodology**

81 *Hand hygiene observational tool*

82 The indications for hand hygiene were based on WHO (2009) and FSA (2013). The following criteria
83 necessitates handwashing: when entering the food handling area (e.g. after a break or going to the
84 toilet), before preparing food, after touching raw food, after handling food waste or bin, after
85 cleaning, after blowing their nose, after touching phones, cash registers, door handles, light switches
86 and surfaces that could come into contact with staff handling raw food. Hand hygiene technique
87 includes handwashing with soap and water. The procedure takes between 40 – 60 seconds. Hygienic
88 hand rubs or gels should not be used in replacement for effective handwashing but could be used as
89 an additional precaution. Similarly, food handlers must wash their hands thoroughly before putting on
90 disposable gloves and after taking them off (FSA, n.d.).

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92 Hand hygiene criteria for consumers include before handling and consuming exposed Ready-to-eat
93 food, after handling food waste or touching the bin, after blowing their nose and touching electronic
94 devices, cash and unhygienic surfaces. Objects such as mobile phones, tablets or other personal
95 electronic devices (Lando et al., 2018; Walia et al., 2014), currencies (Alemu, 2014; Vriesekoop et al.,
96 2010) had been found to harbour a range of pathogens and potential pathogens. A number of food
97 contact surfaces such as cooking equipment, tray and utensils were contaminated with one or more
98 food allergens (Ortiz et al., 2018). Personal items such as wallets, pens and purse were found positive
99 for yeast and mould and *Staphylococcus aureus* (Donofrio et al., 2012). Handwashing, cleaning hands
100 with wipes or sanitisers and handwashing and changing into new gloves were categorised as hand
101 hygiene activities. An additional category of cleaning hands with napkins among consumers or
102 cleaning hands with towels among food handlers were also recorded (but not categorised as hand
103 hygiene activity). Observed behaviours that require hand hygiene activity were divided into food-
104 related behaviour (i.e. before and after handling exposed food), after handling unsanitary objects,
105 equipment and body parts. The observational tool used to monitor hand hygiene practices among
106 consumers and employees was adapted from Behnke et al. (2012), Clayton and Griffith (2004) and
107 Her et al. (2017). The observational tool was designed to record 30 sequential hand activities of
108 consumers and employees. Her et al. (2017)'s tool was built using a mobile-friendly web-based
109 survey platform to increase its ease of use, portability and reduces the Hawthorne effect of direct
110 observation of consumers and staff. The author adopted a similar approach and developed the
111 observational tool using Survey Monkey® survey platform with an android phone.

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113 *Pilot testing and modification of observational tool*

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3 114 The observational tool was pilot-tested in three fast food restaurants and one cafe at both peak (12 –
4 115 2pm) and non-peak hours (3 – 5pm) in Preston, UK. The 30 observations required a larger screen to
5 116 determine the category of hand hygiene behaviour and actions. The scrolling and initiation of a new
6 117 survey for new observation slowed the process down and the author adapted the instrument into an
7 118 MS Excel sheet in a tablet. This allows a bigger screen to note down the actions, objects and hand
8 119 hygiene practices that follow. The adaptation of the tool in MS Excel also excludes the need for
9 120 Internet access and allows the usage of the tool in restaurants or cafes with limited wifi. There are
10 121 two versions of the tool – one for the employee and one for consumers. After pilot testing the
11 122 observational tool, observed actions such as 'finger licking', 'scratching' and use of unsanitary object
12 123 such as 'cigarette' were added.
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18 125 *Sampling of food service outlets*

