Meal-Kit Use in the United Kingdom: Implications for Food Safety

Naomi J. Melville,* Elizabeth C. Redmond, Joseph E. B. Baldwin, and Ellen W. Evans
ZERO2FIVE Food Industry Centre, Cardiff Metropolitan University, Western Avenue, Llandaff, Cardiff, Wales CF5 2YB, UK

SUMMARY

Meal-kit delivery services provide consumers with measured ingredients and step-by-step recipe guidance for the preparation of meals in a domestic setting. Subscriptions to companies that provide meal-kit delivery services have grown over the last decade, with the market value forecast to continue. During this period, a substantial increase in the popularity of domestic cooking has been reported, particularly preparing and cooking food using raw ingredients. Furthermore, during the COVID-19 pandemic, subscriptions to meal-kit delivery services increased considerably. This trend is expected to be maintained, with consumers opting for the convenience of home-delivery options that provide healthier, more diverse, and interesting recipes with less food waste. The domestic kitchen is recognized as a key location for acquiring foodborne illness without implementation of recommended food safety and handling practices. As meal-kit delivery services enable consumers to prepare and cook food at home using raw ingredients, there are possible implications associated with food safety and potentially increased risks of foodborne illness. Given the association of the domestic kitchen with the sporadic incidence of foodborne illness, this current consumer trend presents unique food safety challenges. The aim of the article is to investigate the potential food safety implications associated with increasing meal-kit use in the United Kingdom and provide recommendations for future research in relation to consumer engagement with meal-kits and meal-kit recipe cards.

OVERVIEW

Online food delivery market

Online ordering of food and groceries has increased in popularity in recent years *(3, 37, 54)*. The sector comprises of two distinct categories: ready-to-eat (RTE) food delivery services, which requires no further preparation of food by the consumer, and not-ready-to-eat (NRTE) meal-kit delivery services, which require further preparation of ingredients by the consumer.

RTE food delivery services can be used by consumers to order RTE meals from chains and independent restaurants. In the United Kingdom, platform aggregation services, including Deliveroo, Uber Eats, and Just Eat, collect menus from different restaurants, and RTE meals can be ordered via the service providers' websites or mobile applications. Subsequently, self-employed couriers pick up the RTE meals from the restaurant and deliver them directly to the consumer by either car or bike *(9, 32, 37, 56)*.

NRTE meal-kit delivery services can be distinguished from RTE food delivery services as meal-kits can include raw food ingredients that require storage, preparation, and cooking for some or all components by the consumer. Meal-kits provide fresh ingredients that are measured, appropriately wrapped, packaged, and placed in a branded cardboard delivery box with ice packs, if applicable *(8, 29)*, because NRTE meal-kits frequently include perishable foods that require chilled storage during transportation and at home by the consumer. Some providers only supply ingredient kits, such as cooking pastes, spice blends, and sauces, which are accompanied by a list of fresh ingredients that consumers must obtain from a supermarket *(30)*.

Providers can offer meal-kits via subscription or on demand *(14, 30)*. Because NRTE foods require further processing upon receipt by the consumer, foods can be sent through mail order *(Fig. 1)*. According to UK legislative requirements, distance selling operations of RTE foods are allowed, but such foods are subject to stricter regulations relating to temperature control because of the risk of bacterial growth *(14)*. In contrast, for the selling of NRTE, consumers can order directly from a meal-kit provider's website, where provisions such as menu items (recipes), frequency of delivery, and serving sizes can be tailored to the consumers' preference *(29, 30)*. The selected meals ordered from the provider's website are accompanied by recipe cards that include information on recipe preparation, nutritional information, and what kitchen utilities to use *(27, 29)*.

Meal kits are known by many alternative names; trending names include recipe boxes, meal boxes, meal delivery services, food box subscriptions, and meal box delivery *(30, 49)*. For this general interest article, we refer to these as meal-kits.

Meal-kit appeal

Market data have established that there is wide availability within the growing UK market for purchasing meal-kits and that UK consumers use meal-kit services *(54)*. Consumers perceive that when cooking every day, particularly after work, the meal should be easy to prepare, require minimal time and effort, and be a healthier option *(20)*. Meal-kit provider

*Author for correspondence. Phone: + 44.0.2920.205836; Fax: + 44.0.2920.416982; Email: nmelville@cardiffmet.ac.uk

