FS101098

Appendices

Systematic review of the relative proportion of foodborne disease associated with food preparation or handling practices in the home

Report prepared on behalf of the Food Standards Agency by

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Based on research conducted by Mr Christopher Day[3], Mrs Jenny Morris MBE[3], Professor Anita Eves[4] and Professor Monique Raats[4]

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Chartered Institute of Environmental Health

FOOD, CONSUMER BEHAVIOUR & HEALTH RESEARCH CENTRE

Cardiff Metropolitan University | Prifysgol Metropolitan Caerdydd

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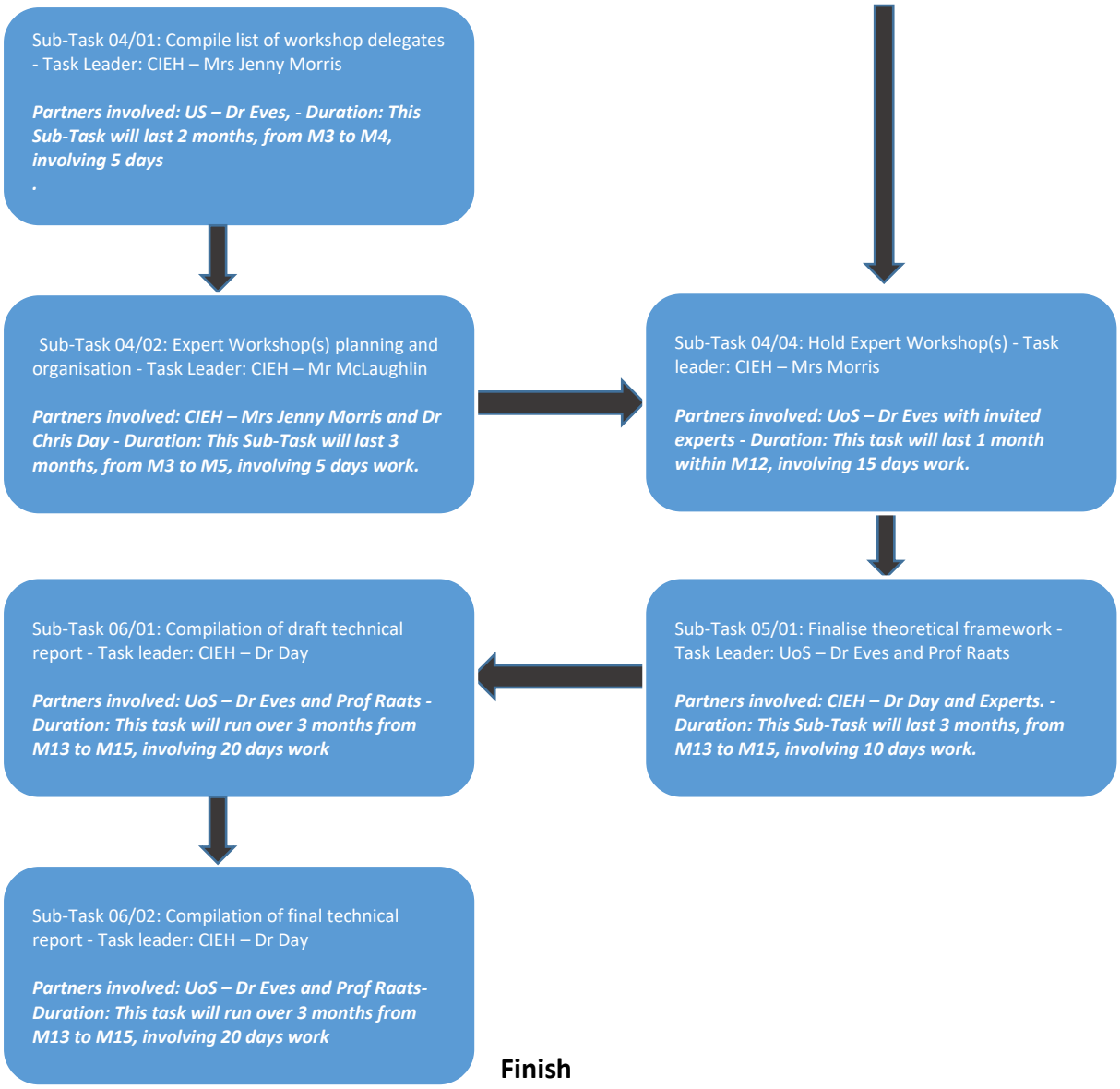
APPENDIX I

Process Flow Chart


Sub-Task 04/01: Compile list of workshop delegates - Task Leader: CIEH – Mrs Jenny Morris
Partners involved: US – Dr Eves, - Duration: This Sub-Task will last 2 months, from M3 to M4, involving 5 days
.
Sub-Task 04/02: Expert Workshop(s) planning and organisation - Task Leader: CIEH – Mr McLaughlin
Partners involved: CIEH – Mrs Jenny Morris and Dr Chris Day - Duration: This Sub-Task will last 3 months, from M3 to M5, involving 5 days work.
Sub-Task 04/04: Hold Expert Workshop(s) - Task leader: CIEH – Mrs Morris
Partners involved: UoS – Dr Eves with invited experts - Duration: This task will last 1 month within M12, involving 15 days work.
Sub-Task 05/01: Finalise theoretical framework - Task Leader: UoS – Dr Eves and Prof Raats
Partners involved: CIEH – Dr Day and Experts. - Duration: This Sub-Task will last 3 months, from M13 to M15, involving 10 days work.
Sub-Task 06/01: Compilation of draft technical report - Task leader: CIEH – Dr Day
Partners involved: UoS – Dr Eves and Prof Raats - Duration: This task will run over 3 months from M13 to M15, involving 20 days work
Sub-Task 06/02: Compilation of final technical report - Task leader: CIEH – Dr Day
Partners involved: UoS – Dr Eves and Prof Raats- Duration: This task will run over 3 months from M13 to M15, involving 20 days work
Finish

APPENDIX II

Project Steering Group: Terms of Reference

1. To contribute to the Scoping Workshop
    - *To agree final scope of Systematic Review*
    - *To agree final research questions*
    - *To agree final search terms*
    - *To suggest potential sources of literature and studies for inclusion in the review*
    - *To agree quality criteria for evaluation of materials*
2. To provide written comments on draft protocol
3. To provide written comment on the draft Systematic Review, including identification of gaps in coverage, gaps in knowledge, research needs and/or potential interventions
4. To contribute to the final Expert Workshop(s) to help the team draw the policy implications from the review findings. This can involve participating in a brainstorm/focus group meeting to review the lessons and implications of the review in terms of policy and practice.
5. To comment on final theoretical framework
6. To assist the study team with dissemination. This can involve advising on the review team's dissemination plan, assist with disseminating the review report/policy briefs or hosting events for the dissemination of review findings.
7. To identify opportunities for policy influence and act as a knowledge broker, providing a link between the author team and the end users and facilitating access to, interpretation, and translation of the review findings into local policy and practice

Steering Group Participants:

- Dr Lisa Ackerley, is a Strategic Adviser to the board of Acoura and Managing Director of Hygiene Audit Systems
- Professor Sarah O'Brien Institute of Infection & Global Health, University of Liverpool; (University of Liverpool) – a clinical research epidemiologist
- Joy Dobbs (Deputy Chair of the FSA's Social Science Research Committee and member of the FSA's Advisory Committee on the Microbiological Safety of Food):
- Mr Richard Elson (Public Health England) Head of Risk Assessment and Response (PHE); – a senior Governmental scientist and adviser
- Professor Sally Bloomfield (London School of Hygiene & Tropical Medicine) Chair, International Federation of Hygiene; – a specialist in the microbiological landscape of the home
- Ms Kaarin Goodburn MBE, Director and Secretary General of the Chilled Foods Association
- Mario Aquilina (Tesco) – Enforcement Liaison lead.

