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Assessing food handler hand hygiene and food safety compliance in a high-risk food manufacturing department

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Abstract

Within the United Kingdom there are regulations and guidance to ensure the hygienic preparation of food products and to keep consumers safe. Despite this, incidents of foodborne illness are still an issue, with over two million people estimated to suffer the effects annually. Many factors can result in the contamination of food; however, it is often food handlers who are implicated in these incidents. Ready to eat foods such as sandwiches are prone to contamination and due to the lack of further processing are classed as high risk. Food handler personal hygiene compliance in ready to eat production departments is therefore paramount. The body of research assessing the hygiene practices of food handlers within this type of department is limited. Covert observation through closed-circuit television (CCTV) provides the most accurate data on the practices of food handlers. This study used CCTV to covertly observe the food handlers within a ready to eat sandwich production facility. A structured observational codebook and notational analysis was used to determine compliance with company hygiene procedure and the actions that had the potential to contaminate the food. Seven food handlers were observed completing a total of 220 actions during observations. A handwash was attempted on 0% of the total occasions that a handwash was required by food handlers. Food handlers were observed changing gloves on 23% of occasions requiring a glove change; however, none of these changes were compliant with company policy. The food handlers were seen on 29 occasions performing actions which had the potential to contaminate food. These findings conclude that the hygiene practices of food handlers within production facilities are poor and worse than those in the catering industry. This study identifies workload as the main barrier to the implementation of hygiene practices in this setting and provides recommendations for the improvement of food handler hygiene practices.

Introduction and literature review

The consumption of convenience foods and pre-prepared sandwich meals is becoming more common in the United Kingdom (Food Standards Agency, 2019). These ready to eat foods are considered high-risk as once they are prepared, they undergo no further processing - specifically heat treatment by cooking - that would kill any residual microorganisms (Sprenger, 2022). Therefore, high risk foods such as sandwiches also rely on control measures to prevent microbiological growth between production and consumption. Should these control measures fail, after the food becomes contaminated, the likelihood of a food poisoning outbreak increases (Wallace, Sperber and Mortimore, 2018, p. 124).

Given their convenience, high-risk, pre-made items such as sandwiches, baguettes and paninis are often produced by food factories that supply not only small food outlets and cafes but also larger organisations with high-risk consumers, such as hospitals and care homes. It is an offence under Article 14 of 'Council Regulation 2002/178/EC on the general principles of food law' to place unsafe food on the market, and so due to the high-risk nature of ready to eat food, a high level of hygiene compliance is needed during manufacture to prevent any contamination and to keep the food safe. However, research shows that it is often food handlers that are implicated in a large percentage of outbreaks of foodborne disease (Todd *et al.,* 2007); therefore, the importance of food handlers' personal hygiene cannot be overstated. A food handler's ability to prevent contamination underpins the success of all hygiene practices, and this relies on food handlers understanding the risks and having the knowledge to prevent them. Providing food handlers with knowledge is done through training, adequate instruction and supervision which, in the United Kingdom, is a requirement under Annex II Chapter XII of 'Council Regulation 2004/852/EC on the hygiene of foodstuffs' (2004). Although specific training providers or processes are not mandated, instruction should include awareness as to when handwashing during food production should be conducted (i.e. at key moments) (Seaman and Eves, 2010). Food handlers in the UK will often be trained via schemes to Level 2 and those in management positions with more responsibility trained to Level 3, to understand the management of staff and the principles of Hazard Analysis and Critical Control Point (HACCP) (Food Standards Agency, 2024).

Article 5 of this legislation requires a food business to undertake a HACCP plan and to identify and manage food safety hazards and risks. For a HACCP plan to be successful, the business must also ensure that prerequisites are in place as a minimum standard to produce safe food (Wallace, Sperber and Mortimore, 2018, p. 11). Many smaller businesses in the United Kingdom follow the Food Standards Agency's management system 'Safer Food Better Business' (Food Standards Agency, 2020b). However, larger businesses will often use their own tailored management system and standard operating procedures (SOP) or a system with the option of certification by audits such as the British Retail Consortium Global Standard (BRCGS) for Food Safety (British Standards Institute, 2024). A management system will detail the specific hygiene practices within policies for all staff members to follow. These policies vary between businesses, with many including aspects such as temperature control (hot and cold), cleaning protocols and emergency procedures. However, handwashing - regardless of food business type - must be performed regularly to an adequate standard and after performing certain tasks during food preparation (Food and Drug Administration, 1997; Holah and Taylor, 2003, p. 299). Examples of when to wash hands are, but not limited to: before handling any food, after touching raw food, after using the toilet and after touching potentially contaminated items (Food Standards Agency, 2020a). Ideal handwashing technique involves the food handler wetting their hand, then applying soap and rubbing palms together to create a lather. The back of the hand should be rubbed by the opposing palm and then vice versa. The fingers should then be interlocked, and thumbs rubbed by the opposing palm. All soap should then be rinsed off and hands dried with a disposable paper towel (Food Standards Agency, 2020a). For a handwash to be successful the duration should be at least 20 seconds (Centers for Disease Control and Prevention, 2024).

Annex II of this legislation makes it a requirement for food businesses to provide adequate facilities to ensure food handlers maintain their personal hygiene. This will include the provision of sinks and handwashing resources, gloves, disinfectant, sanitiser and hygienic maintenance of the surrounding environment. It is recommended that hand sinks in a food factory are knee push operated, reducing the hand contact and reducing the potential for contamination (Holah, Lelieveld and Moerman, 2023, p. 230).

