

# Addressing the Lack of Cognitive and Behavioural Research Detailing Older Adult Consumer's Food Safety Risks Associated with Listeriosis.

Ellen W. Evans\* and Elizabeth C. Redmond

ZERO2FIVE Food Industry Centre, Food and Drink Research Unit, Cardiff Metropolitan University, Wales, UK.

\*Corresponding author: elevans@cardiffmet.ac.uk

## Introduction

*Listeria monocytogenes*, responsible for human listeriosis, is associated with highest foodborne pathogen hospitalisation<sup>1</sup> and mortality rates.<sup>2,4</sup>

Since 2000, incidence of listeriosis has predominantly been associated with adults ≥60 years<sup>5</sup> which has increased significantly.<sup>6,7</sup>

Due to the psychrotrophic characteristics of *L. monocytogenes*,<sup>8</sup> international consumer food safety recommendations to reduce the risk of listeriosis in the home, relate to time and temperature control of ready-to-eat (RTE) foods<sup>9-11</sup> and are identified as:

- Adhering to 'use-by' dates on unopened RTE food products.
- Avoiding prolonged storage of opened RTE food products, by consuming within two days of opening.
- Ensuring the safe operating temperatures (≤5.0°C) of domestic refrigerators.

The UK Food Standards Agency<sup>12</sup>, the Advisory Committee on the Microbiological Safety of Food in Europe<sup>9</sup> and the U.S. Food and Drug Administration<sup>13</sup> all recommended research was required to determine domestic food handling and storage practices of consumers ≥60 years to better understand the risk factors that may be associated with listeriosis.

Bringing cognitive and behavioural data together may be of benefit.

## Purpose

To address the identified need for research, the project aimed to

- Determine older adult consumers' (≥60 years) cognitive and behavioural risk factors of domestic food handling and storage practices associated with listeriosis risk factors.

- Evaluate the potential impact of older adults' domestic food handling and storage practices on *L. monocytogenes*.

Combining findings from cognitive, behavioural and microbiological studies strengthens our understanding of consumer food safety risks such as listeriosis to older adults.

## Methods

To address the aim of the research, the project was completed in a number of research studies consisting of three phases:

- **Phase one:** a desk-based review of consumer food safety studies ( $n=165$ ) to identify data detailing older adults food storage practices relating to listeriosis<sup>14</sup>
- **Phase two:** a mixed-methods approach involving older adults (≥60 years) ( $n=100$ ) which included:
  - Computer-assisted interviews regarding perceptions and attitudes towards domestic food-safety<sup>15</sup>
  - Self-complete questionnaires concerning food safety knowledge and self-reported practices<sup>16</sup>
  - Observation of food safety behaviour in a model domestic kitchen<sup>17</sup>
  - Observational survey of domestic kitchen storage practices<sup>18</sup>
  - Domestic kitchen microbiological survey to isolate *Listeria* spp.<sup>19</sup>
  - Domestic refrigerator time-temperature profiling<sup>20</sup>

Findings from phase two were combined to give a cumulative cognitive and behavioural comparison of older adults' domestic risk factors associated with listeriosis<sup>21,22</sup>

- **Phase three:** observed and self-reported storage malpractices identified in phase two, informed the development of a laboratory based re-enactment to determine the potential impact of older adults domestic food storage practices on *L. monocytogenes* survival and growth<sup>23</sup>

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## Results

### Phase two: Cognitive, behavioural and microbiological study of older adults ( $n=100$ )

One hundred older adults (≥60 years) participated in the mixed-methods research study. A cumulative comparison of older adult consumers' knowledge, attitudes, self-reported practices and observed behaviour data of listeriosis risk factors is presented in Table 3.

Table 3. Cumulative comparison of older adults' ( $n=100$ ) knowledge, attitudes, self-reported and behaviours relating to key practices associated with listeriosis.

	Knowledge	Attitudes	Self-reported practices	Actual behaviour
Following 'use-by' dates on RTE foods	72% knew that the 'use-by' date was the best indicator of food safety.	66% had a negative attitude towards consuming food with expired 'use-by' dates.	57% reported keeping and consuming food beyond the 'use-by' dates.	41% of domestic refrigerators contained RTE food products with expired 'use-by' dates.
Adequate refrigeration temperature (≤5°C)	87% did not know the recommended refrigeration temperatures (5°C).	52% had a positive attitude towards checking the operating temperature of the refrigerator	65% reported to never check refrigerator temperature.	<85% of domestic refrigerators were operating at temperatures ≥5°C.
Consuming RTE food within two days of opening	16 – 44% aware that RTE food should be consumed within two days of opening	68% had a positive attitude towards the importance of consuming RTE food within two days of opening	72% failed to report that RTE food would 'always' be consumed within two days of opening	30% of refrigerators that had opened RTE foods had been opened longer than the recommended two days.