Steering Group Participant Profiles:

Lisa Ackerley (Strategic Adviser to the board of Acoura): Lisa acknowledged that she came to the Group wearing a number of hats, but upon the acquisition of her successful food and health and safety consultancy (Hygiene Audit Systems) by Acoura in July 2015, she has been able to act as a food safety adviser to the British Hospitality Association and non-executive director of the CIEH. An Environmental Health Practitioner by training and early career background, Lisa runs the 'Hygiene Doctor' website. She described her long-standing interest in campylobacter, and its association with poor handling of chicken. She subsequently completed a PhD on consumer awareness of food hygiene using the 'Health Belief' model.

Mario Aquilina (Head of Enforcement Liaison at Tesco): Originally educated and trained as an Environmental Health Practitioner and worked in local government for nearly nine years specialising in food safety and hygiene. He is a former Chair of the CIEH London Food Study Group and served as a LACORS national advisor on their approved establishments and legal working groups. His passion for the law led him to retrain as barrister and be called to the Bar, though he has never practised. In 2007, Mario left local government to work in the commercial sector for Tesco, where he has held a number of senior technical, legal and governance roles. He now leads their Regulatory Liaison and Incident team.

Sally Bloomfield (Chair of the International Scientific Forum on Home Hygiene): Trained originally as a pharmacist, Sally taught for many years in the Pharmacy Department at King's College London. However, in 1976, she wrote a review on hygiene in the home, and as a result became fascinated by the subject and an authority on it. Sally's commitment to home hygiene was recognised when she was approached by Unilever to promote the cause, which resulted in her setting up the International Scientific Forum on Home Hygiene (IFH) which she continues to Chair.

Joy Dobbs (Deputy Chair of the FSA's Social Science Research Committee and member of the FSA's Advisory Committee on the Microbiological Safety of Food): Due to a prior engagement, Joy was unable to join the meeting until the afternoon. Joy is a self-employed consultant and Deputy Chair of FSA's Social Science Research Committee (SSRC), having previously worked for many years at the Office for National Statistics (ONS). Her professional base is in social research and statistics. She spent 20 years working on and running major survey projects, mainly for other Government Departments, before leading four different Divisions, varying from large-scale statistical operations (social surveys, 2001 Census) to in-depth analysis and reporting (social and health analysis; population statistics). The survey projects included a number on diet and nutrition, particularly some of the National Diet and Nutrition Surveys in the 1990s and early 2000s, and this is where her interest in food safety and hygiene began. As well as using her knowledge, expertise and experience in her role on the SSRC, she also advises the FSA on a range of other projects. For example, she sits on the Advisory Committee for Microbiological Safety in Food, the Working Group for 'Food and You' (the Agency's flagship survey of the knowledge, attitudes and behaviours of the general population) and a new Working Group on public perceptions of foodborne viruses.

Richard Elson (Public Health England)*:* Qualifying as an Environmental Health Officer in 1990, Richard worked for Nottingham City Council, before spending time in southern Africa with VSO working on water sanitation and malaria control. Completing a Master's degree at LSHTM in 1999, Richard had planned to return to Africa, but his interest shifted towards food safety in the UK, and particularly how enhanced surveillance served to inform the epidemiology of infectious disease. He duly joined the Public Health Laboratory Service (PHLS) where he was involved in national outbreak and surveillance projects, together with national food studies, including CLASSP. From the PHLS, Richard went to the

CQC and then back to the PHLS's successor, the HPA, which in 2012 became the PHE. Richard is currently involved primarily with VTEC, especially cases presenting as outbreaks at national level, and in this regard working with industry in seeking ways of improving response rates.

Kaarin Goodburn (Chilled Food Association): Describes herself as 'passionate about food safety'. Kaarin worked originally at Leatherhead Food Research on food irradiation, before moving to the Food and Drink Federation and then the Chilled Foods Association (CFA) where she has been since 1989. During this time, and amongst other things, Kaarin has been involved in the development of standards and guidance on good hygiene practice for 'high-risk foods', and was instrumental in the development of good agricultural practice. She has acted as a consultant for over 21 years, working on a variety of projects including vacuum packaging, biocides and Listeria awareness, a subject on which she is currently delivering training to Environmental Health personnel for the FSA through the CIEH.

Sarah O'Brien (Chair of Infection Epidemiology and Zoonoses, University of Liverpool): Professor Sarah O'Brien qualified in Medicine in 1986 at Newcastle University before undertaking Higher Specialist Training in Public Health Medicine in Oxford and Newcastle-upon Tyne. She has held Consultant positions in Health Protection in Birmingham, Glasgow and London before joining the University of Manchester in 2004. In 2011, Professor O'Brien moved to the University of Liverpool to join the Institute of Infection and Global Health where she holds the Chair of Infection Epidemiology and Zoonoses. She is the Chair of the FSA's Advisory Committee on the Microbiological Safety of Food (ACMSF) see http://acmsf.food.gov.uk/acmsfmembers. Prof O'Brien has an extensive publication list and was recently the project lead contractor for 'The Second Study of Infectious Intestinal Disease in the Community (IID2 Study)' as well as the 'IID2 extension study' (http://www.food.gov.uk/science/research/foodborneillness/b14programme/b14projlist/fs231043ext)

APPENDIX III

Attendees to Scoping Workshop

Research Team: Dr Chris Day (Chair), Dr Anita Eves, Mr Jason McLaughlin, Mrs Jenny Morris MBE and Professor Monique Raats.

Food Standards Agency: Ms Helen Atkinson (via telephone), Dr Paul Cook, Mr Darren Holland and Mr Bobby Kainth.

Steering Group: Dr Lisa Ackerley, Mr Mario Aquilina, Professor Sally Bloomfield, Mr Richard Elson and Ms Kaarin Goodburn MBE, Dr Joy Dobbs (afternoon only).

An apology for absence was received from Professor Sarah O'Brien.

APPENDIX IV

Search terms and agreed inclusion criteria for interrogation of academic and grey literature.

