

Research Paper

Identification of older adults' domestic risk factors associated with listeriosis

**Analysis of UK older adults' domestic kitchen storage practices: Identification of risk factors associated with listeriosis**

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**ABSTRACT**

Increased listeriosis incidence among older adults ( $\geq 60$  years) has been reported internationally with many cases reported to be sporadic and associated with ready-to-eat (RTE) food products with extended refrigerated shelf-life. Given the home kitchen is recognized as a significant location where foodborne illnesses are acquired, it is important consumers implement safe food practices to minimize risks. This is crucial for vulnerable consumer such as older adults. UK consumer food safety recommendations to reduce the risk of listeriosis at home include: (i) following 'use-by' dates on unopened pre-packed RTE food products, (ii) consuming RTE food products within two days of opening and (iii) ensuring the safe operating temperatures of domestic refrigerators ( $\leq 5^{\circ}\text{C}$ ). This study utilized observation, self-reported practices and microbiological analysis to determine actual food storage practices to identify behavioural risk factors. A domestic kitchen survey conducted in older adult consumers' ( $\geq 60$  years) domestic kitchens ( $n=100$ ) in South Wales, UK. Forty-one percent of foods in home refrigerators were beyond the 'use-by' date, of which 11% were unopened RTE food products commonly associated with listeriosis. Sixty-six percent of opened RTE foods had been or were intended to be stored beyond the recommended two days after opening. Older adults' failed to ensure safe refrigeration temperatures with 50% of central storage and 85% of door storage areas operating at temperatures  $> 5^{\circ}\text{C}$ . Older refrigerators operated at significantly ( $p < 0.05$ ) higher temperatures. Given that *Listeria monocytogenes* was isolated in 2% of kitchens, findings suggest that storage malpractices may have a greater impact on the potential risk of listeriosis than its presence alone. The study has determined many older adults fail to adhere to recommendations and subject RTE foods associated with *L. monocytogenes* to prolonged storage at unsafe temperatures which may render food unsafe for consumption.

*Listeria monocytogenes* is the only species of *Listeria* that is pathogenic to humans (2) and is the causative pathogen of the rare but potentially life-threatening listeriosis (47, 72). Although incidence is not as prevalent as other foodborne pathogens, *L. monocytogenes* is associated with one of the highest mortality rates among foodborne pathogens in the USA (8, 74) and Europe (18), listeriosis is described as being the foremost foodborne pathogen responsible for mortality in the UK (30) with around 90% of listeriosis cases resulting in hospitalization (36, 51) and 41% of cases resulting in mortality (68).

Vulnerable groups of consumers, such as those with weakened immunity are more susceptible to becoming ill with foodborne disease (60); this is particularly the case with *L. monocytogenes*, as an increased risk of invasive listeriosis exists among immunocompromised people and the elderly (41). Listeriosis can be particularly fatal among such high-risk populations (18) vast data exist reporting on the incidence and increased risk of listeriosis among older adults (20, 38, 39, 43, 58, 69, 78, 84). The World Health Organization (WHO) reported that adults aged  $\geq 60$  years are 2.6 times more susceptible than the general healthy population from the risk of serious illness as a result of consuming high concentrations of *L. monocytogenes* (26).

Data indicate that incidence of listeriosis over the last decade has reportedly increased among adults aged  $\geq 60$  years (21) and particularly among adults over 70 years of age (37). Previously (1990s), 30% of incidence were related to adults aged  $\geq 60$  years (71), whereas recent international data (2000 onwards) indicates that between 58 – 66% of listeriosis incidence is associated with adults  $\geq 60$  years (46, 82), UK incidence has more than doubled (2001 – 2007) (34) and 88% of UK cases are ‘non-pregnancy associated infections’ (35). The increased incidence of listeriosis since 2000 has occurred almost exclusively among adults aged over 60 years with *Listeria* bacteremia ACMSF (1). Up to 70% of listeriosis mortality is associated with adults  $\geq 65$  years (9). However the reason for such an increase is not known (33).