19 126 Fast food outlets and cafes located in cities of North West England (Chester, Cumbria, Greater
20 127 Manchester, Lancashire and Merseyside) were visited between May – August 2017. The author
21 128 requested ~~for~~ consent from the restaurant managers to carry out the study. The food handlers and
22 129 consumers were not aware of the study to prevent the Hawthorne effect. The participants were only
23 130 observed either during peak (12 – 2pm) and non-peak hours (3 – 5 pm). Fast food operations were
24 131 defined as outlets that offer standardised and simple menus within a controlled operating system
25 132 (Jones et al., 2002). All fast food restaurants and cafes in this study consisted of facilities for
26 133 customers to consume food on the premises. The fast food restaurants and cafes include those that
27 134 sell burgers, pizza, sandwiches and finger food. Convenience sampling was used due to resource
28 135 limitations and better access to fast food restaurants and cafes located in city centre or towns. A total
29 136 of 25 restaurants were visited and 29 restrooms were swabbed.
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36 137 37 138 *Hand hygiene observation*

38 139 During the start of each observation, the date, location and demographics such as gender,
39 140 consumers' group size (e.g. 1, 2, 3 or more than 3) and employee working position (e.g. front
40 141 service, cashier, food preparation/cooking) was recorded. Both consumers and employees were
41 142 observed until 30 sequential behavioural transactions were recorded. Observation of consumers who
42 143 left the restaurant or employees who left their workplace resulting in a lag in observation or less than
43 144 30 sequential transactions were discontinued. Each transaction consisted of an observed action (e.g.
44 145 touch with bare hands), object (e.g. exposed ready-to-eat foods) and observed hand hygiene practice
45 146 (e.g. handwashing). The type of objects are divided into food (e.g. exposed or wrapped foods),
46 147 unsanitary object (e.g. electronic device), equipment (e.g. table) and human (e.g. body parts).
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52 149 *Adenosine triphosphate hygiene monitoring of hand-contact surfaces in restaurants' restrooms*

53 150 A 10 x 10 cm² area or contact area of various restroom spaces and touch surfaces were swabbed
54 151 using Ultrasnap ATP and Hygiene Ensure Version 2 ATP hygiene monitoring system (Hygiene LLC, Ca,
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USA). Number of cubicles in each restroom (such as multi-use where there are 2 or more toilet cubicles) or single use (i.e. for male, female and disabled usage) were recorded. Between 5 – 7 surfaces were swabbed including toilet flush, cubicle lock and/or handle, sink faucet control, soap dispenser, hand drying controls and exit door in each restaurant's restroom. Swabbed samples were activated and recorded using the ATP luminometer. Results were expressed numerically as relative light units (RLUs). Score-A score of 10.00 RLUs or less is considered "satisfactory-/pass"; scores from 11.00 – 30.00 are considered "requires improvement-/caution"; and a score of greater than 30.00 RLU is considered as a "fail" (Hygiene, 2018; Lau et al., 2016).

161 *Statistical analysis*

162 Descriptive statistics, chi-square test and univariate Analysis of Variance were carried out using IBM
163 SPSS Statistics Version 24 and significance was set at $p < 0.05$. Shapiro-Wilk test values of > 0.05
164 were used to determine tests of normality whilst homogeneity of variance were checked using
165 scatterplots.

167 **Results**

168 *Demographics*

169 Twenty-five fast food restaurants were visited. A total of 151 consumers and 47 employees were
170 observed (Table 1). There were more females and Caucasians observed for both food handlers and
171 consumers. More cashiers and servers were observed in the study as they represent the front service
172 staff and their hand hygiene activities can be easily viewed and recorded. More than 80% of the
173 observed consumers tend to dine in a party size of two or more people.

175 Insert Table 1 here

177 *Hand hygiene practices among consumers and employees*

178 A total of 4530 hand activities were observed among 151 consumers. Out of the 4,530 transactions,
179 33,010 required hand hygiene activity. However, consumers only practised hand hygiene activity (i.e.
180 cleaning hands with wipes or sanitisers) in 0.33% of the transactions. The highest hand hygiene
181 requirement was before handling exposed RTE (42.32%) but consumers only cleaned their hands less
182 than 1% of the time. The highest cleaning frequency was after handling exposed ready-to-eat food
183 (RTE) (Table 2). There's a higher number of hand hygiene activity post-handling exposed RTE food
184 There was no or very little hand hygiene activity after handling electronic devices, personal
185 belongings or even after handling cigarettes. About 30% of the hand activities involved touching
186 faces, hair, other body parts, finger licking and sneezing or coughing but only one consumer was
187 observed to carry out hand sanitisation. There was a higher rate of cleaning hands with napkins
188 (although this is not categorised as hand hygiene). Most consumers were observed to wipe their
189 hands with napkins post-handling exposed RTE food (5.80%) as most RTE food from fast food