Consequently, the aims of a HACCP plan will not be achieved successfully without detailed and well written SOPs. These SOPs must also be communicated and understood by all food handlers (Mekonen and Melaku, 2014). The management system will also detail the company's personal protective equipment (PPE) policy. This PPE should be changed regularly. Within this PPE policy will be details of whether gloves should be used. There is no requirement in law for gloves to be used as regularly washed clean hands are just as safe and glove use should not be a substitute for handwashing (BRCGS, 2018). Handwashing and hand hygiene practices should remain constant across a food business and are therefore a good measure of the general hygiene practices of food handlers (World Health Organisation, 2009). Ideally, if food handlers apply their training and knowledge, understand their management systems and SOPs, the majority of foodborne illness would be preventable (Todd, 2020). However, in the UK alone there were an estimated 2.4 million cases of food related illness in 2018 (Food Standards agency, 2020b). Seaman and Eves (2010) concluded that whilst training does improve food handler knowledge and attitudes, the positive effects are only short lived. Training is also not a regular occurrence in the real world and is often not detailed enough (Wallace, Sperber and Mortimore, 2018, p. 71). As well as knowledge and training, there are other factors that influence a food handler's ability to maintain hygiene. The main factors identified by previous research include: workload barriers (i.e. not enough time to wash hands), provision of adequate facilities and handwashing stations, glove use and understanding of procedures (Green *et al.,* 2007; Arendt, Strohbehn and Jun, 2015). The impact of these factors has yet to be investigated within a food production department.

Typically, the main methods of research used to evaluate food handler knowledge and practices are questionnaires, face to face or telephone interviews and observations of food handlers whilst they undertake food preparation in person (Bulochova *et al.,* 2024). Studies assessing food handlers' hand hygiene practices also often focus on restaurants, delicatessens and small catering establishments, with few focusing on the hygiene of food handlers in large, factory processing and manufacturing sites (Wallis and Evans, 2020). Although good hygiene at these establishments is vital, an outbreak of foodborne illness from a caterer would be far smaller than one resulting from a food factory producing ready to eat sandwiches

supplying hundreds of businesses (Lee and Seo, 2020). Self-reporting is often used as a measure to investigate food handlers' hygiene and although Lee *et al.'s* (2017) study showed that whilst food handlers' perception of their own hygiene practices was very good, self-reported knowledge of cross-contamination and sanitation of equipment was poor. This study also used microbiological assessment to determine the levels of bacteria on food handlers' hands; it found that despite food handlers having good self-reported knowledge of personal hygiene they had dangerous levels of microorganisms on their hands (Lee *et al.,* 2017). There is also evidence to suggest that even if food handlers have good knowledge of hygiene practices and food safety, this in not always translated into practice (Zanin *et al.,* 2017). The results of these studies indicate that food handlers have a tendency to over report good practice and that, despite having good knowledge of food safety, this was not reflected in their actions. This discrepancy between self-reported and actual hygiene practices was also concluded by Da Cunha *et al.* (2019), which compared self-reported and observed hygiene practices among food handlers. This evidence suggests that whilst self-reported assessments of food handler practices have uses, to gather valid data on food handler practices and food handler hygiene culture, observational techniques provide a more accurate picture (Clayton and Griffith, 2004; Zanin, Stedefeldt and Luning, 2021).

There are two types of observational techniques utilised in research; overt studies, where the researcher's presence is made clear to the participants of the study and covert, where the participants are unaware of the researcher presence (Strudwick, 2019). Studies using overt observations often find mixed results with some studies finding the total number of handwashes conducted to be low, of a poor washing standard and usually non-compliant with company policy (Green *et al.*, 2006; Her *et al.*, 2017). Another study found that some of the observed participants displayed hygiene practices that were highly compliant with hygiene policies, however, others within the same establishment displayed poor hygiene behaviour (Ovca, Jevsnik and Raspor, 2018).

Glove use by food handlers has also been assessed within catering but not within a food production department. Rajagopal and Strohbehn's (2013) study used a combined approach of questionnaires to assess glove use knowledge and observations to determine actual glove use. This study found that although food

handlers were deemed to have compliant knowledge of glove use, the food handlers failed to comply in practice. Another study showed that workers in departments where gloves are worn are less likely to perform handwashing, indicating that food handlers view gloves as a replacement to handwashing (Green *et al.,* 2006). Gloves, when regularly changed by food handlers during the preparation of ready to eat foods, did not present a greater microbiological risk than bare hands. However, when unchanged they have the potential to harbour pathogens and handwashing should still be performed (Selvaraj *et al.*, 2023).

This variation in results may be due to the Hawthorne effect where the research participants' behaviour was impacted by the awareness of being studied (Mohamed and Evans, 2024). This change in behaviour by the participants, whether accidental or intentional, is impossible to completely remove despite control measures (McCambridge, Witton and Elbourne, 2014). These studies also described observation in real time as challenging, as a sequence of events may occur quickly, preventing the observer gathering data in adequate detail. The observer may also miss key events when using a standard observational checklist. Developing a coding structure on the other hand, can aid data collection and when used in conjunction with notational analysis (e.g. providing more specific behavioural information) can be used to track event sequences providing context to food handlers' hand hygiene decisions (Clayton and Griffith, 2004).