The majority of listeriosis cases are reported to be sporadic (33, 58). It is believed that a large number of sporadic cases of foodborne illness may be attributed to the domestic kitchen (27) occurring

as a result of improper food handling and storage practices by consumers (70, 75). Up to 70% of foodborne illness mortality has been reported to be associated with food consumed at home (87). Consequently the consumer handling and storage of foods in the domestic kitchen is of critical importance as the consumer is widely recognized as having the final line of defense in ensuring food safety (53, 70, 75).

To ensure the food safety properties of such RTE food products are maintained, the UK Food Standards Agency (FSA) and Department of Health (DOH) (19), the European Centre for Disease Prevention and Control (22) and the U.S.A. Centers for Disease Control and Prevention (15) have consumer food safety recommendations that relate specifically to time and temperature control of RTE food products that will support the growth of *L. monocytogenes*. Recommendations to reduce the risks associated with listeriosis in the home which include, (i) following 'use-by' dates on unopened pre-packed RTE food products, (ii) consuming RTE food products within two days of opening and (iii) ensuring the safe operating temperatures of domestic refrigerators ( $\leq 5^{\circ}\text{C}$ ).

Due to the psychrotrophic characteristics of *L. monocytogenes*, the pathogen has the ability to survive and grow at refrigeration temperatures (1, 11) and extended storage of contaminated food products may allow high concentrations to be reached (13). Consequently, the foods that are typically associated with listeriosis, are often ready-to-eat (RTE) food products, that do not require any further processing such as cooking prior to consumption by the consumer (42), have extended refrigerated shelf life (49) and have the ability to support the growth of *L. monocytogenes* to a high concentration (25). These RTE foods include meat products (31, 62, 83), smoked fish products (28, 29, 31), sandwiches (59, 86), dairy products (3, 57), soft cheeses (6, 7) and cantaloupe (16). Market intelligence suggests that such RTE food products are purchased, stored and consumed in the homes of older adult consumers (64).

Data regarding the implementation of food consumption, handling and storage practices by older adult consumers in the domestic kitchen are lacking. The U.K. Advisory Committee on the Microbiological Safety of Food (ACMSF) report on the increased incidence of listeriosis in the UK

identified a need to determine the food storage and consumption behaviours of adults aged  $\geq 60$  years to determine factors that contribute to the risk of listeriosis (1). A review of consumer food safety studies determined that observational data on food safety practices are required to understand the risk of listeriosis in the domestic kitchens of older adult consumers (24).

Consequently, the aim of this study was to determine the actual food handling and storage practices of older adult consumers ( $\geq 60$  years of age) in their home kitchens to identify key behavioural risk factors associated with listeriosis. The microbiological and behavioural findings of this study could be used to help inform targeted food safety educational approaches to improve implementation of key risk reducing behaviours that could reduce the risk of listeriosis in the domestic kitchens of older adults.

## MATERIALS AND METHODS

One hundred older adult consumers were recruited (by methods including online advertising and posters on community notice boards) and consented to participate in the study. Predetermined recruitment criteria included being aged  $\geq 60$  years, living independently and not in residential care homes, from South Wales, UK and reported being responsible for preparing and storing raw and RTE food products at home. Participant homes were visited on one occasion during which microbiological samples were taken, observed and self-reported data were recorded using a structured checklist. The checklist included observed storage practices of RTE food products associated with listeriosis, refrigeration temperatures, and self-reported storage, cleaning and refrigeration practices. Supermarket vouchers for £10 were offered to participants as an incentive for participation in the study. Ethical approval was granted from the Cardiff School of Health Sciences (Cardiff Met) Research Ethics Committee (Ref 2221).

**In home domestic kitchen checklist.** A detailed, structured domestic kitchen checklist was devised to record observed and self-reported practices relating to the three key recommended practices

to reduce the risks associated with *L. monocytogenes*. The checklist included recording refrigerator operating temperatures, conditions of surfaces sampled including presence of moisture and food debris, the presence/absence of food products associated with *L. monocytogenes* prevalence such as smoked fish products, pâté, cured delicatessen type meats, RTE meat and soft cheeses. Furthermore, self-reported storage practices of opened RTE foods and observed adherence to ‘use-by’ dates on sealed RTE foods was recorded on the checklist. Depending on the presence of these food products observed being stored in the home kitchen, self-reported practices were determined relating to the storage length of such food products and intended storage prior to consumption or disposal.