190 restaurants are in the form of finger foods such as burgers, fries, sandwiches, bakery products and
191 chicken pieces.

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193 One thousand four hundred and 10 hand activities were observed among 47 food handlers of which
194 1157 required hand hygiene practices. The highest frequency of hand hygiene activity (21.28%) were
195 observed before handling exposed RTE food while no hand hygiene was carried out before putting on
196 new gloves, after handling exposed RTE, unsanitary objects or body parts (Table 3). However, food
197 handlers who changed into new gloves (21.28%) did not wash their hands before putting them on.
198 Out of the 274 equipment related behaviour requiring hand hygiene activity, only one staff was
199 observed to clean her hands with napkins after handling the cooking equipment.

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205 There was no significant association between food handlers and consumers' hand hygiene activity χ^2
206 = 3.18(1), $p > 0.05$. There were no statistically significant associations between employees' working
207 position or gender and hand hygiene activities. Among consumers, females (10.30%) were more
208 likely to clean their hands with wipes ~~or~~ sanitisers compared to males (0%) $\chi^2 = 5.96(1)$, $p < 0.05$.
209 Consumers with a party size of three or more people (13%) were more likely to carry out hand
210 hygiene activity $\chi^2 = 6.36(2)$, $p < 0.05$. Females were also observed to use their phones (64.80%),
211 touched their faces (67.14%) and hair (82.56%) more often compared to males. (Table 4).

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213 Insert Table 4 here

214 215 **ATP swabs of restrooms**

216 A total of 16 female, 6 male and 7 unisex restrooms were swabbed. Fifteen were single-use type
217 whilst the rest were categorised as multi-use (e.g. with 2 toilet cubicles or more). There was a wide
218 variation in ATP results but the mean results for all surfaces were higher than 30 RLUs. This indicates
219 that the surface areas were unhygienic and require re-cleaning (Hygiene, 2018). Fast Food
220 Restaurant (FFR) 1 recorded the highest level of ATP across all surfaces (Figure 1). Out of the 29
221 restrooms, two facilities did not have soap and one hand dryer was not working. Among the facilities,
222 there were 27 facilities with sensor-operated hand dryers, four sensor-operated faucets and two
223 sensor-operated flush. Toilet flushes, sink faucets, soap dispensers and restroom exit doors were
224 significantly higher in FFR1 compared to other FFRs (Table 5). Male restrooms recorded highest
225 values across all surfaces except door locks. Male restroom exit doors' swabs were significantly higher
226 than females ($p < 0.05$).

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228 Insert Figure 1 here

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232 **Discussion**

233 The findings in this study revealed no significant difference between food handlers and consumers in
234 hand hygiene activities. Both groups have low hand hygiene compliance rate in fast food restaurants.
235 Although food handlers involved in food preparation/cooking were more likely to clean their hands,
236 this did not differ significantly from those who serves/work as cashiers. Fast food employees are
237 expected to serve a large number of people with minimum waiting time. In order to be effective, fast
238 food restaurants need to provide quality, consistent and timely meals and services. Jones et al.
239 (2002) reported that fast food retailing in the UK aims to serve customers within three minutes of
240 their entry into the restaurants. Fast food franchises rely on satisfied customers to continue their
241 patronage at the premises (Gilbert et al., 2004; Namin, 2017). Based on the constant demand and
242 time pressure, there is less opportunity for food handlers to carry out hand hygiene activities. This is
243 in agreement with Thaivalappil et al., (2018) who found that handwashing was often not carried out
244 during busy periods.