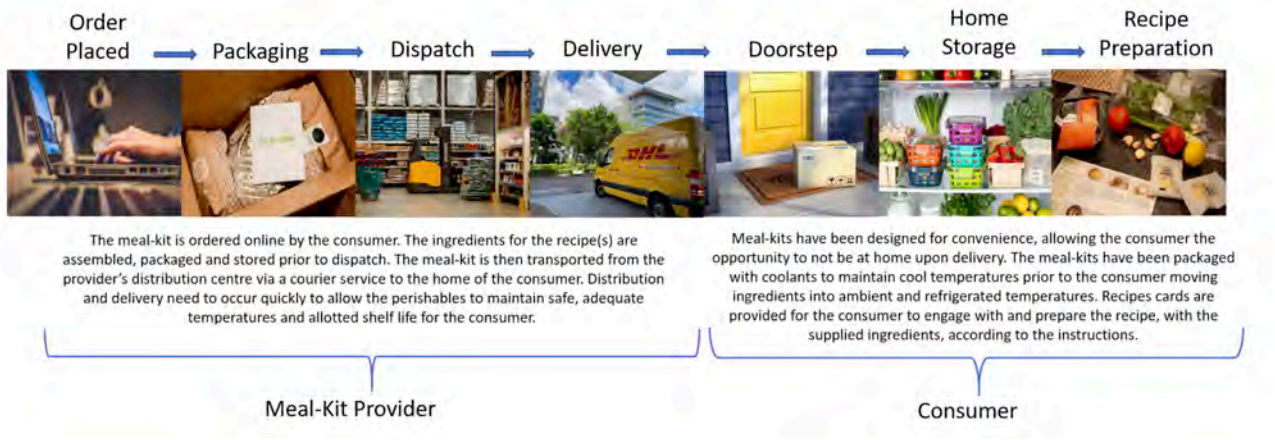

Figure 1. The life cycle of a meal-kit, from the consumer placing the order online through to distribution and delivery to the consumer, who unpacks and stores the ingredients before preparation and consumption.

websites generally promote healthy eating, sustainability, and ethical food choices while catering to consumers' desires for convenient, budget-friendly, and diverse meals *(21, 28, 39)*. Corroborating market research, the appeal of using meal-kits reported among consumers was convenience, healthier options, more diverse and interesting recipes, less food waste, and reduced shopping duration and frequency *(8, 54)*. The reported frequency of meal-kit delivery to consumers ranged from daily to monthly, or less, with most meal-kit consumers opting for weekly deliveries *(54)*.

Reducing food waste is one of the hallmarks associated with meal-kits, with some meal-kit providers producing an annual report on sustainability actions focusing on impacts regarding carbon footprints, responsible sourcing of ingredients, and minimizing or improving packaging *(24, 38)*. An environmental study discussed how the perceptions of some consumers toward meal-kits were unfavorable, with the view that the increased amount of packaging involved was excessive; the contents of the refrigeration packs were also a concern because of the amount of waste and the use of nonrecyclable materials *(4, 26)*.

The meal-kit industry continues to expand, with the market value of meal-kit subscriptions in the United Kingdom increasing from £420 million in 2017 to £1 billion in 2020 and a forecast of a market value of £1.5 billion in 2025 *(54)*. This increased market growth has been seen internationally, and the meal-kit service market is expected to grow from $10.26 billion in 2020 to $24.14 billion by 2027 *(54)*.

Domestic cooking and meal-kit trends in the COVID era

Market research has highlighted that although the meal-kit industry has been steadily growing for several years, the COVID-19 pandemic was a catalyst for increased popularity among consumers. In March 2020, at the start of the COVID-19 pandemic, market research reported that United Kingdom-based meal-kit delivery companies had an upturn in sales because of increased consumer demand *(6)*. One meal-kit provider reported year-on-year growth between the end of 2019 and 2020 as 98%, in contrast to the growth observed the previous year at 38% *(24, 48)*. Key performance indicators suggest that the number of meals delivered globally to subscribers in 2020 was 601.2 million, a 114% increase from the previous year *(24)*. Market research indicates that between 2016 and 2021, the number of global active subscribers for one provider jumped from 860,000 to 7.22 million *(54)*.

In recent years, trends indicate a decline in domestic food preparation, including the use of raw ingredients, with a focus on convenient and less time-consuming preparation and cooking processes *(2)*. Consumer reports indicate that factors including "not having enough time," changes in household size and structure, increased proportion of women in employment, and eating out contributed to the decrease *(2)*. However, during the COVID-19 pandemic, closures to hospitality services in the United Kingdom resulted in consumers being unable to eat out, along with increased time being spent at home, and this resulted in more meals being cooked from scratch and eaten at home *(7)*.

Market research has highlighted the impact that the pandemic has had on consumer cooking behaviors, including the increase of food preparation at home and the use of meal-kits. Research evaluating behaviors before and during the COVID-19 pandemic found that 7% of consumers involved in the preparation and cooking of meals at home ordered meal-kits more often than before the pandemic *(20)*. Additional reports that focused on behaviors, related to the choice of meals and ingredients used during meal preparation, indicated that up to 30% of consumers tried meal-kit delivery services during the COVID-19 pandemic *(7)*. During this period, consumers were increasingly opting

to prepare and cook meals from scratch, with 80% of those involved with meal preparation continuing this trend over the next 12 months to a greater extent than prepandemic levels *(20)*. Additional factors that have facilitated this trend include improved cooking skills, more flexible working patterns, and the perception that meals prepared and cooked from raw ingredients are healthier and more cost effective. The increased focus on health because of the pandemic has encouraged the trend of eating healthily becoming a higher priority for a third of UK consumers *(7)*.

During the COVID-19 pandemic, increased fear of contracting the virus and widespread lockdown measures affected restaurant operations *(23)*. Because of economic difficulties during the pandemic, the restaurant sector adapted as a necessity to enable business sustainability, trading through home delivery or takeout *(43)*. Being limited to home delivery or takeout, the restaurant sector adapted to be more flexible, introducing measures including the provision of NRTE do-it-yourself restaurant meal-kits *(19, 52)*. Given the difficulty in maintaining the quality of some prepared and cooked dishes during transit, meal-kits supplied by restaurants presented the opportunity to create restaurant meals at home.

There also appears to be an opportunity for increased consumer engagement in meal-kits, with growing interest in learning from chefs in cooking classes over internet platforms and the chance for consumers to show off the creations on social media *(52)*. Furthermore, there has been the opportunity for London-based offerings to expand beyond lockdown popularity by offering meal-kits nationwide *(42, 60)*.