**In home domestic refrigerator operating temperatures.** The operating temperature of two locations (central storage location and in the refrigerator door) in older adults’ domestic refrigerators were recorded by using two calibrated digital hand held battery powered thermometer probes (P300 handheld thermometer; Industrial Temperature Sensors Co. Kildare, Ireland; measuring range: -40°C to +200°C, accuracy:  $\pm 1.0^\circ\text{C}$ ). Probes were left in the refrigerator for <5 minutes or until temperature readings stabilized. Participants were also asked specific questions relating to refrigeration practices such as frequency and method of checking refrigeration temperatures.

**Microbiological sampling of domestic kitchen surfaces.** A systematic review of literature was conducted to determine commonly used domestic kitchen surfaces previously implicated as reservoirs of bacterial contamination and particularly *L. monocytogenes* (40, 73, 76). This data informed selection of sites for microbiological sampling. Surfaces included storage areas of the refrigerator (RTE food storage area, raw meat storage area, salad drawer, drip tray and the refrigerator door handle) the sink draining board, hot water tap handle, kitchen worktop surfaces, chopping boards and knives. Items used for cleaning (dishcloths and sponges) were removed from participants kitchens for analysis and replaced with new. Participants were asked about their previous and usual usage and cleaning of sampled surfaces and equipment, and the replacement frequency of cleaning materials sampled.

A sterile in-tube swab (Swab viscose tip in tube breakpoint at 45mm sterile; TS19-P, Technical Service Consultants, Lancashire, UK) pre-moistened in maximum recovery diluent (MRD; CM0733, Oxoid Ltd, Hampshire, UK) swabbed a 10cm X 10cm representative sample of each predetermined site, with the exception of the hot tap handle and a knife blade, which were swabbed entirely. Items such as 'in use' dishcloths and sponges, were removed in a sterile stomacher bag (MPR-417-020Y, Seward Medical Ltd, Worthing) sealed with stomacher bag clips (FB51919 Fisherbrand, Fischer Scientific, Loughborough).

All swabs and items were transported from the domestic kitchens for analysis at the research laboratories of Cardiff Metropolitan University within 1 hour of sampling in an insulated cool-bag with ice packs to ensure that transportation conditions did not promote microbiological growth (77). The method of transportation was validated, and the temperature within the cool-bag with ice packs remained <5.0°C for up to 3 hours post sampling.

Health Protection Agency Standard Methods for the detection and enumeration of *L. monocytogenes* (45) were followed. Swabs were immersed in half Fraser broth (Fraser broth base CM0895, supplemented with half Fraser supplement SR0166, Oxoid Ltd, Hampshire, UK) and vortexed for one minute. Primary enrichment broths were incubated at 30°C for 24 hours. Following incubation, a secondary enrichment stage was carried out by sub-culturing 0.1mL of the primary enrichment broth using a calibrated pipette (Pipetman Neo\_P100N, Gilson, France) to 10mL of Fraser broth (Fraser broth base CM0895, supplemented with Fraser supplement SR0156, Oxoid Ltd, Hampshire, UK). Secondary enrichment broths were incubated at 37°C for 48 hours.

Following incubations, 0.5mL of the primary enrichment broths and the secondary enrichment broths were inoculated onto two types of *Listeria* selective agars plates, Oxford agar (*Listeria* Selective Agar Base, Oxford formulation CM0856 supplemented with *Listeria* Selective Supplement, Oxford formulation SR0140, Oxoid Ltd) and Chromogenic agar (Brilliance™ *Listeria* Agar Base CM1080; supplemented with Brilliance™ *Listeria* Selective Supplement SR0227 and Brilliance™ *Listeria* Differential Supplement SR0228, Oxoid Ltd) and spread using sterile L-shape polystyrene

spreaders (TS30-C, Technical Service Consultants). Plates were dried for 20 minutes to ensure absorption of the inoculum before being inverted and incubated at 37°C for 24 hours. Following incubation, the plates were examined for the presence of typical colonies (44).