Primary search term	Additional search terms
Foodborne illness	Domestic
Food borne illness	Home
Food poisoning,	Household
Epidemiology	Hygiene
Foodborne disease	✧Incidence
Food borne disease	*food
Infectious intestinal disease	

✧incidence not coupled with epidemiology; *food – only coupled with epidemiology

APPENDIX V

List of Evaluation Workshop attendees

The experts involved in the workshop were:

Dr Lisa Ackerley, International Federation Home Hygiene. (Chair Group A.)

Dr Bob Adak, Public Health England

Ms Helen Atkinson, Food Standards Agency

Mr Mario Aquilina, Tesco

Dr John Cowden, Independent Consultant Epidemiologist

Ms Joy Dobbs, FSA Social Science Research Committee. (Chair Group C.)

Dr Richard Elson, Public Health England

Professor Meirion Evans, Cardiff University

Ms Hazel Gibson, Wolverhampton University

Ms Kaarin Goodburn, Chilled Food Association. (Chair Group B.).

Professor Peter Jackson, University of Sheffield, Chair, FSA Social Science Research Committee

Mr Alec Kyriakides, Sainsbury's

Dr Roland Salmon, Consultant Epidemiologist, retired

Dr Alison Smith-Palmer, Health Protection Scotland

Food Standards Agency observers

Mr Darren Holland

Dr Manisha Upadhyay

Dr Antonis Ampatzoglou

Mr Bobby Kainth

Project Team

Dr Anita Eves, University of Surrey

Professor Monique Raats, University of Surrey

Dr Chris Day, Chartered Institute of Environmental Health

Mrs Jenny Morris MBE, Chartered institute of Environmental Health

Mr Jason McLaughlin, Chartered Institute of Environmental Health

Note takers

Ms Georgina Day

Ms Emilee Rapley

Ms Zoe Clothier

Appendix VI

Expert workshop to assess the findings from the "Systematic Review of the relative proportion of foodborne disease caused by faults in food preparation or handling in the home". FSA research project FS101098

2nd February 2017. Chartered Institute of Environmental Health, 15 Hatfields, London SE1 8DJ.

Agenda		
9.30-10.00	**Coffee available**	
10.00-10.10	**Welcome and general introductions**	Jenny Morris
10.10–10.20	**Background to the research project** **Workshop arrangements.** **Aim:** To consider the 'evidence' that suggests that the domestic setting is significant in terms of its contribution to the disease burden, and that this may be due to specific risk factors.	Darren Holland (FSA) Jenny Morris
10.20-11.30	**Session 1** Question 1 From the 'evidence' in Table 1 does this suggest a measure of the contribution to foodborne illness arising from the domestic setting? And if so, which of the sources detailed in Table 1 should be considered reliable enough to base conclusions on? Of the sources detailed, which (if any) should be considered so unreliable or ill-fitting to the task that they should be disregarded? Question 2 Looking at Table 2, which considers the contribution made by specific pathogens, to what extent are the findings sufficiently reliable to draw conclusions in the final report?	Facilitators and Groups
11.30- 12.45	**Session 2** Question 3 Considering the data in Tables 3 and 4, to what extent can conclusions be drawn about the potential to render food "unsafe" through poor practices (malpractices) in the home, specifically: • cross contamination • poor transportation conditions • inadequate storage • inappropriate handling and • inadequate preparation (including cooking)? Exercise 1 Please consider the extent to which it would be feasible to assess the relative likelihood of a specific "malpractice" or particular groups of "malpractice" to cause foodborne illness. See Appendix A for further details of the Exercise.	Facilitators and Groups

	Please record any caveats that group members wish to be considered, such as the significance of exposure to particular pathogens or toxic agents by vulnerable people, or expressions of dissent as to whether, for instance, the situation described poses any risk, or may even be protective.	
12.45-1.30	**Lunch**	
1.30-2.45	**Session 3** **Please note** that Tables 5 to 7 are constructed from Observational or Self-reported studies. As such they are not, unlike the previous Tables, associated with reported illness <u>Question 4</u> Referring to the data in Tables 5, 6 and 7, is there sufficient justification to surmise that the factors attributed to practices and behaviours in the home are <u>causal</u> to the risk posed to human health? And is it reasonable to conclude that they are responsible for the incidence of foodborne disease in the domestic setting? <u>Question 5</u> Considering all findings from the Systematic review to what extent can the overall research question, that follows be answered: *What proportion of UK foodborne disease is caused by faults in transporting, storing, preparing and handling food for consumption within the home?* <u>Supplementary questions</u> If there is insufficient evidence to properly address the main research question, what additional information is available that could assist i.e. other references and sources? And/or: What additional research or actions would be required to properly address the main question?	Facilitators and Groups
2.45-3.00	**Comfort break**	
3.00-3.30	**Session 4. Plenary feed back** Groups will be invited to briefly express their views on the significance of the domestic setting in contributing to foodborne illness and the most significant risk factors arising from kitchen malpractices.	All
3.30-3.45	Next steps and close	Jenny Morris

Appendix VII

A 'Background briefing' on the research project outlining the research questions, the search methodology and evaluation criteria for inclusion of material in the findings

Expert workshop. 2nd February 2017, Chartered Institute of Environmental Health, London

Introduction

In early 2016 the Food Standards Agency (FSA) commissioned the Chartered Institute of Environmental Health (CIEH), together with the University of Surrey (UoS), to carry out a "Systematic review of the relative proportion of foodborne disease caused by faults in food preparation or handling in the home" (Research project FS101098).

The Systematic Review's aim has been to determine whether evidence exists in the 'published' and 'grey' literature to attribute foodborne illness to the domestic setting, and to identify shortcomings in domestic kitchen practices.

Research questions

The overall research question is:

What proportion of UK foodborne disease is caused by faults in transporting, storing, preparing and handling food for consumption within the home?

N.B. "Disease" is taken to include toxicants that increase as a result of poor storage practices; to include time food taken from shelf within retail environments, or pick up or receipt of takeaways, or home deliveries.

Supplementary (non-impact) questions are:

What leads to foodborne disease in the home – contamination of 'safe' food (making it 'unsafe', possibly as a result of poor in-home practices) and/or inadequate transporting/storing/handling/preparation of 'Unsafe foods'? [where safe food is defined as 'food not injurious to health']

Is it feasible to determine the proportion of foodborne disease cases caused by specific pathogens?

Which pathogens are most likely to lead to foodborne disease through faults in transporting, storing, preparing and handling food for consumption within the home, and in what proportions?

What are the likely causes of foodborne disease in the home, e.g. contamination of food stuffs in the food chain or malpractices whilst transporting, storing, preparing and handling food within the home?

Search methodology

A bank of search terms was developed to search for both academic ('published') and 'grey' literature sources. Key academic databases interrogated were ZETOC, and Medline. 'Grey' literature was sought through general database searches, an FSA call out to Local Authorities and a request for information through the CIEH's electronic mailing system EHCnet. Beyond this, specific organisations, such as FSA (research team) Public Health England, the project Expert Advisory group and researchers known to the project team and Steering Group were contacted for additional material.