Research indicates that meal-kit services have expanded and are capitalizing upon lockdown popularity. Some meal-kit companies have partnered with supermarket retailers to provide meal-kit services in stores, whereas other supermarket retailers have invested in the meal-kit sector by providing own-branded options *(40, 44, 51, 59)*.

Given the burgeoning popularity among consumers to prepare and cook food in the domestic setting and engage with meal-kit services, there are opportunities for research in the area related to consumer food safety to determine how consumers interact with these meal-kits and to explore the potential impact on food safety.

Existing research regarding meal-kits

In recent years, several studies have been undertaken in relation to various aspects of a meal-kit. For example, a study on the environmental impact of meal-kits found that despite negative perceptions of meal-kits having an unfavorable environmental effect, meals supplied from a grocery store tend to have higher environmental repercussions because of food loss and waste *(26)*. Another study explored socioeconomic factors of meal-kits in the United States, which determined that meal-kits could be a pragmatic approach to improving the diet quality of low-income families if the service is affordable, maintains high nutrition standards while considering the dietary preferences of the target audience, and is easily accessible *(55)*. An Australian study evaluated the characteristics, such as number of recipes, ingredients and cooking duration, and nutritional composition, of meal-kits *(41)*. The study concluded that with the growing popularity of meal-kits and the capacity to influence consumer diets and health, health professionals need to fully appreciate the suitability, risks, and benefits of recommending these services to the wider public.

Limited studies have been published specifically relating to meal-kits and food safety. Hallman et al. *(25)* focused on vendors in the United States that exclusively dealt with the courier of high-risk ingredients such as meat, poultry, and fish (but not as part of a meal-kit) and indicated that there were concerns related to adequate temperature control during the cold supply chain, customers' perception of little risk associated with deliveries of the products, and a lack of food safety information provided to consumers *(25)*.

Mickanuck's *(35)* study of meal-kit providers in Canada reviewed websites for the provision of food safety information and provided a time-temperature analysis of meat, poultry, and fish products supplied from meal-kit delivery services. Results suggested that the packaging methods used were insufficient at maintaining temperatures below the danger zone. The study concluded that meal-kit providers should provide food safety information to consumers as a dedicated webpage, through a pamphlet included in the delivery, in a follow-up email, or through notifications on an app *(35)*. To date, this study is the only study that has explored meal-kits specifically in the context of food safety.

The literature conveys that although meal-kits are a growing area of interest, there is a lack of research, particularly within the United Kingdom, in relation to meal-kits and food safety. The research has highlighted the lack of provision of food safety information for consumers and inadequate temperature control of high-risk ingredients *(25, 35)*. To date, no research has considered consumer engagement with meal-kit recipe cards within the domestic environment.

Food safety requirements and meal-kits

One important food safety requirement in reducing the risk of foodborne illness is temperature control for the safe storage of foods, because foodborne pathogens can readily grow at temperatures between 8°C and 60°C. When above or below these temperatures, growth is significantly reduced or stopped or the bacteria begin to die, mitigating the risk of foodborne illness *(16)*. Chilled storage advice provided by the UK Food Standards Agency (FSA) discusses temperature and its importance in relation to food safety, with emphasis on storing chilled foods at or below 5°C to reduce bacterial growth *(18)*. This is particularly important to control the growth of *Listeria monocytogenes (13)*. During the

lifecycle of a meal-kit *(Fig. 1)*, the perishable goods must be assembled and packaged and then go through dispatch and transportation to the consumer, all while maintaining safe storage temperatures.

Mail-order distance selling of perishable foods in the United Kingdom is bound by Commission Regulation (EC) 853/2004 *(10)* on the hygiene of foodstuffs and the Food Hygiene Regulations 2006 legislation. These provide guidance related to temperature control requirements. Before dispatch, regulations in the Food Industry Guide to Good Hygiene Practice require certain foods to be held at temperatures that will prevent the growth of harmful bacteria or the formation of toxins *(14)*. The regulations stipulate that it is an offense to allow foods to be kept at temperatures that would cause a health risk (above 8°C). During dispatch, a maximum single 2-h period is allowed during which goods may go outside temperature control requirements to accommodate the practicalities of handling goods during preparation, storage, and transportation. However, the acceptable limits depend on a combination of time and temperature factors *(14)*.

In the United Kingdom, the mail-order guidance for foodstuffs, with regards to packaging, states that during transportation, the food must be transported in a way that reduces the risk of contamination. Primary requirements would be to use well-insulated outer packaging that can sufficiently prevent the damage of the contents or temperature seal, effectively avoiding contamination of the food or the loss of temperature control *(14)*. The Food Industry Guide to Good Hygiene Practice further stipulates that the food should be safe to eat within the allotted shelf life. Another key necessity is the refrigerant used, which depends on numerous factors relating to the outer packaging, the initial temperature at the time of packing, and time and temperature factors during transit *(14)*. Refrigerant options referred to in the Food Industry Guide to Good Hygiene Practice include ice in plastic pads, gel pads, and plastic packs containing a readymade eutectic mixture, with consideration being given to ensuring the suitability for use with food. Temperature control requirements require certain foods, such as dairy products, prepared RTE foods, or smoked and cured RTE meat or fish, to be held at temperatures that will prevent the growth of harmful bacteria or the production of toxins *(14)*.