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246 Lack of space and resources such as soap and poor accessibility to handwashing facilities also
247 contribute to reduced adherence to food safety practices (Clayton et al., 2015). Strategic placement
248 of hand hygiene foam dispensers were found to significantly increased the use of the dispenser
249 (Thomas et al., 2009). Social norms too can influence food handlers' adherence to hand hygiene
250 activities. Support and guidance from managers or supervisors and co-workers will create a positive
251 food safety culture and better conformance to hand hygiene activity (Pragle et al., 2007). Perceptions
252 of optimistic bias among food handlers where they perceived themselves as less likely than their
253 peers to transmit foodborne diseases too can cause food handlers to overlook the food safety
254 procedures. Optimistic bias among food handlers can lead to food safety breaches as an optimistic
255 food handler may overlook hand hygiene practices and contaminate food products (da Cunha et al.,
256 2014; Rossi et al., 2017). Timely and correct handwashing is important to prevent spread of
257 pathogens. Handwashing is required before preparing food, after handling raw food, when entering
258 the food preparation area, after going to the toilet or break, after touching bins and items such as
259 door handles, light switches, cash registers, after blowing their nose or changing a dressing.
260 Employees should be reminded that disposable gloves are not to be used as an alternative hand
261 hygiene activity (FSA, 2013).

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263 Consumers were more likely to clean their hands with napkins. Although the customers in this study
264 were observed for an average of 8 minutes per 30 sequential transactions, Paddock et al. (2017)
265 revealed that customers spend an average of 1 hour or less in the restaurant. This provides

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3 266 customers with time to carry out hand hygiene activity. A high number of transactions also involved
4 267 customers touching their mobile phones and skin (especially facial area) and this could have triggered
5 268 customers to wipe their hands before using their phones or touching their faces. Consumers who tend
6 269 to lick their fingers did not clean their hands after licking. In fact, "finger-lickin' good" is a famous
7 270 catchphrase of a well-known fast food brand and signifies that customers will not be able to resist
8 271 polishing the food off their fingers (Visser, 2017). However, finger licking is not an acceptable dining
9 272 etiquette in some culture (Visser, 2017) nor an appropriate food safety practice especially when
10 273 preparing food (Eves et al., 2006). Finger licking behaviour were also observed in popular television
11 274 cooking shows where 47 finger licking behaviour were observed in the shows (Irlbeck et al., 2009).
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18 276 Females were observed to clean their hands more frequently. Females also tend to touch their
19 277 phones, face and hair more often compared to males. Her et al. (2017) observed similar behaviour
20 278 among females in their study. Females were more likely to experience social physique anxiety
21 279 (Kowalski et al., 2006) and tend to address the anxiety via appearance management and repetitive
22 280 body checking behaviour (Haase et al., 2007; Reilly and Rudd, 2009; White and Warren, 2014). In
23 281 this study, there was also one observation of a consumer who picked a dead fly from the table but
24 282 did not clean her hands prior to eating. Flies may transmit pathogens to food or hands. Previous
25 283 studies reported that houseflies can transmit *Escherichia coli* (Lindeberg et al., 2018; Talley et al.,
26 284 2009) and Salmonella enterica (Pace et al., 2017) to food. A party size of three and above
27 285 encourages hand hygiene activities and this could be due to subjective norm effects where individuals
28 286 are influenced or pressured to comply with expectations from other individuals (Ajzen, 1985).
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35 288 RLU scores greater than 30.00 indicated a fail, demonstrating that the surface areas highlighted as
36 289 human touch points should be re-cleaned. The ATP on the surfaces may have derived from food
37 290 residues, dead microorganisms or hand ATP (Worsfold and Griffith, 2001). Additionally, aerosol
38 291 contamination of surfaces generated from the action of flushing can contribute to the high surface
39 292 ATP reading. Barker and Jones (2005) simulated the effects of flushing a toilet and recorded the
40 293 spread of aerosol contamination of surfaces. They found bacterial contamination of between 20 – 50
41 294 CFU per plate on the toilet seat, shelf, cistern and front of toilet within 30 minutes of flushing. The
42 295 surface ATP in FF1 increased progressively from toilet stall doors to soap dispensers although the ATP
43 296 reading declined 23% on the restroom exit door. The high number of surface ATP in this study is a
44 297 cause for concern as the effectiveness of handwashing practices may diminish post-handwashing
45 298 when touching the sink faucet and restroom door handle / panel to exit. Posting reminders or
46 299 reinforcement such as effective handwashing steps, posters or consequences (e.g. fines, health
47 300 violations) can influence food safety practices (Thaivalappil et al. 2018). Clark et al. (2018) developed
48 301 the handwashing intervention ladder and suggested a number of methods to address the lack of hand
49 302 hygiene compliance. This can potentially be applied in fast food restaurant settings to encourage
50 303 food handlers and customers to wash their hands effectively.
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305 Limitations