Having identified material containing the search terms, relevance was determined using the PICOS approach. PICOS (population, intervention, comparator, outcomes) questions are generally used to in clinical studies, and whilst this study is not clinical the approach has merit for all types of research.

PICOS approach

Population:

Who is the target of the research?

In terms of the population: all occupants of a household who come into contact with foods to be consumed in the home and who consume foods within the home.

In terms of the foods included: all foods bought, stored and prepared for consumption in the home, from the point at which an occupant of a household takes receipt of the food, but excluding shelf-stable foods (to include: high risk foods -raw or processed, including meat and poultry, and dairy products, ready to eat foods, foods requiring some handling, homemade foods – including preserves, Takeaways/doggy bags from restaurants, meals on wheels, foods prepared at school to be consumed at home, food from farmers' markets, fish stalls and salads and vegetables).

In what setting? At all points where the occupant(s) of a household has responsibility for the safety of the food – to include transport to home, storage in the home, preparing and handling food in the home.

Are there any sub-groups that need to be considered? To include those who contract food poisoning as a result of specific medical conditions that predisposes them to illness or more severe outcomes.

Intervention:

Although the study does not involve an intervention, the following food–related actions have been considered: Hand washing (before/during/after contact with contaminants), cleaning and disinfection, temperature control (chilling and cooking), use of durability indications, indirect transmission (including such things as contamination arising from, or being spread through, washing meat or through the presence of companion animals in the kitchen), background, attitude and awareness of the food handler, place of consumption (e.g. garden, BBQ), and catering for not-for-profit events.

Studies that have used interventions to improve domestic food safety practices, and their outcomes have been included in the review, though only after evaluation as to their suitability for inclusion).

Comparator: What are the alternative choices of action?

In clinical studies this might include alternative treatments to that being tested. In the current study, there is no real comparator. A possibility could be a comparison with the professional food preparation environments, but this would increase the scope of the study beyond that which is feasible in the time and budget allocated. Some literature may make reference to both domestic and professional settings, in which case the information may be included, but there has been no active search for literature on professional food preparation.

Outcomes: What is the purpose of the research? What does it hope to achieve?

The research aims to establish if it is possible to separate foodborne disease acquired in the home from that contracted elsewhere, and thus establish the proportion of foodborne disease attributable to failures in food management by occupants of households. It also seeks to establish the pathogens and food-related practices most often implicated. The study will identify gaps in knowledge, and possible interventions that could be tested to improve domestic food safety practices.

Restrictions on search:

- Only literature published in English and after 1990 was included
- Whilst the literature was limited to that pertaining to the developed world, as a general rule it was sourced from countries with similar dietary patterns to the UK, so, primarily USA, Canada, Australia, New Zealand, Europe and Scandinavia.

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Evaluation for inclusion

Evaluation for inclusion in the review findings was determined by use of a specially developed tool which assessed rigour but also allowed inclusion of grey literature. Judgement included use of PICOS questions for relevance, clarity of research hypotheses and objectives, appropriateness of approach and accuracy and honesty of reporting. The process was completed by 2 individuals independently.

Next steps

Expert workshop

The key findings from the documents considered in the Systematic Review have been summarised, in tables, contained in a document entitled: Summary Tables. Systematic review of the relative proportion of foodborne disease caused by faults in food preparation or handling in the home.

These tables will be presented for discussion and review by a group of experts at a workshop on 2nd February 2017 at the offices of the Chartered Institute of Environmental Health – Chadwick Court, 15 Hatfields, London, SE1 8DJ.

The experts have been selected using criteria based on their specialist expertise in surveillance, epidemiology, infection control and the management of hygiene. The aim of this expert workshop is to establish the strengths and weaknesses of the Systematic Review's findings.

Whilst there is no intention to stifle dissent or the expression of a minority view, it is anticipated that by the end of the day a consensus will be reached on a theoretical framework that summarises the current state of knowledge and identifies areas where further research is required. Such a framework is also expected to provide a sound basis for the development of effective strategies to reduce foodborne disease arising from faults in food preparation or handling in the home.

APPENDIX VIII

Geographic origin of evaluated academic articles.

Geographic origin	Behavioural (B) study *n*	(%)	Incidence (I) study *n*	(%)	I/B *n*	(%)	Total *n*	(%)
Australia	7	(4)	5	(6)	0		**12**	(4)
Belgium	2	(1	2	(2)	0		**4**	(1)
Brazil	1	(1)	0		0		**1**	(<1)
Canada	4	(2)	7	(8)	0		**11**	(4)
Denmark	1	(1)	5	(6)	0		**6**	(2)
England	2	(1)	1	(1)	0		**3**	(1)
England and Wales	0		5	(6)	0		**5**	(2)
EU	2	(1)	3	(4)	0		**5**	(2)
France	2	(1)	0		0		**2**	(1)
Germany	1	(1)	1	(1)	0		**2**	(1)
global	34	(18)	16	(19)	0		**50**	(18)
Ireland	10	(5)	2	(2)	0		**12**	(4)
Israel	1	(1)	0		0		**1**	(<1)
Italy	9	(5)	3	(4)	0		**12**	(4)
N Ireland	1	(1)	0		0		**1**	(<1)
Netherlands	10	(5)	2	(2)	0		**13**	(5)
New Zealand	3	(2)	1	(1)	0		**4**	(1)
Norway	0		1	(1)	0		**1**	(<1)
Poland	0		2	(2)	0		**2**	(1)
Portugal	2	(1)	1	(1)	0		**3**	(1)
Scotland	0	(0)	2	(2)	0		**2**	(1)
Slovenia	5	(3)	0		0		**5**	(2)
Spain	0		4	(5)	0		**4**	(1)
Sweden	4	(2)	1	(1)	0		**5**	(2)
Switzerland	2	(1)	2	(2)	0		**4**	(1)
Turkey	1	(1)	1	(1)	0		**2**	(1)
UK	22	(11)	7	(8)	0		**29**	(10)
USA	50	(26)	9	(11)	1	(50)	**60**	(22)
USA and EU	0		0		1	(50)	**1**	(<1)
USA, EU, Australia, NZ	1	(1)	0		0		**1**	(<1)
Wales	14	(7)	1	(1)	0		**15**	(5)
Total	**192**		**84**		**2**		**278**	

APPENDIX IX

Academic articles evaluated according to the year of publication

	Behavioural (B) study		Incidence (I) study		I/B		Total	
Year of article publication	***n***	**(%)**	***n***	**(%)**	***n***	**(%)**	***n***	**(%)**
1992-1996	13	(7)	4	(5)	0		**17**	**(6)**
1997-2001	31	(16)	14	(17)	0		**45**	**(16)**
2002-2006	46	(24)	15	(18)	0		**61**	**(22)**
2007-2011	59	(31)	19	(23)	1	(50)	**79**	**(28)**
2012-2016	44	(23)	32	(38)	1	(50)	**77**	**(28)**
Total	**193**		**84**		**2**		**279**	

APPENDIX X

Method of data collection for 279 academic articles selected for evaluation for systematic review (articles 1990 – 2016).