The package labeling normally indicates this requirement with use-by dates and keep-refrigerated guidance *(14)*. Temperature variations in a U.S. study were attributed to the type of coolant used and the proximity of the coolant to the product, including dry ice, gel packs, and wet ice. Gel packs were found to be the most popular coolant yet were considered inferior for keeping perishables below 40°F (4.4°C) in comparison to dry ice *(25)*. A study of surface temperature found that nearly half of products arrived with a surface temperature above recommendations. The packages were found to have lacked appropriate coolants, padding, and labeling. The research concluded that because some food items arrived in the danger zone, the products should be considered unsafe to consume. Research conveyed that those vendors should ensure that sufficient packing standards regarding the coolant, padding, and shipping container are attained *(25)*. Although guidance exists for recommendations for packaging, because of the lack of research on meal-kits in the United Kingdom, it cannot be determined what type of insulated packaging or refrigerant options are commonly used by meal-kit providers to maintain cold storage of perishables.

Mail-order food does not need to be chilled during delivery transit to the consumer. However, during transportation, it must not exceed temperatures that could cause a health risk *(14)*. Raw food intended for further processing, such as fresh meat, fish, and shellfish, does not come under the temperature and hygiene of foodstuff regulations and is considered outside the scope of mail-order food guidance *(14)*. Nevertheless, during transportation, legislation associated with temperatures related to raw meat and poultry specifies that the temperature should be no higher than 7°C along a chilling curve that ensures a continuous decrease of temperature for red meat and no higher than 4°C for poultry *(10)*.

Concerns raised by Hallman et al. *(25)* included that perishables are treated no differently than any other package handled by courier services. One courier service indicated that closed, parked carrier vehicles during the summer months can reach temperatures of 140°F (60°C), highlighting the issue of packages having to maintain adequate cold temperatures because of external environments. Food safety recommendations included policy advice regarding adding sensors to packages to alert customers when contents exceed safe temperatures and providing accurate food safety information with shipments. Further industry recommendations included displaying food safety information more prominently on websites that include proper food safety handling practices, ensuring that the information provided is accurate, and anticipating worst-case scenario conditions for the packaging, e.g., temperature abuse. Because consumers do not perceive this as a risk, they are not looking for or expecting it *(25)*. Mickanuck *(35)* also concluded that current temperature control methods used during delivery are inadequate and the provision of food safety information is insufficient, supporting previous research. Hallman et al. *(25)* acknowledged the growing nature of the food delivery business and that shipping perishable items directly to consumers can be done correctly and safely.

One meal-kit provider acknowledged the issue of potential temperature abuse of the products, with the company performing International Test Laboratory models of various scenarios and packaging concepts to ensure the boxes arrive

at the customer at optimal temperatures *(48)*. Mickanuck *(35)* measured surface temperatures of products over 8 h to replicate the average consumer working a 9-to-5 job. At the 8-h mark of analyzing the temperature, three-quarters of the average surface temperatures were above 4°C, which is above the recommended chilled temperatures in Canada *(22, 35)*. Mickanuck *(35)* acknowledged one limitation of the research with the temperature analysis occurring in the winter months and recommended that temperature analysis of meal-kits could be investigated during the warmer, summer months. Although legislation in the United Kingdom indicates that foods, including meal-kits, delivered via mail order should be maintained at adequate and safe temperatures, there is no research to demonstrate adherence to these measures. The research literature indicates the need to identify the potential gap in temperature control between delivery and receipt of meal-kits under different external conditions. There is an opportunity to explore and measure the temperature of meal-kits when directly delivered to the consumer to help determine the impact that delivery and storage conditions have on the temperature of food products.

Consumer food safety: opportunities and implications

The responsibility for the safe production of food can lie with government, food business operators (FBOs), and ultimately, consumers. Governments can provide the framework and guidance for implementing legal requirements, and FBOs can adhere to said legislation and regulations for the production of safe food *(10)*. However, the domestic kitchen is also recognized as a key stage in which foodborne illness can occur without proper food safety and handling practices *(5)*. Because consumers constitute the last step in the food preparation process, the consumer in the domestic kitchen is considered the final line of defense for food safety *(46)*. The appropriate food hygiene practices undertaken by consumers can effectively eliminate the risk of transmission of foodborne pathogens. Although origination in the domestic setting has been difficult to determine, with some studies estimating up to 64% of cases resulting from the domestic kitchen *(45)*, the incidence of sporadic foodborne illness associated with the domestic setting is widely acknowledged *(5, 11, 46, 50)*.

Redmond and Griffith *(46)* extensively reviewed food safety research that focused on consumer cognitions associated with safe food handling in the home. Findings established that consumer knowledge, attitudes, intentions, and self-reported practices determined by interviews and questionnaires do not correspond well with observed practices. Observational studies have indicated that unsafe food handling practices are still frequent during the preparation of food in the domestic environment *(46)*. For example, up to 100% of study participants were found to have failed to wash and dry hands adequately after handling raw chicken. These findings have since been corroborated by a more recent review from Redmond et al. *(45)* that found inadequate implementation of recommended practices, including hand washing, to be a risk factor for the potential of foodborne illness.