306 Due to resource limitations, the researcher could only visit a small number of fast food restaurants
307 and cafés and the outlets were only visited once. The outlets were also limited to those located in city
308 or town centres. The current study was only conducted in North West England and the findings
309 should not be generalised to other locations. It is recommended that future studies should include
310 information on how frequently the restrooms were cleaned. ATP swabs could be conducted to
311 determine the level of hygiene before and after cleaning and during peak and non-peak use.

312

313 Conclusion

314 The findings from this study revealed poor hand hygiene activities among food handlers and
315 consumers at fast food restaurants. Food handlers were observed to change into new gloves before
316 handling exposed RTE but did not clean their hands after handling food, unsanitary objects or
317 touching their face or other body parts. Only female consumers were observed to clean their hands
318 with wipes or sanitisers. Consumers were observed to clean their hands with napkins more often after
319 handling exposed RTE compared to other surfaces. This study also revealed that the hand-contact
320 surfaces in restrooms are unhygienic and can potentially re-contaminate washed hands upon touching
321 unhygienic surfaces such as the exit door panel or handle. Reinforcement such as posters or
322 reminders of risk of transmission of foodborne pathogens can help to increase hand hygiene
323 compliance. Effective handwashing and hand hygiene activities are the best methods to prevent
324 transmission of foodborne disease.

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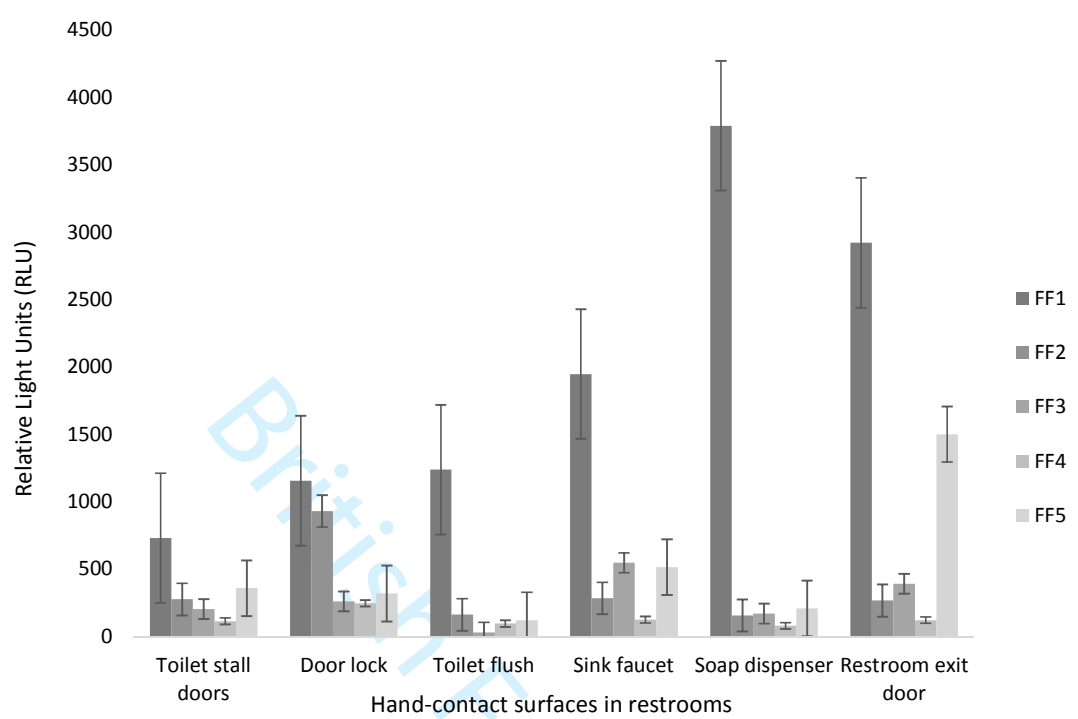