#### Following 'use-by' dates on unopened RTE food products.

Discrepancies were determined, 62% reported to 'always' look at 'use-by' date, however 57% reported consuming food with expired 'use-by' dates.

A negative attitude towards 'use-by' dates was significantly associated ( $p<0.001$ ) with self-reporting to consume foods beyond the 'use-by' date

No significant associations ( $p>0.05$ ) were determined between cognition and observed practices relating to 'use-by' date adherence.

#### Ensuring refrigerator operating temperature is ≤5.0°C

Despite 79% expressing positive attitudes towards importance of refrigeration, only 52% had positive attitudes towards checking temperatures.

A positive attitude towards checking the temperature was significantly associated ( $p<0.001$ ) with reporting to 'always' check the temperature.

Self-reported frequency of checking operating temperature was significantly associated ( $p<0.05$ ) with actual operating temperatures. Those reporting to check the temperature were more likely of having refrigerators operating at recommended temperatures.

#### Consuming RTE food within two days of opening.

A positive attitude towards consuming foods within two days of opening was significantly associated ( $p<0.005$ ) with reporting to 'always' implement the practice. Knowledge of the recommendation was significantly associated ( $p<0.05$ ) with self-reported frequency of consuming food products within recommended two days after opening.

No significant associations ( $p>0.05$ ) were determined between observed storage behaviour and cognition.

### Phase one: Review of consumer food safety cognitive and behavioural studies ( $n=165$ )

Cumulatively, 165 published consumer food safety studies, undertaken between 1993 and 2013, from 20 different countries, were included for review. The majority of studies were undertaken in the USA (40%) and the UK (21%) other countries of origin for studies included the Netherlands (6%), Ireland (5%) and Australia (4%), thus indicating that consumer food safety is of international interest.

#### Inclusion of listeriosis related practices

The review determined only 41% of studies included consumer data associated with food safety recommendations to reduce the risk of listeriosis (see Table 1). Of these studies, questionnaires/interviews were most frequently utilised; and the majority of findings were based on self-report (74%) and knowledge (44%). Observation of behaviour was less frequently utilised (31%).

Table 1. Inclusion of food safety behaviours required to reduce risks of listeriosis in reviewed consumer food safety studies ( $n=165$ )

Recommended food safety practices	Of studies (%)
*Use-by' date adherence	20%
Storage length of opened RTE foods	22%
Safe refrigeration temperature	24%
Inclusion of one or more practices	41%

As detailed in Table 2, consumers may indicate awareness or have positive attitudes towards recommendations to reduce the risks associated with listeriosis, however concurring with other general food safety research,<sup>24</sup> self-reported practices and actual behaviours did not correspond. Although discrepancies have been determined between different studies, there is a lack of research that compares consumer behaviour and cognition specifically relating to consumer food safety risk factors associated with listeriosis

Table 2 Consumer (general population) knowledge, attitudes, self-reported practices and actual behaviour relating to food safety practices required to reduce risks of listeriosis in reviewed consumer food safety studies.

	Knowledge	Attitudes	Self-reported practices	Actual behaviour
'Use-by' date adherence	49 – 62% aware 'use-by' date was the best indicator of food safety	73 – 75% believed avoiding foods with expired dates to be important	18 – 56% reported to 'never' eat food beyond its expiry date	41 – 89% had foods beyond expiry dates in refrigerators
Refrigeration temperatures	44 – 93% unaware of recommended refrigeration temperatures	97% believed ensuring correct refrigerator temperature important	0 – 24% reportedly to own a refrigerator thermometer	47 – 81% refrigerators exceeded recommended temperatures
Storage of opened RTE foods	96% aware that storage of food may be hazardous	No data available	40 – 69% reported 'always/usually' follow storage instructions	No data available