Up to five typical colonies from the Chromogenic agar plates were sub-cultured by a single stab and streaking inoculation to horse blood agar (Blood Agar Base CM0055, enriched with 7% Defibrinated Horse Blood SR0050, Oxoid Ltd). Plates were incubated at 37°C for 24 hours. Following incubation plates were examined for beta hemolysis. Verification using presumptive colonies from the non-selective horse blood agar involved performing a biochemical identification test (API *Listeria* identification 10-300, bioMérieux, France) following manufacturer's instructions to determine the species of *Listeria* (12).

**Data analysis.** Quantitative and qualitative data including self-reported and observed data collected from older adults' home kitchens were entered and stored in a specifically designed Microsoft Access 2010 (Microsoft; Redmond, WA, USA) database. Microbiological data were stored and analyzed using Microsoft Excel 2010 (Microsoft; Redmond, WA, USA). Descriptive and inferential statistics were conducted using SPSS Statistics 20 (IBM® Software Group; Chicago, IL, USA).

## RESULTS

**Respondent demographic.** A total of one hundred older adults' domestic kitchens in South Wales, UK were visited to conduct the survey. Of the kitchens surveyed 44% were reported to be single person households. Eighty percent of females reported being responsible for the majority of food preparation and storage practices, the majority (86%) of those responsible for food preparation and storage practices were 'retired'. Most of older adults were observed to store and consume foods commonly associated with *L. monocytogenes* in their domestic refrigerator at the time of the study.

**Self-reported storage practices of opened RTE foods.** The majority (68%) of older adults' domestic refrigerators in this study contained at least one RTE food product associated with prevalence of *L. monocytogenes*. In total, 69% of the RTE food products associated with listeriosis were observed to have been opened and returned to the refrigerator for storage, of which, over a third (36%) had been left uncovered. Soft cheese observed stored in older adults domestic refrigerators, 68% were reported to have been stored for longer than the recommended two days after opening, although 32% had not been stored beyond the recommendations, it was reported that they would be stored beyond recommendations with the intention of consuming.

A third (35%) of the opened RTE food products were reported to have been stored for longer than the recommended two days after opening (19) at the time of the study (See Table 1). Furthermore, it was reported that 30% of those food products that had been opened for less than two days were intended to be stored beyond the two days. Consequently, 66% of opened RTE foods had been or were reportedly intended to be stored beyond the UK recommendation of two days after opening for further consumption. In total, 70% of older adults reported that RTE food products associated with *L. monocytogenes* would be stored for longer than recommendations.

**Observed adherence to 'use-by' dates on sealed RTE foods.** Overall, 41% of refrigerators in older adults' home kitchens in this study contained food products that were beyond the 'use-by' date, of which 11% were sealed RTE food products commonly associated with listeriosis (see Table 1). Furthermore, 12% of opened RTE food products associated with listeriosis were also observed to be beyond the 'use-by' date. Additionally 67% of the older adults in this study believed it a 'safe' practice to consume RTE food products beyond the 'use-by' date (23).

**In home domestic refrigerator operating temperatures.** The majority of domestic refrigerators in older adults' home kitchens in this study were found to be operating at temperatures exceeding recommendations ( $\leq 5.0^{\circ}\text{C}$ ) for the safe storage of foods. As indicated in Figure 1, operating temperatures ranged from  $0.2^{\circ}\text{C}$  to  $17.4^{\circ}\text{C}$ , with temperatures exceeding  $5.0^{\circ}\text{C}$  determined in 50% of central storage areas and 85% of refrigerator door storage areas. Differences were determined

between the operating temperatures of the central storage areas and the door storage areas of refrigerators. On average there was a 2.0°C (S.D.  $\pm$  1.8°C) difference between the operating temperatures of the central storage areas and the door storage areas of refrigerators, the greatest difference recorded was 8.3°C.