Figure 1. ATP levels (RLUs) of hand-contact surfaces in fast food restaurants' restrooms
 Notes: FFR1 – FFR4 represent individual leading fast food brands i.e. FFR1: Fast food restaurant that predominantly sells burgers and finger food; FF2 and FF3: burgers and fries; FF4: sandwiches and salad; FFR5 = others [made up of five fast food brands that sell pizza, burgers and sandwiches]; vertical bars = standard error;
 n=29

Table 1. Demographic characteristics of observed participants

Food handlers (n=47)	Number (%)	Consumers (n=151)	Number (%)
<i>Gender</i>		<i>Gender</i>	
Male	16 (34.04)	Male	54 (35.76)
Female	31 (65.96)	Female	97 (64.24)
<i>Employee working position</i>		<i>Party size</i>	
Food preparation or cooking	17 (36.17)	One	30 (19.87)
Cashier or serving	30 (63.83)	Two	67 (44.37)
		Three and above	54 (35.77)

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Table 2. Number of observed hand hygiene activity among consumers (n = 151)

Behaviours requiring hand hygiene practice	Number of observations requiring hand hygiene		Observed hand hygiene practice		Observed other forms of hand cleaning activity	
	Number	%	Number	%	Number	%
Food						
Before handling exposed ready-to-eat (RTE) food	1274	42.32	3	0.23	30	2.35
Exposed RTE food			4	0.31	74	5.80
Total	1274	42.32	7	0.55	104	8.16
Unsanitary object						
Electronic device (mobile phone, laptop, tablet)	267	8.87	0	0	1	0.37
Paper (receipt, order receipt)	43	1.43	0	0	0	0
Cash, credit card	7	0.23	0	0	0	0
Condiments	154	5.12			2	1.30
Personal belongings (wallet, purse, glasses, cap)	159	5.28	2	1.26	0	0
Pencil / pen	4	0.13	0	0	0	0
Cigarette	6	0.20	0	0	0	0
Others (e.g. tray, menu, bin door, newspaper, walking aid)	90	2.99	0	0	0	0
Total	730	24.25	2	0.27	3	0.41
Equipment						
Surface / table	111	3.69	0	0	1	0.90
Door	5	0.17	0	0	0	0
Other (e.g. vending machine)	1	0.03	0	0	0	0
Total	117	3.89	0	0	1	0.85
Human						
Body parts (e.g. face, nose, ears)	421	13.99	0	0	3	0.71
Other body parts	69	2.29	0	0	2	2.90
Hair	86	2.86	0	0	0	0
Cough, sneeze, spit	11	0.37	0	0	0	0
Finger licking	160	5.32	0	0	1	0.63
Other (e.g. skin contact other family members or friends)	142	4.72	1	0.70	0	0
Total	889	29.53	1	0.11	6	0.67
Total number of requirements and hand hygiene activities	3010		10	0.33	114	3.79

Total number of transactions – 4530; Hand hygiene activities among consumers include cleaning hands with wipes / sanitiser. Other observed form of hand cleaning activity was wiping with napkins (this is not categorised as hand hygiene)