Studies using notational analysis coding techniques found handwashing frequency to be poor, specifically after touching potentially contaminated equipment and when transferring between preparing different food types, but of these hand washes that were performed, most were deemed to be adequate (Clayton and Griffith, 2004; Green *et al.*, 2006; Lubran *et al.*, 2010). However, these studies were often conducted in catering style businesses and not a food factory setting. The only way to completely remove the Hawthorne effect is to use covert observation. Covert observation is often completed via closed-circuit television (CCTV) which is an unintrusive form of observation and therefore reduces reactivity bias. CCTV also has a number of benefits as footage can be reviewed and replayed allowing for the monitoring of multiple food handlers and production areas over the same period. The ability to replay footage allows for potentially missed actions to be rewatched and recorded or be viewed by multiple researchers if required (Chapman, MacLaurin and

Powell, 2013). There are nevertheless few covert observational studies using CCTV in food manufacturing, one of which assessed food handler hand hygiene compliance in changing rooms before entry into food production. The study found that 10% of staff entering failed to undertake any form of handwash with 90% of those who did, failing to do so adequately in accordance with company policy (Evans and Redmond, 2018). This study, whilst providing valuable data about hand hygiene compliance rates in this industry, did not provide any data about handwashing during production. A similar study by Evans, Samuel and Redmond (2022) showed similarly low compliance rates for handwashing and whilst expanding knowledge in this area, once again provided limited data of practices during food production. Mohamed and Evans (2024) sought to address this knowledge gap, observing food handlers in a high-risk sandwich factory production department. The study found that of the observed handwashes recorded, the number that were hand hygiene policy compliant were very low. In any event, the total number of handwashes that were completed, regardless of whether they were compliant or not, were much lower than that required for safe food production (Mohamed and Evans, 2024). This study only provided a snapshot in time for a specific business and so further research needs to be conducted to improve knowledge of food handler personal hygiene standards during food production. Findings can potentially be used to improve training procedures in future which will contribute positively to enhancing safe food practices. Hence, utilising CCTV footage and a notational analysis coding technique, this study will assess food handlers' hand hygiene and food safety compliance in a high-risk food manufacturing department.

Methods

To assess food handler compliance with personal hygiene company policy and expectations, the following method was utilised.

Food manufacturing business selected for this study

The food factory had numerous departments spread across three sites. These sites all produced different food types, had different levels of risk and therefore had

different hygiene requirements. Previous audits and inspections of the site had determined that the food hygiene was exemplary. The food production department preparing sandwich fillings and pre-packed sandwiches was potentially of the highest risk for consumers (manufacturing ready to eat foods undergoing no further treatment before consuming) and was therefore selected for study. However, due to the time constraints of the project, only the section preparing sandwiches was observed. Hereafter referred to as Site A, this department at peak times would process thousands of sandwich orders per day and once produced, were supplied nationwide to many commercial food businesses, caterers, cafes and hospitals.

Production area layout

The production department shown in Figure 1 had two handwashing sinks, with the first located on the wall next to the entry point (Sink A) and the second located on the opposite wall (Sink B). Both these sinks are knee push operated and provided hot water. Above these sinks were dispensers for soap, disposable paper hand towels and hand sanitiser. In other locations around the department were the dispensers containing food handler PPE including food safe blue gloves, sleeve covers and aprons to be used during the production shift. Also located next to the entry point were red fabric aprons which were to be donned on entry to the food production room and to be worn under the blue disposable aprons. Multiple waste bins were also located around the department which were frequently handled (or moved) by food handlers during a shift. Figure 1 provides the field of view captured by the closed-circuit television (CCTV) camera utilised for observations in green, indicating the location of the handwashing sinks, entry doorway and production tables or benches (for preparing sandwich orders).

Covert observation was selected as it removes reactivity bias caused by being observed in person directly, providing more reliable behavioural data reflecting day to day practices (Bruchez *et al.,* 2020). A total of 17 hours 10 minutes of CCTV footage was secured for this study and observation of the department began mid shift during peak production (after the production room set-up and configuration). This ensured that observations were focused on hygiene practices and behaviours performed during the busiest food production times. Any food handlers observed within the

CCTV field of views indicated at Figure 1, were identified (ID) with a unique number so that they could be tracked around the food production department. Food handlers were observed for 30 minutes continuously (Fix *et al.*, 2022) with actions performed in sequence being captured.