On average, reported age of refrigerators was 8 years, with age ranging from 4 months to 40 years. Statistical analysis using a Pearson product-moment correlation coefficient determined that a significant relationship existed between the reported age of refrigerators and the operating temperature (Central storage area  $r = 0.22$ ,  $n = 100$ ,  $p < 0.05$ . Door storage area  $r = 0.29$ ,  $n = 100$ ,  $p < 0.01$ ). Findings indicated that older refrigerators were determined to be operating at significantly higher temperatures.

**Presence of *L. monocytogenes* in older adults' domestic kitchens.** A total of 1026 swabs were taken from the domestic kitchens of 100 older adults. Microbiological results determined the presence of *Listeria* spp. in 7% of older adult kitchens, of which 2% were *L. monocytogenes*, both of which were on hand contact surfaces, one refrigerator door handle and a hot water tap handle (see Table 2).

## DISCUSSION

The majority of older adults were observed to store and consume foods commonly associated with *L. monocytogenes* in their home kitchen domestic refrigerator at the time of the study. This concurs with various market research reports that suggest older adults are the greatest consumer group of such foods (65-67). Findings from this study suggest that older adults fail to implement practices to safeguard such food during storage in the domestic kitchen.

**Self-reported storage practices of opened RTE foods.** The shelf-life of RTE foods can be extended by utilizing modified atmosphere packaging (MAP) (5, 80) which changes the environment within the packaging, however after opening aerobic growth resumes, and in the case of RTE meat, populations of *L. monocytogenes* will increase after opening if present (81). After opening MAP food products, it is essential for consumers to avoid prolonged storage to reduce the risk of *L.*

*monocytogenes* growing to a dangerous level. UK consumer food safety guidance recommends after opening, RTE foods should be stored and consumed within two days (19). Previous research has indicated that the majority of consumers report consumption of foods within 2 days of purchase/opening (61), however, data specific to the older adult adherence to such recommendations were previously lacking (24). This study has determined that of the opened RTE foods associated with listeriosis in older adults' home kitchen domestic refrigerators, 66% had been or were reportedly intended to be stored beyond the recommended two days after opening. Consequently, prolonged storage of RTE foods after opening may increase the risks associated with listeriosis, although many studies have determined the impact of storage and packaging on *L. monocytogenes*, data on the impact of consumer storage practices on growth is lacking (88).

**Observed adherence to 'use-by' dates on sealed RTE foods.** 'Use-by' dates on RTE foods are calculated based on shelf-life studies of recommended storage times and temperatures, to ensure that the limit of 100 CFU/g *L. monocytogenes* will not be exceeded at any point between its production and consumption (14), thus ensuring that food products remain safe for consumers (85). It is therefore critical that consumers adhere to the 'use-by' dates on foods to ensure food safety of the food that they consume. Data suggests that although the purpose of 'use-by' dates is reportedly understood by older adults, however such dates may not always be adhered to (48). Comparison of observed adherence to 'use-by' dates determined in this study with existing data is problematic as previous studies have determined adherence to 'use-by' dates for food products that were not specifically associated with *L. monocytogenes* and were in the homes of consumers from the general population; actual behavioural data regarding older adults adherence to 'use-by' dates is lacking (14, 24). In this study, 23% of food products associated with listeriosis were observed to be beyond the 'use-by' date. Such practices may increase the risk of listeriosis as presence of *L. monocytogenes* is reported to be greatest in RTE foods beyond their expiration dates (32, 59). Older adult consumers should be encouraged to purchase smaller quantities to limit storage time and ensure that 'use-by' dates are adhered to.