Table 3. Number of observed hand hygiene activity among employees (n=47)

Behaviours requiring hand hygiene practice	Number of observations requiring hand hygiene		Observed hand hygiene practice and other* forms of hand cleaning activity	
	Number	%	Number	%
Food				
Before handling exposed food	47	4.06	10	21.28
After handling exposed food			0	0
Before putting on new gloves	11	0.95	0	0
Other	7	0.61	0	0
Total	65	5.62	10	15.38
Unsanitary object				
Electronic device (mobile phone, laptop, tablet, ordering machine, cash machine)	185	15.99	0	0
Paper (receipt, order receipt)	53	4.58	0	0
Cash, credit card	93	8.03	0	0
Clothes, aprons, cap	83	7.17	0	0
Condiments	6	0.52	0	0
Bottled/cup beverage	94	8.12	0	0
Pencil / pen	5	0.43	0	0
Cleaning items (broom/dishcloth)	61	5.27	0	0
Other (e.g. tray, menu, dirty utensils, food wastes, bin door)	148	12.79	0	0
Total	728	62.92	0	0
Equipment				
Cooking equipment (grilling, deep fryer, pots)	149	12.88	1*	0.67
Fridge / storage handle	16	1.38	0	0
Surface / table	96	8.30	0	0
Other (e.g. drawer, dishwasher, ordering machine)	13	1.12	0	0
Total	274	23.68	1*	0.36
Human				
Body parts (face, nose)	47	4.06	0	0
Hair	10	0.86	0	0
Other body parts	32	2.77	0	0
Other (e.g. scratching)	1	0.09	0	0
Total	90	7.78	0	0
Total number of requirements and hand hygiene activities	1157	100	11	0.95

Total number of transactions – 1410; Hand hygiene activities among employees include handwashing, changing into new gloves; cleaning hands with wipes / sanitiser. *Involved cleaning hands with napkins (this is not categorised as hand hygiene activity)

Table 4. Cross-tabulations of hand hygiene practices

Observed participants	Hand hygiene observation (%)		χ^2	<i>p</i>
	Yes	No		
Food handlers (n=47)	21.30	78.80	3.18	0.12
Consumers (n=151)	10.30	89.70		
Food handlers			1.44	0.20
Male	31.30	68.80		
Female	16.10	83.90		
Food preparation / cooking	35.30	64.70	3.12	0.14
Cashier / serving	13.30	86.70		
Consumers			5.96	0.014
Male	0	100		
Female	10.30	89.70		
Party size			6.36	0.036
One	6.70	93.30		
Two	1.50	98.50		
Three and above	13.00	87.00		

Table 5. Univariate analysis of variance on the effect of fast food restaurants and type of restrooms on ATP level

Dependent variable	Fast Food Restaurants (*FFRs 1 – 5)			Restrooms (gender)		
	F	<i>p</i> value	η^2	F	<i>p</i> value	η^2
Toilet stall doors	1.315	0.329	0.345	0.086	0.918	0.014
Door lock	1.363	0.276	0.185	0.374	0.692	0.028
Toilet flush	31.358	<0.0001	0.845	1.254	0.303	0.091
Sink faucet	6.698	0.001	0.538	0.435	0.652	0.034
Soap dispenser	195.292	<0.0001	0.970	0.478	0.625	0.035
Restroom exit door	17.838	<0.0001	0.836	2.703	0.097	0.253

Note: *FFR1 – FFR4 represent individual leading fast food brands i.e. FFR1: Fast food restaurant that predominantly sells burgers and finger food; FF2 and FF3: burgers and fries; FF4: sandwiches and salad; FFR5 = others (made up of five fast food brands that sell pizza, burgers and sandwiches). η^2 = effect size where 0.04 = recommended minimum effect size (RMPE); 0.25 = moderate effect; 0.64 = strong effect (Ferguson, 2009)