Young and Waddell *(61)* reviewed barriers and facilitators of safe food handling among consumers. Food safety practices relating to temperature probing and separation of equipment for raw and RTE foods during food preparation were viewed as hassles, and lack of time was noted as one contributing factor. Supporting Redmond and Griffith *(46)* was the reported knowledge and behavior gap regarding general concepts of recommended food safety practices *(61)*. Consumers lacked knowledge and had misconceptions around practices related to proper refrigeration practices, not washing chicken before cooking, and consumption of high-risk foods by vulnerable groups.

Cognitive factors influencing implementation of food safety behaviors include perceptions of risk, control, and responsibility*(47, 61)*. Research has indicated that consumers' perception of personal risk of illness when consuming foods they prepared is low, and this is correlated ($P \leq 0.05$) with the perception of being in full control of food safety when preparing food *(47)*. These judgments indicate optimistic bias, which may cause individuals to believe that they are less likely to experience a negative event and has been linked to risky behaviors and increased incidence of accidents and foodborne illness *(31, 47)*. Previous research into meal-kits found that consumers perceive a minor risk associated with home delivery kits, with further discussion of consumers perceiving lower personal risk of foodborne illness *(25, 35, 47)*. Given that the risk is underestimated by consumers, this may result in a lack of appropriate steps taken to reduce the risk of the hazards of foodborne illness, which could be compounded by compromised food products.

Previous research has shown how poor refrigeration practices by consumers can potentially increase the risk of foodborne illness. A study was conducted to identify risk factors associated with listeriosis in older consumers' domestic kitchens *(11)*. One risk factor identified was the association of *L. monocytogenes* and the link to poor refrigeration of RTE foods. In-home domestic refrigerator temperatures were measured to ensure adherence to food safety practices; temperatures should be ≤ 5°C, with results conveying that older adults fail to adhere to food safety recommendations, subsequently increasing the risk of foodborne illness *(11)*. Supporting this research was a laboratory reenactment of poor refrigeration storage practices found in the domestic refrigerators of older adults *(13)*. Foods inoculated with *L. monocytogenes* that were not stored at recommended refrigeration temperatures were found to have a statistically significant increase in bacterial growth rate. A follow-up investigation determined that most consumer refrigerators in UK homes operate above recommended temperatures *(12)*. Post-delivery storage conditions of meal-kits are unknown, and it has been established that there is insufficient research relating

to consumer engagement with meal-kits. Further exploration of food safety practices in the home is required to determine how consumers engage with meal-kits after delivery.

Consideration of previous literature relating to consumer food safety behaviors conveys how consumers lack awareness and, even with some knowledge, there is a disconnect between self-reported and observed behaviors *(46, 47, 61)*. Given the increasing popularity of domestic cooking and meal-kits, there is a need for the investigation of consumer interaction with the recipe cards provided within the meal-kits. There is a lack of available data relating to meal-kit use within the domestic kitchen, and determination of consumer food safety knowledge, attitudes, and self-reported practices relating to the preparation of meal-kit subscription boxes in the domestic environment is required.

Food safety information provision

The FSA guidance on food safety relates to the four Cs: cook, clean, chill, and cross-contamination. The aim of the guidance is to introduce measures that reduce the risk of harmful bacteria causing foodborne illness during the storage, preparation, and cooking of food. Recommendations include appropriately storing chilled and frozen products, effectively defrosting food, following use-by dates, washing fresh produce, hand washing, and cleaning the kitchen, and equipment, to prevent the spread of bacteria *(15–18)*.

Government guidance normally relates to the handling of high-risk ingredients such as poultry; however, there have been studies produced to indicate the importance of correctly handling produce, because pathogens can still be found on fruits and vegetables, increasing the risk of cross-contamination *(3, 33)*. Washing fresh produce is normally associated with the removal of pesticides, not reducing microbiological contaminants *(57)*. When determining whether fruit and vegetables that were going to be eaten raw were washed, 55% of respondents stated they always washed fruit and vegetables but 11% stated that they never did this *(57)*. Hallman et al. *(25)* and Mickanuck *(35)* were similar in the focus on high-risk raw ingredients, even though meal-kit delivery subscriptions could potentially have further raw ingredients to assess, such as fresh fruit, vegetables, and herbs.

Food safety practice during the preparation of a recipe is important in preventing the spread of bacteria and reducing the risk of foodborne illness. Studies have explained that although consumers may be aware of food safety handling practices, there is a disconnect between food safety knowledge and behaviors of consumers when engaging in food preparation *(5, 36)*. Hand washing during recipe preparation is an important factor in reducing cross-contamination *(57)*. Previous studies have established that hand washing during recipe preparation was insufficient or nonexistent when transitioning between tasks. Areas in the kitchen affected by the lack of decontamination include frying pan handles, faucets, cupboards, and refrigerator doors *(57)*.

In the United Kingdom, the FSA advises cooking poultry, pork, and minced meat products such as sausages until none of the meat is pink and any juices run clear *(16)*. However, further instruction acknowledges that a thermometer should be used to ensure food has reached 70°C and stayed at that temperature for 2 min *(16, 58)*. Time and temperature are both crucial factors to allow proteins to be heated up long enough to be broken down and inactivated *(16)*. It is unclear whether meal-kits provide advice and information on ensuring cooking adequacy, because there is no research detailing consumer methods of ensuring cooking adequacy when preparing meal-kits.