*Although studies indicated many consumers reported awareness of 'use-by' dates and indicated positive attitudes towards their importance, self-reported practice and actual behavioural data suggest that consumers frequently fail to adhere to 'use-by' dates.*

*A positive attitude towards the importance of refrigeration temperatures did not correspond with knowledges of safe temperature, self-reported practices of checking refrigerator temperature, Furthermore, temperatures recorded in domestic refrigerators exceeded recommendations.*

*Knowledge, attitudinal, self-reported and actual behavioural data on consuming opened RTE food within two days were lacking, however data suggest that foods associated with listeriosis may be subject to prolonged storage.*

#### PHASE ONE OUTCOMES

The review of consumer food safety research studies determined:

- Actual behaviour and attitudinal data relating to listeriosis risk factors are particularly lacking.
- Majority of data details food safety cognition associated with the general population. Data detailing older adult consumers, were included in only 7% of reviewed studies.

#### PHASE TWO OUTCOMES

The in-depth cognitive, behavioural and microbiological analysis of listeriosis risk factors associated with older adults determined:

- Prolonged storage of RTE foods and inadequate refrigeration temperatures (>5.0°C) was widespread among older adults.
- *L. monocytogenes* was seldom isolated in older adults' domestic kitchens (2%).

### Phase three: Laboratory re-enactment of observed storage malpractices ( $n=550$ )

Observed and self-reported data from phase two were utilised to inform the laboratory based re-enactment of storage practices to determine the potential impact for growth of *L. monocytogenes*.

#### Re-enacted storage conditions.

Re-enactment occurred using soft-cheese and RTE meat inoculated with ~3.7 log CFU *L. monocytogenes*, stored at recommended refrigeration temperatures (2.5°C) ( $n=110$ ); refrigeration temperatures exceeding recommendations (7.8°C) ( $n=110$ ) and ambient temperature (19.5°C) ( $n=55$ ). Samples were analysed every 24h for <21d.

#### Growth of *Listeria monocytogenes*.

Results indicated *L. monocytogenes* grew at all storage temperatures (Table 4). Generation times indicated slower growth of at 2.5°C (94h t<sup>-1</sup>) than at 7.8°C (21.5h t<sup>-1</sup>) and 19.5°C (11h t<sup>-1</sup>).

Table 4. Growth rate (μ hour<sup>-1</sup>) and generation times (hours t<sup>-1</sup>) of *L. monocytogenes* at 2.5°C 7.8°C and 19.5°C.

Storage Temperature (°C)	Growth rates (μ hour <sup>-1</sup> )		Generation times (hours t <sup>-1</sup> )	
	RTE Ham	Soft cheese	RTE Ham	Soft cheese
2.5°C± 2.2	0.012	0.022	58.9	32.1
7.8°C± 0.4	0.029	0.031	23.7	22.0
19.5°C± 1.2	0.061	0.036	11.4	11.2

Storage of RTE ham and soft cheese at temperatures exceeding recommendations had a statistically significant impact on mean populations (Figure 1), the growth rate, generation rate and maximum population of *L. monocytogenes* when compared to storage at recommended storage temperatures.