	Behavioural (B) study		Incidence (I) study		I/B		Total	
Data collection method	***n***	**(%)**	***n***	**(%)**	***n***	**(%)**	***n***	**(%)**
Audit	3	(2)	0		0		**3**	**(1)**
Case control study	19	(10)	5	(6)	0		**24**	**(9)**
Case report	5	(3)	3	(4)	0		**8**	**(3)**
Comment/presentation	9	(5)	1	(1)	0		**10**	**(4)**
Delphi	1	(1)	0		0		**1**	**(<1)**
Experimental	5	(3)	0		0		**5**	**(2)**
Expert elicitation	2	(1)	3	(4)	0		**5**	**(2)**
Focus group	3	(2)	0		0		**3**	**(1)**
Focus group/interviews	1	(1)	0		0		**1**	**(<1)**
Intervention	1	(1)	0		0		**1**	**(<1)**
Interviews	7	(4)	0		0		**7**	**(3)**
Meta-analysis	1	(1)	0		0		**1**	**(<1)**
Microbiological	13	(7)	0		0		**13**	**(5)**
Mixed methods	5	(3)	0		0		**5**	**(2)**
Modelling	1	(1)	0		0		**1**	**(<1)**
Observation	10	(5)	2	(2)	0		**12**	**(4)**
Observation and interviews	2	(1)	0		0		**2**	**(1)**
Observation and microbiology	1	(1)	0		0		**1**	**(<1)**
Q sort	1	(1)	0		0		**1**	**(<1)**
Review	30	(16)	12	(14)	0		**42**	**(15)**
Simulation	0		1	(1)	0		**1**	**(<1)**
Surveillance data	1	(1)	53	(63)	2	(100)	**56**	**(20)**
Surveillance/questionnaire	0		1	(1)	0		**1**	**(<1)**
Survey	60	(31)	1	(1)	0		**62**	**(22)**
Survey + focus group	1	(1)	0		0		**1**	**(<1)**
Survey + microbiological	3	(2)	0		0		**3**	**(1)**
Survey + observation	2	(1)	0		0		**2**	**(1)**
Temperature measurement	2	(1)	0		0		**2**	**(1)**
Tool development	1	(1)	0		0		**1**	**(<1)**
Workshop	1	(1)	0		0		**1**	**(<1)**
(Blank)	1	(1)	2	(2)	0		**3**	**(1)**
Total	**192**		**84**		**2**		**278**	

APPENDIX XI

Behavioural and incidence studies, published in the academic literature, included or excluded from the systematic review following evaluation.

	Included	IQ	Excluded	Grand Total
Behavioural	52 (71)	36 (100)	100 (63)	**188 (70)**
Incidence	19 (26)	0	59 (37)	**78 (29)**
I/B	2 (3)	0	0	**2 (1)**
Grand Total	**73**	**36**	**159**	**268**

[IQ relates to studies which have been reviewed as credible, but were based entirely on self-reported behaviours collected mainly by questionnaire]

APPENDIX XII

Summary of studies investigating proportion of cases of foodborne disease from different settings (1990 -2016) *[* based on outbreaks unless specified otherwise; shading indicates grey literature]*

Source	Country	Illness investigated	Sample size	% outbreaks linked to the home*	% outbreaks linked to Food service	Comment
GEZI 2011	UK	Gastrointestinal illness	61 outbreaks; 1396 cases	?	85	
O'Brien *et al* 2002	England and Wales	Infectious intestinal disease	1462 outbreaks where food was vehicle	?	52	Under reporting Different levels of reporting by setting No strong evidence food was vehicle in 34% cases Confirmatory microbiology in 7% cases
WHO 2000	England and Wales	Foodborne infections and intoxications	3712 general outbreaks of which 1093 foodborne (29.5%)	12	Restaurant: 24, Hotel: 14 pub/bar: 6	
Evans *et al* 1998	England and Wales	Infectious intestinal disease	341 foodborne outbreaks	13	54	Only 22% cases foodborne; foodborne includes water borne Different levels of reporting by setting?
Cowden *et al* 1995	England and Wales	Infectious intestinal disease	458 outbreaks	17	?	Contributory factor identified in 61% of outbreaks (inappropriate storage' x-contamination; inadequate heating) Specific food suspected in 45% of outbreaks
Fitzgerald 2016	Ireland	Infectious intestinal disease	66 complete outbreak data sets	12	45	Small data set Only 58% foodborne No path of infection identified in 24% of outbreaks
WHO 2000	France	Foodborne infections & intoxications	2189 outbreaks; foodborne agent was identified in 1428 (65.2%)	39.6	Restaurant: 14.8;	'While most of the total number of outbreaks from 193-97 were reported to occur, outside of the home, the majority of salmonellosis outbreaks occur in the home'
	Germany	Foodborne infections & intoxications	933 foodborne disease	35.9	Restaurant / hotel: 13.9; mass	

	Spain	Foodborne infections & intoxications	outbreaks, causative agent found in 683 (73.2%) 5517 foodborne disease outbreaks; causative agent found in 63.6%	49.0	catering for groups: 7.5; Restaurant: 21.7, bar: 6.8	Very different surveillance system in place in Germany at the time
EFSA 2011	EU	Foodborne illness		36.4	26 – restaurant, cafe, bar, hotel	EFSA offers caveat to this and subsequent reports when comparing data on causative organism / vehicle from different NS but not so setting
EFSA 2014	EU		592 with strong evidence	37.3	26 – restaurant etc.	
Source	Country	Illness investigated	Sample size	% outbreaks linked to the home*	% outbreaks linked to Food service	Comment
EFSA 2015	EU		839 with strong evidence	38.5	22.2	
Ostrek *et al* 2014	Poland	Foodborne infection and intoxication	491 outbreaks (5774 cases)	48 outbreaks (16.5 cases)	13.4 outbreaks (22.9 cases)	Included toxins and pesticides Could not confirm setting in all cases
Lindqvist *et al* 2002	Sweden	Foodborne disease	555 incidents (464 outbreaks; 91 sporadic)	20 all incidents (22 sporadic cases)	60 all incidents (62 sporadic cases)	Reported cases Reporting not mandatory Could not identify organism in 368 incidents Most incidents unexplained
Broner *et al* 2010	Spain	Foodborne disease	181 outbreaks (2119 cases)	42.5	43.6	Setting not identified in some cases owing to lack of information Underreporting
Callejon *et al* 2015	USA and Europe	Foodborne disease	377 outbreaks USA 198 outbreaks EU	Not stated	54 USA; 40 Europe	Fresh produce only % from home not given
Vrbova *et al* 2012	Canada	Gastrointestinal illness	29897 cases, of which 20062 followed up	45.5 (of which 62.6% from food)	39.7	Only reflects cases followed up Recall bias? Reported cases Evidence for setting attribution low