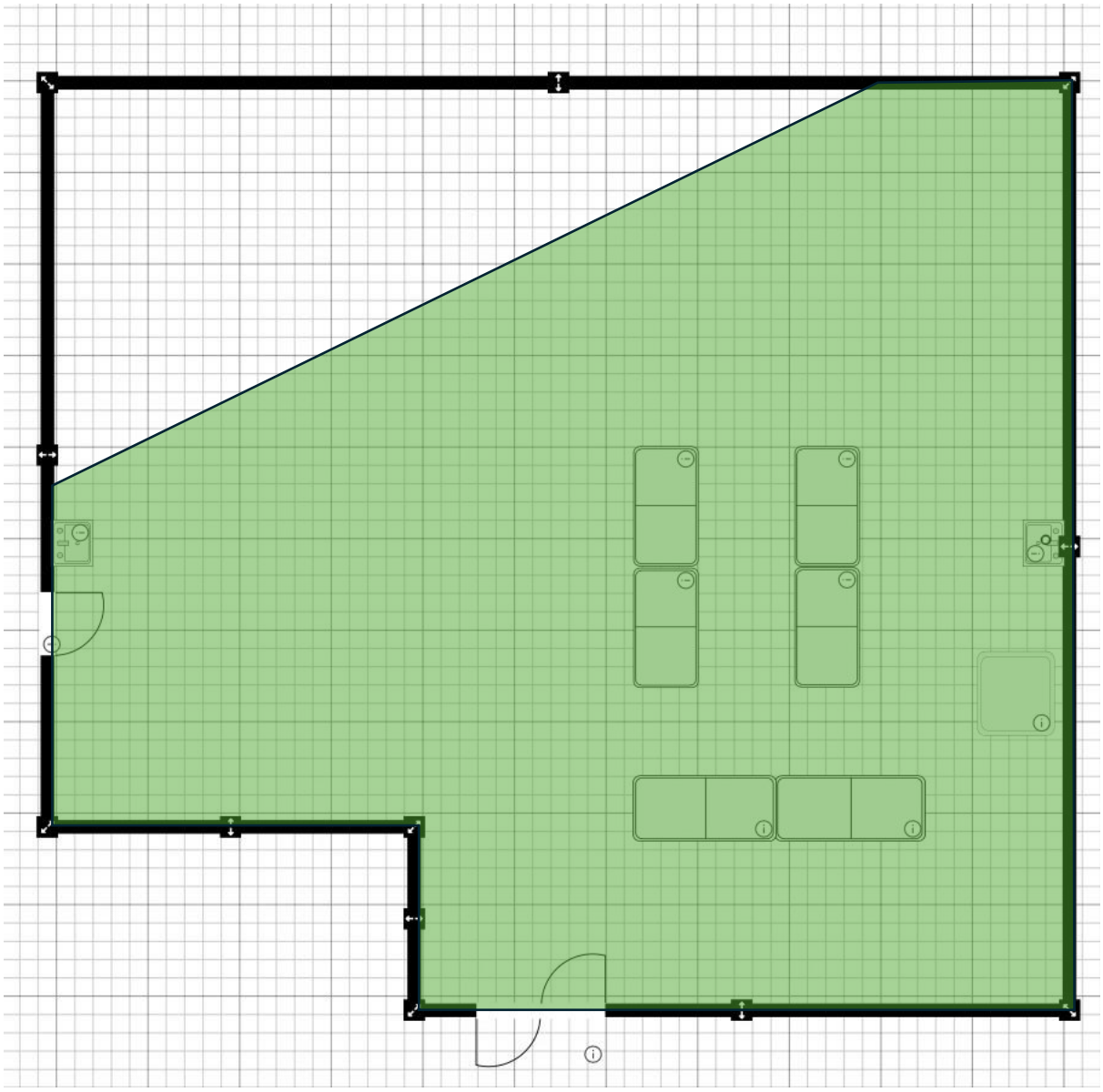
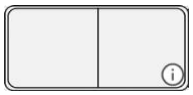


Figure 1: Layout of the production room

Key	
Handwashing sink	
Production table	

Food handler training and hygiene policy and procedure

According to the company documents food hygiene compliance is regarded as being of the upmost importance. Job descriptions for the food handlers had no requirement for previous experience or training as the food handler would undergo food safety and allergen training.

Training

Food safety training would be provided by the business in-house (by the food safety manager at corporate head office), with induction training specific to each food manufacturing site conducted locally by a member of the technical management team. Food handlers would be required to read through policy and procedure during induction and provide a signature to indicate training had been received. A demonstration of the hand hygiene procedure would be provided in the changing room location prior to entering food production, with senior food handlers responsible for supervising new employees (although this was not stipulated in job descriptions or monitored by production management). Food handlers would be trained to an equivalent Level 2 Food Hygiene which is a generic food safety training standard used widely across the food industry (i.e. not specific to food manufacturing).

Hand hygiene policy and procedure

All employees and food handlers within the business were expected to comply with various policy documents. The documents relevant to personal hygiene and food safety behaviours were the personal hygiene policy, the glove policy and the allergen handling policy. According to the personal hygiene policy, hands should be washed

before handling food, when transferring between food production orders, entering or returning to the production area, after handling waste and after using a tissue or nose wiping. In addition to this, the separate policy document regarding allergens detailed how a handwash and a change of all disposable PPE must be performed after handling allergens.

Correct handwashing should involve the following:

1. Wetting hands with hot water
2. Application of soap
3. Rubbing hands together to create a lather ensure all fingers, thumbs and fingernails have been rubbed
4. Rinse off all soap and then dry hands with a disposable towel

(Food Standards Agency, no date)

For a handwash to be compliant with company policy and ensure hands were clean enough to produce safe food, it should have been at least 20 seconds (World Health Organisation, 2006; National Health Service, 2023; Centers for Disease Control and Prevention, 2024).

The policy documents provided instructions on other personal hygiene requirements. These included the removal of all outdoor clothing and the removal of all items from clothing pockets prior to entry into the production area. The food handlers were allowed pens in the production area; however, these were issued by the company and could not be stored in the food handlers' pockets. The food handlers were expected to wear the aforementioned PPE over a white coat at all times during production and this PPE must cover all clothing and lose articles. Hair nets were compulsory for all staff, as was a beard snood for those with facial hair, and this PPE must be removed before leaving the production area. Food handlers were required to wear gloves during the production of all food products. These were to be changed between different products or 'sooner than this if required' as stipulated in company policy. When gloves were removed, hands should be washed and sanitiser applied in advance of applying a fresh pair of gloves.