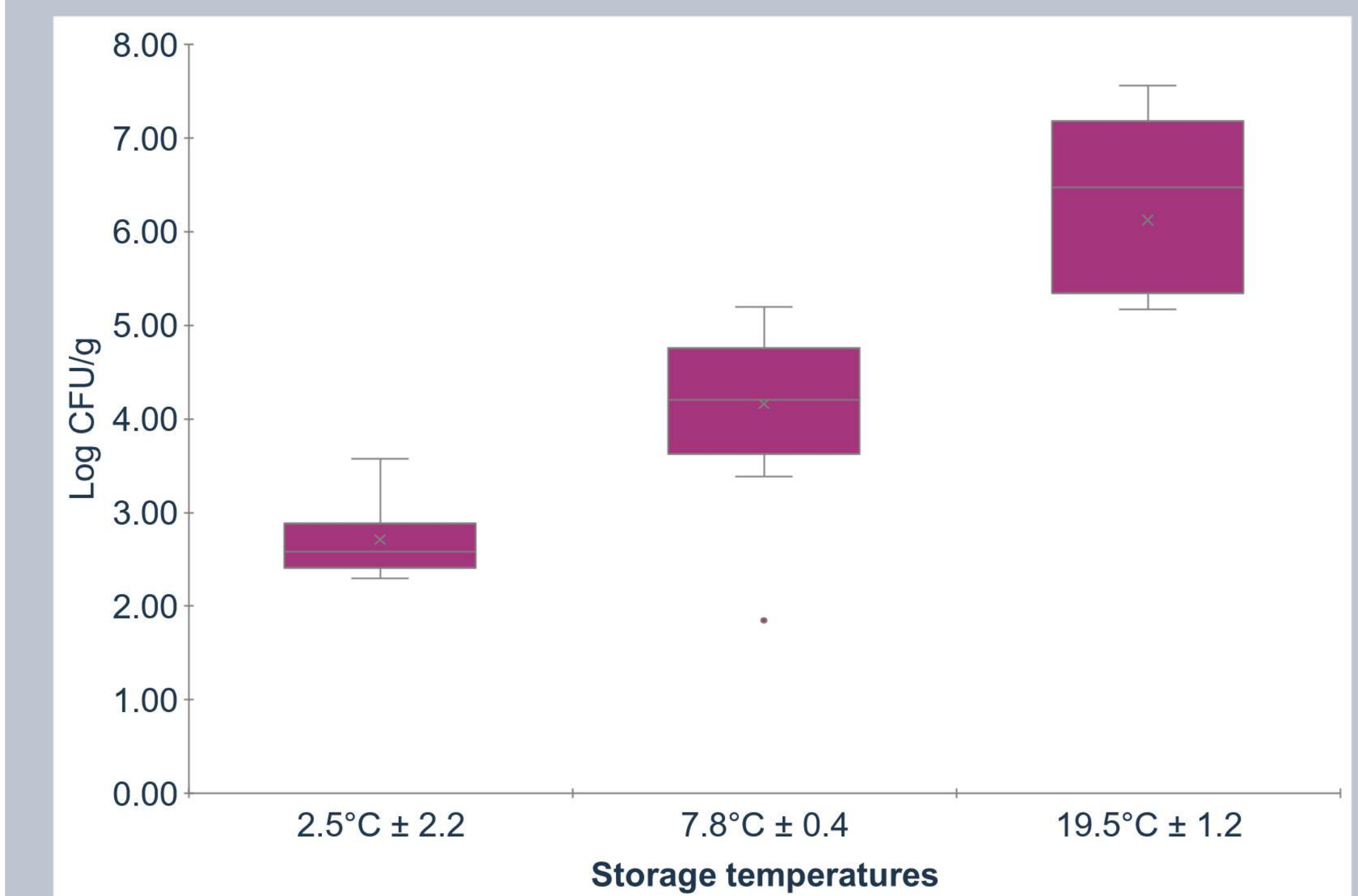


Figure 1. Boxplot illustrating the mean *L. monocytogenes* populations (log CFU/g) in RTE ham at three different domestic storage temperatures (2.5°C ± 2.2 for ≤21 days; 7.8°C ± 0.4 for ≤21 days and 19.5°C ± 1.2 for ≤10 days).

#### PHASE THREE OUTCOMES

The re-enactment of observed and self-reported food storage practices of older adults determined:

- Storage of RTE foods at temperatures exceeding recommendations for prolonged periods increased *L. monocytogenes* populations.
- Domestic storage conditions exceeding recommended consumer refrigeration temperatures alone increased *L. monocytogenes* more so than prolonged storage at recommended temperatures.

## Significance of study

- This research has taken a novel approach to address the identified lack of older adult data relating to listeriosis. An innovative combination of research methods, allowed for a cumulative comparison of cognitive, behavioural and microbiological data of older adults' domestic food safety practices.
- Malpractices were determined to be greater among older adults than literature suggests for the general population. Findings provide important insight on domestic food safety practices that can be utilised to inform development of targeted food safety education.
- Given that unsafe refrigeration temperatures and prolonged storage of RTE foods were identified, and that such storage malpractices were determined to be more widespread than the isolation of *L. monocytogenes*, findings suggest that storage malpractices are a greater risk factor for listeriosis than presence and potential cross-contamination of the pathogen.
- Additionally, by means of laboratory re-enactment, identified storage malpractices by older adults in the home kitchen have been ascertained to significantly increase the growth of *L. monocytogenes* in RTE food, thus increasing the relative risk of listeriosis among older adult consumers.

## Older adult consumers' domestic food storage practices increase the growth of *L. monocytogenes* in RTE food products.

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