						Setting only identified for 15% of sporadic cases No split between outbreaks and sporadic cases Other settings not identified in paper
CDC / FDOSS 2015	USA	Foodborne outbreaks	9178 outbreaks; 178181 cases	13	?	Data obtained by interrogating FDOSS for the decade 2005-2014
Jones *et al* 2004	USA	Foodborne disease	336 outbreaks; 6076 cases	7	66	Authors acknowledge that small proportion attributed to domestic premises was a consequence of not investigating these as fully or as frequently as outbreaks associated with restaurants
OzFoodNetwork 2002	Australia	Foodborne disease/ gastroenteritis	92 foodborne outbreaks (1819 cases)	13 (7 of cases)	62 (54 of cases)	No food vehicle in 34% outbreaks Not all notifiable More likely to identify setting/source if large outbreak

Grey literature = shaded

APPENDIX XIII

Summary of studies investigating different organisms and the relative proportion of cases occurring in the home and in commercial foodservice settings *[*outbreaks unless stated otherwise; shading indicates grey literature]*

Source	Country	Organism investigated	Sample size	% outbreaks from home*	% outbreaks from food service	Limitations
Wieneke *et al* 1993	UK	*St. aureus*	359 incidents;193 general outbreaks; 86 family outbreaks; 45 sporadic cases (4836 cases)	29.5	9	Underreporting No information available for 10% of outbreaks Other settings included shops, schools, hospitals and catered events. Setting not known in 16% of outbreaks.
Gillespie *et al* 2005	England and Wales	*S. enteriditis PT4*	497 foodborne outbreaks; 69 where setting established	19 (of 69 outbreaks where setting established)	27 (of 69 outbreaks where setting established)	Setting often not established (for only 69 of 497 outbreaks where was a single risk factor)
Sockett *et al* 1993	England and Wales (1989-91)	*Salmonella* Other bacterial organisms *Campylobacter*	2766 outbreaks 252 outbreaks 1097 outbreaks	86 family outbreaks 12 'single households' 97.5 'family outbreaks'	-	'Rise in family outbreaks probably resulted from improvements in data collection on individual cases from 1989, allowing identification of persons by name and location
Ryan *et al* 1996	England and Wales	*Salmonella* (in eggs and poultry)	1282 outbreaks (642 foodborne)	16 for catered events from home	-	Confusingly, source refers to food prepared for large numbers on domestic premises as either 'family outbreaks' (where only residents of the home affected) or general outbreaks' (presumably, where others are affected)

Source	Country	Organism investigated	Sample size	% outbreaks from home*	% outbreaks from food service	Limitations
Palmer *et al* 2000	Wales	*Salmonella*	87 foodborne outbreaks	6	39	Questions relative likelihood of follow up Mostly *S. enteriditis* PT4 No vehicle confirmed in 43% outbreaks Other settings 55% of outbreaks; most notable 19.5% from small retailers
Source	Country	Organism investigated	Sample size	% outbreaks from home*	% outbreaks from food service	Limitations
Faustini *et al* 2003	Italy	*Salmonella* spp, *S. enteriditis*, Staphylococal toxin, botulism, mushrooms, scombroid poisoning, *Cl perfringens, Shigella flexneri*, *V parahaemolyticus*, *E. coli*, ciguatoxin.	410 outbreaks (5165 cases)	% by setting not reported Average 5.1 cases *Salmonella* from home per outbreak; 65 from restaurants *Sh flexneri*, *V parahaemolyticus*, *E coli* mainly from home (small number of outbreaks) All mushroom cases originated in the home		Very small number of outbreaks relating to some organisms making firm attribution difficult; agent confirmed in only 50% of outbreaks.
Ostrek *et al* 2014	Poland	(Para) typhoid, *Shigella*, *Salmonella*, *E coli*, *St aureus, Cl botulinum, Cl perfringens,* other bacterial, *Listeria*, leptosporidia, viral, Hepatitis A, trichinella, echinococci, mushrooms, other plant, pesticide	491 outbreaks (5774 cases)	Most *Salmonella* (78), *E coli* (40), 'other bacterial' (29), viruses (35) and mushroom (100) cases originated in the home.	Foodservice settings accounted for 9 of *Salmonella*, 20 *E. coli*, 12 viruses.	24% outbreaks of unknown agent (46% outbreaks from foodservice; 12% from home)
Dominguez *et al* 2008	Spain	Norovirus	60 outbreaks (30 foodborne)	20 of foodborne	67 foodborne	Not all cases foodborne

Source	Country	Organism investigated	Sample size	% outbreaks from home*	% outbreaks from food service	Limitations
Callejon *et al* 2015	USA and Europe	Norovirus	USA 223 outbreaks EU 108 outbreaks	?	60 USA 45 Europe	Fresh produce only; not complete in attribution to setting. Other organisms not broken down by setting
Callejon *et al* 2015	USA and Europe	*Salmonella*	71 outbreaks USA 40 outbreaks EU	34 Europe ? USA	40 USA ? Europe	Fresh produce only; not complete in attribution to setting. Other organisms not broken down by setting
Varga *et al* 2015	Canada	*S enteriditis*	1336 cases	6.9 cases (9.6 outbreaks with exposure setting)	6.4 cases (8.9 outbreaks with exposure setting)	No confirmation of organism No confirmation of being food-related 20% of cases originated from overseas travel; 38% of unknown setting; 28% missing Recall bias
Voetsch *et al* 2009	USA	*S enteriditis*	173 cases	31 cases (eggs) 38 cases (chicken)	31 cases (eggs) 56 cases (chicken)	Only 42% of cases followed up Focussed on two food sources only (albeit with different preparation methods for eggs)
Grass *et al* 2013	USA	*Cl perfringens*	289 confirmed outbreaks; 15208 (cases)	16	62	underreporting
Gould *et al* 2013	USA	*Salmonella* and *Campylobacter*		20 *Salmonella* 16 *Campylobacter*	-	The authors concluded: 'Poor food handling practices in the home could be responsible for approximately one-fifth of all foodborne disease in the United States'

Source	Country	Organism investigated	Sample size	% outbreaks from home*	% outbreaks from food service	Limitations
Vrbova *et al* 2012	Canada	Amoeba, *Cl botulinum*, *Campylobacter, Cryptosporidia, Cyclosporidia, Giardia*, hepatitis A, *Listeria*, paratyphoid fever, *Salmonella*, Shigella, typhoid fever, *E coli* 0157, *Yersinia*	29897 cases of which 20062 followed up	Cases originating in the home not broken down by food and other sources		Extent of follow up varied by organism

Grey literature = shaded

APPENDIX XIV

Summary of case reports of food borne illness arising from the domestic setting (1990 – 2016)

Source	Food implicated	Organism implicated	Behaviour leading to illness	Limitations
Naranjo *et al* 2011	Spaghetti	*B cereus*	Food stored for 5 days at room temperature	Not conclusive, owing to delay in analysis
Dierick *et al* 2005	Pasta salad	*B cereus*	Made on Friday, taken to picnic on Saturday, stored in fridge 14°C, consumed on Monday. Also found in other foods in household.	No information on duration of picnic or temperatures food may have reached during that time
Lowther *et al* 2011	gravy	*Salmonella*	Cross-contamination from reptile following multiple use of kitchen area; gravy not heated to high enough temperature when initially cooked and also when reheated	
Salamina *et al* 1996	Rice salad	*Listeria*	Made 24h prior to use and not refrigerated as lack of space; cross-contamination as found in other foods	Initial source not established
Holtby *et al* 2008	Chicken curry	*Cl perfringens*	Cooked, but then cooled for 10h at ambient temperature; possibly not adequately reheated	Reheating suggestion based on anecdotal report only
Ryan *et al* 1996	Events catered from home (n=642 outbreaks)	Not specified	Inappropriate storage (62%) Storage at ambient for long periods (58%) Inadequate heat treatment (43%) Cross contamination (35%)	11 outbreaks linked to infected food handler, of which 3 were asymptomatic.