Observational coding structure and data analysis

In order to aid observation to answer the research question, an observational coding structure was developed based off Samuel's (2024) code and the notational analysis method proposed by Clayton and Griffith (2004) was utilised. A form of semi-structured observation (Merriem, 2009, p. 89), notating behaviours as they occur provides additional detail surrounding the sequence of events leading up to an anticipated handwashing event (Clayton and Griffith, 2004; Samuel, 2024). This is necessary so that the key moments which prompted a handwashing event - or alternatively, a missed opportunity to handwash - are captured accurately to reflect hand hygiene standards during a busy production shift.

Therefore, to capture hand hygiene behaviour in the Site A food production department under observation, the following code book (Table 1) was developed based on the expectations as set out in company policy and procedure. Additionally, to identify any behavioural idiosyncrasies not necessarily mentioned in company documentation, but which could potentially compromise hand hygiene, an initial review of the CCTV footage was undertaken to understand the practical sequences of events that occur in situ and test the code book.

Table 1 Observational code with variable descriptions

Code Number	Original Code	Description of variable
1	Gloves applied	New set of gloves applied in isolation
2	Gloves removed	Used gloves removed in isolation
3	Gloves removed-gloves applied	Used gloves removed followed immediately by a new set being applied
4	Sleeve covers applied	New set of sleeve covers applied in isolation
5	Sleeve covers removed	Used set of sleeve covers removed in isolation

6	Apron applied	Apron applied in isolation
7	Apron removed	Apron removed in isolation
8	Sleeve covers and apron applied	Sleeve covers and apron applied one after another
9	Removed all PPE to waste	All PPE (gloves, sleeve covers and apron) removed and placed in PPE waste bin
10	Removed food from packaging	
11	Prepares food product	Handling of food products
12	Picks food up off floor	Picks food up off floor (contaminating hands)
13	Picks items up off floor	Picks items up off floor (contaminating hands and item)
14	Leaves production room	Leaves production room
15	Returns to production room	Returns to production room having just left
16	Handwashing	Handwashing as described earlier in the chapter
17	Wipes hands on PPE	Wipes hands on any item of PPE
18	Handles waste	Handles waste (touching waste bin or its contents)
19	Touches face, nose, mouth	Touches face, nose, mouth with their hand

20	Hand in pocket/pen	Hand in pocket to retrieve pen
21	Hand in pocket/used mobile	Hand in pocket to retrieve mobile
22	Cleans work bench	Cleans work bench with spray and paper towel
23	Cleans knife	Cleans knife
24	Cleans room after food handing (General)	Deep clean of the entire production department
25	Handles paperwork	Touching any paperwork or order sheet
26	Task change/NOTES	Changing between tasks within the department

Observation techniques and CCTV

As food handlers were observed, each action performed was recorded in the SPSS Statistics spreadsheet (Version 28.0, IBM Corp) following the coding structure outlined above. The spreadsheet recorded the food handler ID and gender, the time the actions occurred to ensure sequential analysis, and the tasks and duties being performed according to the coding checklist. If a handwash was performed, the duration and style of handwash was recorded together with a binary indication (1=Yes, 2=No) of whether the procedure was deemed compliant with the company procedure (as provided earlier in the chapter). Additional qualitative field notes could also be added to the spreadsheet capturing behaviour or events outside the scope of company procedure but considered relevant to maintaining food safety according to the initial literature review.

Data analysis

Although data is predominantly quantitative in nature (i.e. capturing a range of numerical variables in SPSS), notational analysis incorporates a qualitative aspect to

enable an informative descriptive understanding of sequential behaviours (i.e. as they occur in order). Clayton and Griffith (2004) indicate that notational analysis is particularly beneficial while conducting observations in the food industry, as it utilises a systematic coding technique (user-defined) to ensure consistency as well as specific detail connected with each event in relation to frequency and process. Seldom utilised for observations in food manufacturing however, notational analysis is more often applied to annotate sport performances (Eaves, 2015), as analysis is more meaningful, and particularly so if improvements or intervention are the aim in future (Samuel, 2024). Consequently, descriptive statistics were used to identify the number of compliant and non-compliant hygiene events according to company expectations (i.e. personal hygiene, glove and allergen policy) and for identifying common themes related to the behavioural events captured (Miles, Huberman and Saldana, 2014; Bryman and Cramer, 2011). The data analysis allowed for identification of complex food handler behaviours and routine practices culture within Site A food production.

Ethical approval

Ethical approval for this study was granted by Cardiff Metropolitan University's School of Sport and Health Sciences - ethical approval reference number: UG-10213. The CCTV footage and company policy documents used in this study had already been gathered, albeit unused, for a previous project. This previous project was also granted ethical approval by the Research and Ethics Committee of the Cardiff Metropolitan University School of Sport and Health Sciences - reference number: PGR-1527. The footage and policy documents had all identifying information removed prior to the researcher receiving them, thus maintaining the confidentiality and anonymity of the business and all food handlers observed.