Research indicates that the inclusion of food safety information in recipes improves consumer food safety practices *(34)*. Food safety practices related to hand washing and thermometer use during recipe preparation were found to significantly improve when food safety instructions were provided within the recipe instructions. Although the study shows that recipe modification influences behavior, it is unclear how consumers directly interact with food safety information provided within recipes. There is an opportunity to use previously identified technologies to provide in-depth understanding and evaluation of consumers' engagement with food safety training and subsequent education interventions *(1)*. The implementation of wearable eye-tracking technology can be applied to explore consumer interaction and engagement with food safety educational interventions such as the aforementioned recipe cards *(1)*. Through the application of this technology, it is possible to see meal preparation from the perspective of consumers, allowing the implicit study of attention and providing behavioral insights that would help inform the purposeful placement of food safety interventions. There is a lack of research detailing the inclusion of food safety advice in meal-kit recipe cards, and evaluation for determining the inclusion of food safety information for consumers in meal-kit recipe cards is recommended. Furthermore, there is a need to establish whether the inclusion of food safety information in meal-kit recipe cards has an impact on food safety behaviors.

Hallman et al. *(25)* evaluated food safety information on vendor websites and reviewed delivery policies, which were found to be insufficient, inaccessible, and inaccurate, concluding with recommendations for consumers and the industry on how to improve food safety. Inaccurate information provided by vendors included terms such as cool to the touch, which stated that these were U.S. Department of Agriculture standards. Mickanuck *(35)* explored the provision of food safety information by reviewing the companies' websites. Information was found to be lacking, with none of the websites disclosing the risk of foodborne illness occurring because of temperature abuse. Furthermore, none advised disposing of food if the products appeared to be spoiled, and there were no recommendations for the disposal of high-risk food products if above the danger zone upon

receipt. These studies were conducted in North America, so there is an opportunity for further research to be conducted in the United Kingdom to determine the provision of food safety information to consumers. There is a need to identify food safety-based activities conducted by meal-kit providers, such as temperature and cooking validation and adherence to food safety and quality standards.

CONCLUSIONS

Not only is there an increase in domestic cooking after the COVID-19 pandemic, but there is also a growing trend in the use of meal-kit delivery services by consumers, reportedly because of the convenience and healthy options. There is no available research, within the United Kingdom, regarding meal-kits and food safety. Previously conducted research is lacking in areas related to consumer engagement with meal-kit recipe cards and meal-kits in general. Given the increase in the use of meal-kits and previous literature conveying a lack of appropriate consumer food safety knowledge and behaviors, a unique opportunity is presented to explore consumers' engagement with meal-kits and meal-kit recipe cards.

Previous studies regarding recipe modification suggest that the inclusion of food safety information in recipes has a positive impact on consumer behavior. Consequently, there is a need to review and evaluate recipe cards provided in meal-kit subscription boxes to determine whether there is an inclusion of food safety information. Furthermore, there is an opportunity to establish consumer food safety behaviors and interaction with provided recipe cards when preparing meal-kit subscription boxes in the domestic kitchen using eye-tracking technology. This will enable determination of the impact of food safety information on the behavior of consumers. There is an opportunity to explore consumer food safety practices in relation to appropriate storage of meal-kits upon receipt of delivery within a domestic environment.

The article has established the potential food safety implications associated with meal-kits, and given the gaps in the literature, there is an opportunity to explore the implications through evaluation of meal-kits and provide recommendations based on further food safety interventions.