**In home domestic refrigerator operating temperatures.** The safety of food is reported to be significantly impacted by refrigeration practices in the domestic kitchen (55), particularly RTE food

products associated with *L. monocytogenes*, as the pathogen is a psychrotrophic mesophile which can grow at refrigeration temperatures (2). Consequently, there is a need for consumers to ensure that their domestic refrigerators operate at temperature  $\leq 5.0^{\circ}\text{C}$  to ensure food safety (19). Previous data on the actual operating temperatures of domestic refrigerators are not easily comparable due to small sample sizes and recommended safe refrigeration temperatures varying in different countries, however such data suggest that between 70 - 81% of temperatures recorded from older adult domestic kitchen refrigerators were reported to operate above recommended temperatures (48, 52), which corresponds with the findings of this study that up to 85% of refrigerators in older adults' domestic kitchens have temperatures  $>5.0^{\circ}\text{C}$ . This may have implications for food safety given that the generation time of *L. monocytogenes* decreases substantially when storage temperatures increase (56), thus increasing the risk of listeriosis.

**Presence of *L. monocytogenes* in older adults' domestic kitchens.** Given the recognized potential of the domestic kitchen in the role of transmitting foodborne disease (70, 75); the implementation of hygienic practices by consumers to reduce the presence of *L. monocytogenes* is of importance. Although isolation of *L. monocytogenes* and *Listeria* spp. in the domestic kitchen may indicate the need for older adult consumers to implement greater hygiene practices, findings were similar to those determined by other studies which isolated *Listeria* spp. in 2.1 – 8.0% (4, 10, 17, 75) of sites of domestic kitchens and individual isolates of *L. monocytogenes* were determined (63, 79) and isolated in 5.4% of sinks (54), and 1.2% (50) – 3.5% (4) of refrigerators; isolation of *L. monocytogenes* in this study was less frequent than previously reported in general consumers' domestic kitchens.

Self-reported and observed storage malpractices of RTE food products commonly associated with *L. monocytogenes* in older adults home kitchens determined in this study may increase the risk of listeriosis. Indeed, findings may suggest that prolonged storage and inadequate temperatures may have a greater impact on the potential risk of listeriosis than the presence of the pathogen in the domestic kitchen alone.

However, the limitations of this study must be considered that a single temperature was recorded, this does not account for temperature fluctuation during conventional domestic use. Further consumer research is required to validate the reliability of a single temperature recording as an indicator of typical operating temperatures. The findings of this study not only contribute to an identified gap of knowledge relating to older adult consumers actual food safety behaviours, but have identified potential behavioural risk factors associated with *L. monocytogenes* in the domestic kitchen. The study has determined through the means of observation that older adults fail to safeguard themselves from opportunistic pathogens in their own home kitchens by failing to adhere to recommendations to reduce the risks associated with listeriosis. Non-adherence to 'use-by' dates was observed by many older adults during the domestic kitchen survey; prolonged storage of RTE food products beyond the recommended two days after opening was widely reported and the majority of domestic refrigerators were discovered to be operating at temperatures exceeding the recommended  $\leq 5.0^{\circ}\text{C}$ .

This indicates that older adults fail to adhere to recommendations and subject RTE foods associated with *L. monocytogenes* to prolonged storage at unsafe temperatures which may increase the risks associated with listeriosis. Consequently, there is a need to determine the potential effect of identified food storage malpractices on *L. monocytogenes* growth in RTE food products by re-enacting domestic storage practices in the laboratory environment

The presence of *L. monocytogenes* in home kitchens may suggest the need for older adult consumers to improve domestic hygiene practices, however, observed and reported implementation of food safety malpractices were more common than the detection of *L. monocytogenes*. Findings suggest a need for targeted consumer food safety education to improve food handling and storage practices among older adult consumers to reduce the risk factors associated with listeriosis in the domestic kitchen.

There is a need to combine 'in home' observational and microbiological domestic kitchen findings from this study with actual food preparation handling practices observed in a model domestic kitchen in conjunction with social cognitions such as knowledge, attitudes, beliefs and self-reported practices.

This will provide a more detailed understanding of older adult consumers' domestic food handling practices and safety behaviours in the home kitchen. Such findings would enable food safety educators to better understand cognitive and behavioural risk factors of older adults that may impact on the risks associated with listeriosis. This will facilitate and inform the design and development of targeted food safety education for older adults to reduce incidence of listeriosis.

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