Grey literature = shaded

APPENDIX XV

Summary of case-control studies of food borne illness arising from the domestic setting (1990 – 2016)

Source	Illness investigated	Location study	Sample size	Risk factors	Comments
Millman *et al* 2014	*Campylobacter*	UK	182 initially; 77 at 6 months	Washing raw chicken and washing prepared salad	Social desirability bias in responses
Adak *et al* 1995	*Campylobacter*	England and Wales	598 cases	Occupational exposure to raw meat. Consumption of chicken at BBQs, pets with diarrhoea	Systematic bias through cases identifying controls Controls had greater immunity?
Parry *et al* 2002	*Salmonella*	Wales	137 cases	Younger food preparer (25 – 34 years), child under 5 years, handling frozen or raw whole chicken or chicken portions, consumption raw egg	Small sample for any one practice
Parry *et al* 2004	*Salmonella* (sporadic)	Wales	140 cases	Cases perceived personal risk from food poisoning to be higher than controls and had less optimistic bias. No difference in perceived knowledge or personal control.	Results may reflect fact of being ill, rather than situation prior to illness.
Parry *et al* 2005	*Salmonella*	Wales	137 cases	No differences between groups in *Salmonella*, total enterobacteriaceae and total aerobic colony counts between dishcloths and refrigerators. No evidence of case households having higher levels of contamination.	
Delaroque-Astagneau *et al* 1998	*S enteriditis* (sporadic)	France	108 cases	Eating raw/undercooked eggs; prolonged storage eggs; consumption ready-to-eat chicken	Children < 5 years only Recall bias (parents)
Bless *et al* 2014	*Campylobacter*	Switzerland	159	Consumption chicken and raw/undercooked meat	

Source	Illness investigated	Location study	Sample size	Risk factors	Comments
Preusel *et al* 2015	*Listeria*	Germany	109	Immunosuppressive condition/treatment, gastric acid suppression, consumption non-reheated cold sausage, packaged or pre-sliced cheese	Median age 69 years Small sample Education level of controls above average Limited questioning on preparation/cooking/storage practices
Neimann *et al* 2003	*Campylobacter*	Denmark	282 cases	Consumption undercooked poultry, pork chops (frequently), red meat at BBQs, grapes, unpasteurised milk; presence of animal with diarrhoea and less thorough cleaning	Only 37% cases had control who completed the questionnaire Delayed recruitment and interview of controls
Studahl and Andersson 2000	*Campylobacter*	Sweden	101	Consumption unpasteurised milk, home cooked chicken or pork on the bone, BBQ meat; not washing hands between different foods	
MacDonald *et al* 2015	*Campylobacter*	Norway	995 cases / 1501 controls	Drinking water directly from lake/river or bottled water; eating chicken; eating BBQed food; having dog in household	
Kohl *et al* 2002	*Salmonella* (sporadic)	USA	115 cases included of 888 total	never/rarely washing hands between meat and non-meat; reptile in home; diaper using elderly in household; others in house with diarrhoea	Some associations are weak Recall bias Limited questioning on preparation/cooking/storage practices
Mitakakis *et al* 2004	gastroenteritis	Australia	600 families; 2669 episodes	Consumption of cold sliced salami, fried rice, fast food, takeaway food, eating at a reception or restaurant, babies in diapers in household; defrosting chicken in microwave, placing cooked chicken where raw had been, keeping	Only 32% gastroenteritis in Australia is food-related Recall bias No confirmatory microbiology

				food out of fridge for > 2 hours	
Ebershart-Phillips *et al* 1997	*Campylobacter*	New Zealand	621 cases	Consumption raw/undercooked chicken, chicken at a full-service restaurant, BBQed or fried chicken, unpasteurised dairy	Recall bias Controls having 'at home' lifestyle?

Grey literature = shaded

APPENDIX XVI

Summary of studies of domestic refrigerators (1990 – 2016) included in the systematic review

Source	Nature of study	Sample size	Location	Findings
George *et al* 2010	Temperature	329 households	UK	Mean air temperature 5.9°C; 29% operating at <5°C or less; 29% operating at >9°C
Johnson *et al* 1998	Temperature	645 fridges	UK	70% ≥ 6°C; sample taken from homes of those >65 years
George *et al* 2010	Temperature	Temp changes retail to refrigerator and beyond (simulation)	UK	Temperature rises of up to 11°C following transport from store (depending on type of bag used) Some products once in refrigerator took up to 15 hours to return to <5°C in chiller operating at 4.3°C
Jackson *et al* 2007	microbiology	342	Northern Ireland	TVCs evidenced poor standards of fridge management *St aureus* found in 6.4% fridges; *L monocytogenes* in 1.2%; *E coli* (not 0157) in 1.2%; *Y enterocolitica* in 0.6%
Kennedy *et al* 2005a	Microbiology temperature	100	Ireland	71% fridges operating at >5°C 52% fridges contained at least one pathogen 41% fridges contained *St aureus* Contamination levels were highest for a consumer cluster found to lack knowledge to prevent cross-contamination (Kennedy *et al* 2005b)
Flynn *et al* 1992	temperature	150	Ireland	Temperatures in fridges between 0.8 and 12.6°C 71.3% fridges operating at >5°C
Bolton *et al* 2005	Microbiology and temperature		Ireland	Average TVC 12.6 million bacteria cm^{-2} Average coliform count 10,000 cm^{-2} *St aureus* present in 41% fridges; *E coli* 6%; *Salmonella* 7%; *L monocytogenes* 6%; *Y enterocolitica* 2% 40% operating at 0 – 5°C; 54% 5 – 10°C; 6% > 10°C
Koidis *et al* 2015	Temperature and observation	100 fridges	Ireland and RoI	Mean temperature 4.9°C; range -4°C to 12.5°C; 40% > 5°C 10% fridges contained high-risk RTE foods beyond their use by date; 8% contained foods beyond on pack storage instructions
Catellani *et al* 2014	microbiology	293	Italy	Higher TVCs at bottom of fridge *Salmonella* found in 1.7% fridges; *B cereus* in 5.6%; pathogenic *Staphylococcus* in 4%
Gilbert *et al* 2007	temperature	127	New Zealand	55% fridges operating at >5°C 20% fridges operating at >7°C

Grey literature = shaded

APPENDIX XVII

Summary of studies of kitchen equipment and sites included in the systematic review (1990 – 2016).