Findings and results

The hygiene practices of seven food handlers (five women and two men) were observed for 30 minutes each during peak production within a sandwich manufacturing department. This resulted in a total of 210 minutes (3 hour 30 minutes) of footage being watched. During this time a total of 220 actions were

performed by the food handlers. This was an average of 31 actions per food handler per 30 minutes. However, depending on the tasks being performed by the food handlers the range of actions completed was 38. The range and number of actions completed by food handlers shows not only the complexity but also the fast paced, repetitive nature of food production in a food factory.

Handwashing compliance

During observations, to be compliant with the company policy, handwashing should have been performed 62 times. However, the handwashing frequency compliance rate was 0%. The food handlers present in this department repeatedly performed actions that had the potential to contaminate their hands. Examples of this included (*n*=28) the handling of vehicles of contamination such as pens, paperwork and order notes after preparing food products. Food handlers would then touch the same order sheets and then go onto handle and prepare other food types. Food handlers were observed (*n*=19) handling waste by pushing food packaging down into the waste bins with their hands. Having done this the food handler would then immediately return to producing food or handling equipment involved in the processing of food. Only on one occasion did a food handler perform a hygiene action after having done this, which was a change of gloves. A common occurrence for food handlers in this facility was the repeated handling of transport trollies and pallets used to store packaged food and prepared sandwiches. These trolleys were handled by various food handlers throughout the shift, often following on from producing a batch of sandwiches. Having done this food handlers should then have washed their hands before returning to handling food, which was once again never done in this production department during observation. Due to the nature of the tasks, food handlers in this department should have performed approximately 18 handwashing actions per hour to comply with company policy.

Glove use and compliance

Due to the vague nature of the company glove policy, it was impossible to determine the exact number of glove changes that should have occurred to ensure compliance

with the company policy. Therefore, the researcher has determined that gloves should be changed before handling a food product and after performing a task that has the potential to contaminate the hands. Overall, 62 glove changes should have been completed to ensure safe production of food. Table 1 below shows the frequency of the observed glove changes and the glove change frequency compliance by the food handlers with the glove policy. The observed actions which most frequently required a glove change were prior to the preparation/handling of food products (*n*=33) and after handling waste (*n*=16). Of these tasks the glove change compliance frequency was very poor with food handlers only changing gloves a total of three times (6%). Food handlers did fare better when it came to glove change compliance frequency following cleaning duties (100%), after handling paperwork (100%), transferring between products (100%) and before leaving or returning to the production room (83%). Overall, the glove change frequency compliance rate was low with an overall compliance rate of 23%. The glove policy also detailed how a handwash should be performed followed by the use of an alcohol sanitiser. During observations of the 14 glove changes, there were no instances of these actions being completed. Therefore, overall compliance with the glove policy was 0%. Food handlers were seen performing other potentially risky behaviour with regard to glove changes. One food handler was seen changing the glove on one hand having handled food, then moving to handling a different food type and then changing the glove on the other hand. Having done this the food handler was observed wiping their hands on their PPE. Other food handlers were seen wearing a white liner glove underneath the disposable blue glove (the management of this was not mentioned in company procedure).

Table 1. Observed glove change frequency compliance with company glove policy

Task	No. of times gloves should have been changed	No. of times gloves were changed	% frequency compliance with glove policy
Before preparation and handling of food	33	1	3
Changing between product batches/food types	2	2	100
After cleaning	2	2	100
Upon returning to or leaving production room	6	5	83
After handling paperwork	1	1	100
After handling equipment	2	1	50
After handling waste	16	2	13
Total	62	14	23

PPE use and compliance

During observations of the department, PPE was changed by the food handlers on 16 occasions. Food handlers were observed leaving the department on seven occasions; on four of these occasions food handlers were seen failing to comply with the company PPE policy. On three of these occasions a food handler very briefly left the production room, and no PPE was removed prior to doing so. On the other occasion the food handler removed gloves and both aprons but failed to remove their sleeve covers. Upon returning to the department the food handler no longer had these sleeve covers on and went onto apply only one sleeve cover. Whilst this food handler did not go on to perform any more food production during the remainder of the observation, wearing all PPE, at all times, was a requirement within this production department. Food handlers within the department had similar compliance when returning to production. Out of a total of seven occasions, in four of these occasions there was a failure to comply with the policy.

Cleaning and allergen control

Cleaning practices were observed being completed on 15 occasions. The majority of these were the cleaning of work surfaces which were deemed to be compliant with company procedure. However, on one occasion a food handler was seen wiping down a work surface whilst holding foodstuffs in the other hand. As well as this, the control of allergens did not appear to be complied with or enforced within the department. Food handlers were required to perform a detergent wash between food product lines. Whilst it was difficult to determine the exact food product handled through CCTV observation, the number of actions performed by the food handlers and the nature of the products meant it is highly likely that during this time allergens were handled. There was nil compliance with the allergen policy.

Hygiene malpractices and behaviour with the potential to contaminate food

Malpractices were observed at various points during observations (n=29), these malpractices are shown in Table 2 below. These malpractices have the potential for

food handlers to contaminate their hands and gloves with bacteria and physical contaminates.

Table 2. Hygiene malpractices observed during production

Malpractices	No.	% of total actions completed by food handlers
Wipes hands on PPE	10	5
Touches face, nose, mouth	11	5
Hand in pocket	7	3
Adjusted Hairnet/Beard snood	1	1
Total	29	13

Individual examples of food malpractices of particular concern within this department included a food handler sneezing into the crook of their elbow, which was in compliance with the policy (i.e., to cover nose and mouth with elbow or shoulder when coughing or sneezing). However, the food handler immediately touched their nose and face which may have contaminated their hands. A food handler was also seen cleaning glasses with paper towel during production. At no time were food handlers seen being supervised by a production manager and no production managers were seen on the factory floor during the observations. Blue food grade paper sheets were used in the department to separate batches of sandwiches within pallets. During observations, food handlers were seen dragging these sheets on the floor. The floor in the food production department was often wet due to deep clean downs performed at the start and end of shifts.