REFERENCES

1. Baldwin, J. E. B., and E. W. Evans. 2020. Exploring novel technologies to enhance food safety training and research opportunities. *Food Prot. Trends* 40:456–463.
2. Benson, A., D. Irdam, I. Bulceag, T. Barber, and A. Draper. 2019. The food and you survey: Wave 5. Available at: https://www.food.gov.uk/sites/default/files/media/document/food-and-you-wave-5-secondary-analysis-current-food-landscape.pdf. Accessed 22 March 2022.
3. Berger, C. N., S. V. Sodha, R. K. Shaw, P. M. Griffin, D. Pink, P. Hand, and G. Frankel. 2010. Fresh fruit and vegetables as vehicles for the transmission of human pathogens. *Environ. Microbiol.* 12:2385–2397.
4. Butler, K. 2017. The truth about meal-kit freezer packs. Available at: https://www.motherjones.com/environment/2017/06/meal-kit-freezer-packs-blue-apron-hello-fresh/. Accessed 18 April 2022.
5. Byrd-Bredbenner, C., J. Berning, J. Martin-Biggers, and V. Quick. 2013. Food safety in home kitchens: a synthesis of the literature. *Int. J. Environ. Res. Publ. Health* 10:4060–4085.
6. Caddy, T. 2020. COVID-19 impact on foodservice. Available at: https://reports.mintel.com/display/1010528/. Accessed 9 March 2022.
7. Caines, R. 2021. Attitudes towards cooking in the home–UK, 2021. Available at: https://reports.mintel.com/display/1048611/. Accessed 11 March 2022.
8. Cho, M., M. A. Bonn, S. Moon, and H. Chang. 2020. Home chef meal kits: product attributes, perceived value and repurchasing intentions the moderating effects of household configuration. *J. Hosp. Tour. Manage.* 45:192–202.
9. Deliveroo. 2022. About Deliveroo. Available at: https://deliveroo.co.uk/about-us. Accessed 18 April 2022.
10. European Commission. 2004. Commission Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for on the hygiene of foodstuffs. Off. *J. Eur. Union L* 139:22–34.
11. Evans, E. W., and E. C. Redmond. 2015. Analysis of older adults' domestic kitchen storage practices in the United Kingdom: identification of risk factors associated with listeriosis. *J. Food Prot.* 78:738–745.
12. Evans, E. W., and E. C. Redmond. 2016. Time–temperature profiling of United Kingdom consumers' domestic refrigerators. *J. Food Prot.* 79:2119–2127.
13. Evans, E. W., and E. C. Redmond. 2019. Laboratory re-enactment of storage practices of older adults to determine potential implications for growth of *Listeria monocytogenes*. *Food Prot. Trends* 39:225–236.
14. Food Industry Guide to Good Hygiene Practice. 2007. Mail order food. The Stationery Office, Norwich, UK.
15. Food Standards Agency. 2017. How to avoid cross-contamination by following simple practices in the preparation and handling of food products. Available at: https://www.food.gov.uk/safety-hygiene/avoiding-cross-contamination. Accessed 10 March 2022.
16. Food Standards Agency. 2018. How to cook your food to prevent food poisoning. Available at: https://www.food.gov.uk/safety-hygiene/cooking-your-food. Accessed 10 March 2022.
17. Food Standards Agency. 2020. Advice on how to clean effectively in the kitchen and prevent harmful bacteria from spreading onto food. Available at: https://www.food.gov.uk/safety-hygiene/cleaning. Accessed 10 March 2022.
18. Food Standards Agency. 2020. How to chill, freeze and defrost food safely. Available at: https://www.food.gov.uk/safety-hygiene/chilling. Accessed 10 March 2022.
19. Fusté-Forné, F., and A. Hussain. 2021. We are open: understanding crisis management of restaurants as pandemic hits tourism. *J. Hospitality* 3:41–48.
20. Goode, A. 2020. Attitudes towards cooking in the home–including the impact of COVID-19. Available at: https://reports.mintel.com/display/988896/. Accessed 11 March 2022.
21. Gousto. 2022. Gousto. Available at: https://www.gousto.co.uk/. Accessed 17 June 2022.
22. Government of Canada. 2021. Safe food storage. Available at: https://www.canada.ca/en/health-canada/services/general-food-safety-tips/safe-food-storage.html. Accessed 31 March 2022.
23. Goyal, A., and P. Verma. 2021. Do it yourself effect on restaurants–the pandemic effect: driven by the fear appeal theory. *J. Hosp. Tour. Manage.* 48:76–87.
24. Griesel, T. 2021. 2020–Sustainability report. Available at: https://ir.hellofreshgroup.com/download/companies/hellofresh/Annual%20Reports/HF_Sustainability-Report-2020_EN_FINAL.pdf. Accessed 3 March 2022.