Discussion

Food handlers within ready to eat sandwich production facilities are responsible for producing vast quantities of sandwiches for distribution nationwide. Due to the wide consumption of these products, food handlers within these facilities must ensure that they implement the food hygiene practices, particularly relating to personal hygiene, detailed within the company policy to ensure the safety of the products produced. The research previously conducted to assess the hygiene practices of food handlers within a food factory production department was limited. This research, therefore, assessed food handlers' compliance with company hygiene procedure and the number of personal hygiene malpractices within this type of department.

The findings of this study show that food handler compliance with the handwashing policy was 0%. There were incidents of glove changes being performed, with glove policy frequency compliance at 23%. However, due to a failure of these glove changes to comply with the glove policy requirements, overall glove policy compliance was 0%. Of the actions by the food handlers that were observed, 13% were deemed to be hygiene malpractices. Overall, the food handlers within the department had very poor levels of compliance with the company hygiene policy and displayed poor hygiene practices.

Handwashing compliance was much lower in this study than other studies observing food hygiene practices in high-risk production. Mohamed and Evans (2024) study found that a handwash was attempted on 68% of occasions requiring a handwash inside a similar production facility. Evans and Redmond (2019) found that hand hygiene frequency compliance upon entry to a food production facility was approximately 90%. Whilst only around 2% were deemed to be compliant with company policy, around 9% were deemed to be adequate. This suggests that whilst handwashing rates upon entry were lower than they should have been, they were still better than within production. This is likely due to the fact that the key focus of these pre-production hygiene rooms is for handwashing, whereas during production the focus shifts towards the manufacturing of products. Comparatively, studies have shown that food handlers hygiene practices are more compliant in restaurant, delicatessen and catering settings than production settings (Clayton and Griffiths, 2004; Green *et al.,* 2006; Rajagopal and Strohbehn, 2013; Ovca, Jevsnik and

Raspor, 2018). Unlike handwashing, some aspects of the glove policy were complied with by food handlers in this department. These findings support a previous study that suggest that glove use has a negative impact on the handwashing rates within food businesses (Green *et al.*, 2006). Food handlers may have lacked knowledge and understanding that handwashing remains vital, as wearing gloves on unwashed hands can result in a contamination risk to food (Selvaraj *et al.*, 2023). Glove use in this department may have been viewed by the food handlers as a substitution for handwashing which has also been concluded by other studies (Green *et al.,* 2007; Rajagopal and Strohbehn, 2013).

This study found that food handlers were completing an average of 31 actions per hour. This is far greater than the average amount performed by food handlers in restaurant settings (*n=8.6*) (Green *et al*, 2006) and therefore the number of hand hygiene actions that should have been performed would also be far greater, in this case (*n=18*). This suggests that food handlers in a production setting have far greater hygiene demands than those in restaurant and catering environments. The lack of hygiene actions performed during the observations in this study suggest that the number of food production actions completed by food handlers is inversely proportional to the number of hand hygiene actions completed by food handlers. This confirms previous research that time constraints are a barrier to food hygiene (Arendt, Strohbehn, Jun, 2015; Mohamed and Evans, 2024). However, this is even more relevant in a food production department and creates somewhat of a hand hygiene paradox in food production. A compliant handwash takes at least 20 seconds, not including adequate drying of hands (Mohamed and Evans, 2024); therefore, if food handlers in this study had been compliant with company hand hygiene policy they would have been washing hands for a minimum of six minutes every hour. This would have implications on the productivity of food handlers within a department and negative economic impacts on the business. As well as this, food handlers may experience negative physical effects of repeated handwashing such as contact dermatitis (World Health Organisation, 2009). These factors make handwashing at this rate within production problematic and disruptive.

Another commonly cited barrier to food production is the failure to provide adequate facilities and resources to implement hand hygiene (Pragle, Harding and Mack, 2007; Arendt, Strohbehn, Jun, 2015). The food business within this study did provide

adequate facilities to staff to perform handwashing - previous research identified that food handlers in premises with multiple hand hygiene sinks had better compliance with company hand hygiene policy (Green *et al.*, 2007). As well as this, soap, hot and cold water, all PPE (i.e., gloves, aprons, sleeve covers and hair nets) and hand sanitiser were provided to food handlers. Despite the provision of adequate hygiene facilities, hygiene practice compliance was still very low. One of the two handwashing sinks provided was obscured from the view of food handlers which has been linked to a reduction in handwashing rates (Green *et al.*, 2007); however, in this case the other sink was clearly visible next to the entry and exit point of the food production facility. Had both sinks been visible it would have been unlikely that rates would have improved within this department.