25. Hallman, W. K., A. Senger-Mersich, D. Schaffner, S. Godwin, F. Chen, and R. Stone. 2017. Food safety risk factors associated with home delivery of meat, game, poultry, and seafood products. Available at: https://www.food-safety.com/ext/resources/FSS_Event/2017/2017_Presentations/Home-Delivery.pdf?1520779775. Accessed 1 February 2022.
26. Heard, B. R., M. Bandekar, B. Vassar, and S. A. Miller. 2019. Comparison of life cycle environmental impacts from meal kits and grocery store meals. *Resource. Conserv. Recycl.* 147:189–200.
27. HelloFresh. 2022. Everything you need to know about meal kits. Available at: https://www.hellofresh.com/food-guide/meal-kits. Accessed 22 March 2022.
28. HelloFresh. 2022. HelloFresh. Available at: https://www.hellofresh.co.uk/. Accessed 8 March 2022.
29. Hertz, F. D., and B. Halkier. 2017. Meal box schemes a convenient way to avoid convenience food? Uses and understandings of meal box schemes among Danish consumers. *Appetite* 114:232–239.
30. Hill, B., and S. Maddock. 2019. (No) time to cook: promoting meal-kits to the time-poor consumer. p. 272–282. In J. Byrom and D. Medway (ed.), Case studies in food retailing and distribution. Woodhead Publishing, Duxford, UK.
31. Jefferson, A., L. Bortolotti, and B. Kuzmanovic. 2017. What is unrealistic optimism? Conscious. Cogn. 50:3–11.
32. Just Eat Takeaway. 2021. Our story. Available at: https://www.justeattakeaway.com/what-we-do. Accessed 18 April 2022.
33. Lopez-Galvez, F., P. A. Gomez, F. Artes, F. Artes-Hernandez, and E. Aguayo. 2021. Interactions between microbial food safety and environmental sustainability in the fresh produce supply chain. *Foods* 10:1655.
34. Maughan, C., S. Godwin, D. Chambers, and E. I. Chambers. 2016. Recipe modification improves food safety practices during cooking of poultry. *J. Food Prot.* 79:1436–1439.
35. Mickanuck, K. 2020. Investigating food safety implications of meal-kit delivery subscription services in Toronto. Available at: https://www.ryerson.ca/content/dam/occupational-public-health/PosterPDFs/2020/2020-katrina-mickanuc-investigating-food-safety-implications-of-meal.pdf. Accessed 1 February 2022.
36. Mihalache, O., D. Augustin, N. Loredana, I. Anca, and D. Borda. 2021. Food safety knowledge, food shopping attitude and safety kitchen practices among Romanian consumers: a structural modelling approach. *Food Control* 120:107545.
37. Miller, M. 2021. Online food delivery report. Available at: https://www.statista.com/study/40457/food-delivery/. Accessed 1 March 2022.
38. Mindful Chef. 2021. Sustainability report 2021. Available at: https://f.hubspotusercontent10.net/hubfs/8585017/MC_Sustainability%20report_2021_AW.pdf. Accessed 8 March 2022.
39. Mindful Chef. 2022. Mindful Chef. Available at: https://www.mindfulchef.com/. Accessed 17 June 2022.
40. Mintel. 2022. Waitrose teams up with Mindful Chef to launch recipe box service. Available at: https://reports.mintel.com/sinatra/oxygen/display/id=1118101?fromSearch=%3Ffreetext%3D%2522mindful%2520chef%2522. Accessed 11 March 2022.
41. Moores, C. J., L. K. Bell, M. J. Buckingham, and K. M. Dickinson. 2021. Are meal kits health promoting? Nutritional analysis of meals from an Australian meal kit service. *Health Promot. Int.* 36:660–668.
42. Murray, M., and L. Sinclair. 2022. Restaurant kits 2022: DIY meals from your favourite restaurants delivered to your home. Available at: https://www.stylist.co.uk/food-drink/restaurants-bars/restaurant-kits-diy-food-meal-deliveries/431899. Accessed 19 July 2022.
43. Panzone, L., S. Larcom, and P. She. 2021. Estimating the impact of the COVID-19 shock on UK food retailers and the restaurant sector. Available at: https://eprints.ncl.ac.uk/file_store/production/273097/E3E212AF-497F-4A42-84B8-31D400ACBEC9.pdf. Accessed 23 March 2022.
44. Park, E. 2021. HelloFresh launches online market for meal kit subscribers. Available at: https://www.supermarketperimeter.com/articles/6923-hellofresh-launches-online-market-for-meal-kit-subscribers. Accessed 9 March 2022.
45. Redmond, E., A. Curnin, C. Day, J. Morris, A. Eves, and M. Raats. 2018. Systematic review of the relative proportion of foodborne disease associated with food preparation or handling practices in the home. Available at: https://www.food.gov.uk/sites/default/files/media/document/fs101098fbdinthehome-technicalrep.pdf. Accessed 8 March 2022.
46. Redmond, E. C., and C. J. Griffith. 2003. Consumer food handling in the home: a review of food safety studies. *J. Food Prot.* 66:36.
47. Redmond, E. C., and C. J. Griffith. 2004. Consumer perceptions of food safety risk, control and responsibility. *Appetite* 43:309–313.
48. Richter, D. 2020. HelloFresh–Sustainability report 2019. Available at: https://ir.hellofreshgroup.com/download/companies/hellofresh/Annual%20Reports/HelloFresh_Sustainability_Report_2019_EN.pdf. Accessed 1 March 2022.
49. Salience Search Marketing. 2021. Meal delivery services 2021. In R. Waters (ed.), Annual insight report. Salience Search Marketing, Chester, UK.
50. Scott, E. 2003. Food safety and foodborne disease in 21st century homes. *Can. J. Infect. Dis.* 14:277–280.
51. Selwood, D. 2021. Tesco links with SimplyCook for "Let's Cook" in-store meal kits. Available at: https://www.thegrocer.co.uk/ranging-and-merchandising/tesco-links-with-simplycook-for-lets-cook-in-store-meal-kits/654808.article. Accessed 22 March 2022.
52. Spence, C., J. Youssef, and C. A. Levitan. 2021. Delivering the multisensory experience of dining-out, for those dining-in, during the COVID pandemic. *Front. Psychol.* 12:683569.
53. Statista. 2021. UK consumers: Online grocery shopping. Available at: https://www.statista.com/study/39216/uk-consumers-online-grocery-shopping-statista-dossier/. Accessed 1 February 2022.
54. Statista. 2022. Meal kits in the United Kingdom. Available at: https://www.statista.com/study/108464/meal-kits-in-the-united-kingdom/. Accessed 24 February 2022.
55. Sweeney, L. H., K. Carman, E. G. Varela, L. A. House, and K. P. Shelnutt. 2021. Cooking, shopping, and eating behaviors of African American and Hispanic families: implications for a culturally appropriate meal kit intervention. *Int. J. Environ. Res. Publ. Health* 18:9827.
56. Uber Eats. 2022. How Uber Eats works. Available at: https://about.ubereats.com/gb/en/. Accessed 18 April 2022.
57. Weller, J., G. Kaptan, R. Bhandal, and D. Battachery. 2022. Kitchen life 2: Literature review. Available at: https://www.food.gov.uk/print/pdf/node/8366. Accessed 5 April 2022.
58. World Health Organization. 2006. Five keys to safer food manual. Available at: https://www.who.int/foodsafety/publications/consumer/manual_keys.pdf. Accessed 28 March 2022.
59. You Magazine. 2020. M&S and Morrisons are both launching recipe boxes to rival the likes of Hello Fresh. Available at: https://www.you.co.uk/supermarket-recipe-boxes/. Accessed 22 March 2022.
60. You Magazine. 2021. The best restaurant meal kits to make at home. Available at: https://www.you.co.uk/restaurant-meal-kits-nationwide-uk-delivery/. Accessed 19 July 2022.
61. Young, I., and L. Waddell. 2016. Barriers and facilitators to safe food handling among consumers: a systematic review and thematic synthesis of qualitative research studies. *PLoS One* 11:e0167695.