The hygiene practices of food handlers depends on the knowledge they possess and how they translate it into practice, which as discussed previously is provided through training and the understanding of hygiene policy documents (Seaman and Eves, 2010; Mekonen and Melaku, 2014; Todd, 2020). The food handlers in this department had undergone training, however this training was generalised to cover all food hygiene. Aspects of this training are redundant for this type of food handler due to the nature of the cold ready-to-eat food produced. This presents the case for specialised training that covers only the actions undertaken by food handlers in this type of department. As well as this, the policy documentation provided to food handlers was vague, open to interpretation and had a lack of information on the key hygiene actions food handlers needed to maintain the safety of the food products. Despite food handlers providing confirmation they understood this policy, the volume of information that the food handlers had to understand may have led to confusion and a lack of understanding of how to produce food in compliance with the safety procedures. No management figures were seen in the production department during observations. Previous research indicates that management and social environment plays an important role in encouraging food handlers to perform hygiene actions (Green *et al.*, 2007; Arendt, Strohbehn, Jun, 2015).

The department observed in this study had all the hallmarks of having a poor hygiene culture (Zanin, Stedefeldt and Luning, 2021). This confirms the findings of previous studies that food handlers within food production have worse hygiene practices than those in restaurants and catering environments, despite in theory

having more stringent hygiene requirements and better reported compliance (Evans, Samuel and Redmond, 2020; Mohamed and Evans, 2024). These findings are concerning as the practices observed by food handlers had the potential to contaminate the food with pathogens, which if consumed, would have grave consequences for the consumer, particularly those who are vulnerable.

Recommendations

In light of the aspects resulting in poor food hygiene which have been identified within this food manufacturing department and by previous research of food manufacturing departments (Evans and Redmond, 2018; Evans, Samuel and Redmond, 2020; Mohamed and Evans, 2024), the following recommendations are suggested to improve hygiene culture within this type of department and keep food safe.

- As handwashing at the current rate to keep food safe within this type of department is economically and physically problematic, there is a need to reduce the number of handwashes required by the food handlers. Other research has suggested restructuring actions (Green *et al.*, 2006; Clayton and Griffith, 2004). This will allow food handlers to complete all actions that have the potential to contaminate hands prior to handling food. This would be particularly relevant to food production departments where food handlers were seen repeatedly handling vehicles of contamination and then food.
- Perhaps the principal change to improve the hygiene in these production environments is the need for more simplistic but specialised training with key emphasis on personal hygiene and cross contamination, a food safety key in this environment. Regular assessment of food handlers' knowledge within a department like this may ensure that the often short-lived effects of training (Seaman and Eves, 2010) are preserved long term.
- Company procedure would benefit from being simplified to stress the importance of key points regarding handwashing and glove changes being immediately prior to handling food.
- Visible management within the production department is key to ensuring and encouraging staff to complete hygiene actions (Evans and Redmond, 2018).

Production facilities could have a dedicated production department floor manager with specific training for this role.

Strengths and limitations of this study

The assessment of food hygiene practices within a food production department is a complex and potentially challenging task. This study utilised covert observation through CCTV footage, which provided numerous advantages as it negated the Hawthorne effect and allowed the same footage to be viewed multiple times. These factors greatly improve the validity and reliability of this study (Chapman, MacLaurin and Powell, 2013). The original version of the observational code was developed by Samuel (2024) for a PhD project and the code was altered to ensure suitability to the environment observed in this study and tested through piloting. This observational code book allowed for comparable hygiene actions to be recorded throughout observations. As well as this, notational analysis allowed potential cross-contamination events to be identified (Clayton and Griffith, 2004) and field notes to capture actions which may not have been included in the code book (Fix *et al.*, 2022).

This study is an undergraduate project undertaken by only one researcher who recorded observations to the best of their ability. However, the observations underwent no form of intraoperator and interoperator reliability to confirm the accuracy of observations (Mohamed and Evans, 2024). Due to time constraints only 3 hours 30 minutes of footage was viewed, whereas observations for a longer duration over multiple shifts and departments would increase the reliability of results. Due to the nature of CCTV (limited viewing angle and poor quality) it can make determining some actions performed by food handlers challenging and food handlers can leave the CCTV's field of view.

Conclusion

This study, using covert observation and a combination of quantitative and notational analysis, set out to assess the hygiene compliance of food handlers in a sandwich production department and to understand the reasons for the observed hygiene

actions, or lack thereof. Overall, the department observed in this study showed poor compliance with all company polices and hygiene practices, particularly for handwashing. Food handlers were observed regularly performing actions which had the potential to contaminate both hands and the food produced. The department observed had multiple failings resulting from the production department's very poor food hygiene culture. This study confirms the findings of previous research that food handlers within production facilities perform fewer hygiene actions and a greater number of malpractices than those in restaurant settings. The impacts of these, should contamination of food product occur, would be far reaching due to the distribution and consumption of these products. Not only was the nature of hygiene compliance of food handlers identified, barriers to maintaining hygiene were also observed and identified within this study. The main barrier during production being the repetitive nature of food production, resulting in the need for a large amount of hygiene actions to be completed for the safe production of food. Whilst this time and workload barrier is not a specific issue to food production it is certainly emphasised in a food production setting. To combat this, various recommendations have been theorised in this research and others, which food production businesses can use to improve the hygiene practices of food handlers in the future. Future research should aim to explore the effectiveness of these recommendations. It should also aim to explore how to balance the hygiene practices of food handlers whilst still having regard for the productivity of food employees and the potential economic costs. This study was one of only few that have assessed the hygiene practices within high-risk production; therefore, to build a larger knowledge base on the actual practices and food handlers' attitudes across the manufacturing industry, further studies using mixed methods of quantitative observation and qualitative interview are needed.

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