Source	Nature of study	Sample	Test sites	Findings
Erikson *et al* 2015	Microbiological; experimental	na	Knives and graters	Cross contamination from inoculated produce processed with knives and graters to foods
Curtis *et al* 2003	microbiology	10 homes in UK with child <3 year	Swabs of various domestic sites	Polio virus recovered from 10% of kitchen sites tested, particularly liquid soap bottles and taps
Azevada *et al* 2014	microbiology	15 homes in Italy	Swabs of various kitchen sites	Enteric organisms and pathogens on pets' feet, kitchen taps and counters, cooker and kitchen knobs, fridge, cutting boards and dishwasher handles and kitchen cloths.
Jones 1998	Microbiology	60 homes in UK	Sampling various sites in kitchen and bathrooms	High coliform counts around sink, cloths, chopping boards, waste bin, floor and inside surfaces of fridge.
Gorman *et al* 2002	microbiology	25 homes in N Ireland	Swabs of kitchen sites following preparation of roast chicken in home	APC increased in kitchen sites following preparation chicken; Pathogens derived from chickens contaminated kitchen sites; Intestinal disease organisms found in dishcloths; hands; fridge handles; oven door handles; counter tops; draining boards
Redmond *et al* 2004	microbiology	24 consumers in test kitchen; S Wales	Swabs of kitchen sites following preparation of chicken and pasta salad in test kitchen	Campylobacter from raw chicken contaminated kitchen sites; older consumers more likely to cross-contaminate and to contaminate multiple sites.
Sanna *et al* 2014	microbiology	80 homes in Italy	Analysis of food prepared and kitchen sites following preparation of cheese salad, and storage of pasta with sauce and cooked meat.	Highest mesophilic counts on knife blades, chopping boards, hands, cheese graters, fridge wall, salad, cheese and cooked chicken. Enterobacteriaceae high on cheese, salad and cooked chicken
De Jong *et al* 2008	microbiology	Unclear; homes in Netherlands	Contamination of kitchen equipment with *C jejuni* following preparation chicken salad, and cleaning measures	Cutting boards/utensils cleaned with hot water, or hot water with soap, led to lowest recovery of organism from salad. Washing in cold water no better than no washing. Some contamination of hands for all washing routines.

Source	Nature of study	Sample	Test sites	Findings
Cogan *et al* 2002	microbiology	80; UK homes	Contamination of kitchen sites following preparation of raw chicken, and cleaning measures	Hands and surfaces contaminated with *Salmonella* and *Campylobacter* (prior to washing). High counts on chopping boards. Bowl washing with detergent, plus rinse more effective in reducing % sites contaminated pathogens High counts of *Salmonella* on dishcloths
Roccato *et al* 2015	microbiology	78 samples of chicken	Recovery *S typhimurium* following manufacturer's cooking recommendation and 'plausible improper cooking'	'Improper' cooking led to lower core temperatures and pathogen survival in 26/78 samples
Bergsma *et al* 2007	Microbiology, experimental	Unclear; Netherlands	Recovery of *C jejuni* following cooking chicken using most frequently identified method – frying/stir frying	Higher D values determined for whole fillet, suggesting recommended cooking times were only marginally safe.
Central Science Laboratory B02015	Microbiology	UK	Sampling in use dishcloths n=1009	TVC 99% of cloths; Enterobacteriaceae 36.4%; *St aureus* 12.3*%; L monocytogenes* 1.4%; *S arizonae* 0.1%; *Campylobacter* and *E coli* not detected.
Mead *et al* 1997	Microbiology		Sampling various sites in 15 homes	125 Enterobacteriaceae isolates; 86 *St aureus*, coagulase positive; 5 *Listeria* spp; 13 *E coli*; no *Campylobacter*. Handles, knobs and domestic animals' feet most contaminated.
De Boer *et al* 2015	Microbiology	N Ireland and RoI	Contamination of dishcloths of different materials and decontamination practices n=200	*E coli* present on 27.5%; *Listeria* spp on 13.5% (*L monocytogenes* on 3%); *Campylobacte*r and *Salmonella* not isolated Cloths most commonly cleaned in domestic washing machine or by soaking in bleach, the former being most effective even at 30°C.
Slader 2002	Microbiology	Wales	70 participants preparing salad in their home; 609 samples	Commonly contaminated items included salads and wiping cloths; most common exposure routes through inadequate

				washing/drying of hands, chopping boards / knives
Newsholme 2002	Microbiology (TVC and Enterobacteriaceae)	UK	Consumers preparing one of 5 recipes in test kitchen; kitchen thoroughly cleaned prior to use	Surfaces had higher counts where meat handled Bacteria on chopping boards could survive and sometimes grow within 48h of use, even if washed with hot, soapy water. Other sites contaminated were handles, drawers, taps oven controls. Counts on dishcloths increased over the 48h after use

Appendix XVIII

Summary (1) of observation studies of household hygiene behaviours included in the systematic review (1990 – 2016)

Source	Sample and setting	Nature of study	Results: hygiene behaviours reported that might increase the risk of food borne illness
Wills *et al* 2015	Home; n=20 UK	Ethnographic study of kitchen use and food-related activities in households	Non-food related activities in kitchen incl. childcare, laundry, cleaning, pet care, work/craft activities. Food not restricted to kitchen, incl storage outside if fridge too full. Wide range hygiene-related activities observed.
Worsfold & Griffith 1997	Home; 108 consumers; Wales	Direct observation of preparation of provided recipes	Temperature rises during transport 58% stored food above 5°C Up to 60% exhibited behaviours that might increase the risk of food borne illness re handling and preparation of raw foods Holding food at ambient for more than 90 minutes (35%). Extensive opportunities for indirect cross-contamination
Clayton *et al* 2003	Model kitchen; n=40; Wales	Observation preparation beef burger, chicken salad and egg and ham sandwich, focussing on hand washing, cleaning surfaces and utensils	None of participants washed their hands at all appropriate times Inadequately washed surfaces and utensils between preparation raw and RTE foods. Mismatch noted between reported and actual behaviours.
Kennedy *et al* 2011	Home; 60 participants; Ireland	Video observation of preparation of either beef burgers or warm chicken salad	Infrequent hand washing Inadequate washing of knives/boards Thoroughness of cooking judged largely by visual methods.
Terpstra *et al* 2005	Home; n=33 Netherlands	Observation of storage and disposal practices	Sliced cooked meats more often stored open by older consumers. Smell and appearance often used to judge 'freshness' Leftovers often stored beyond 2 – 3 days, especially by older consumers. Cheese often stored beyond best before dates, with mould the most frequent reason for disposal.
Fischer *et al* 2007	Home; 25 consumers; Netherlands	Video observation when preparing chicken curry salad.	Incorrect hand washing practice. Drawers and cupboards frequently opened during food preparation Boards used for raw chicken reused for cooked chicken or fruit.
Van Asselt *et al* 2009	Home; n=25; Netherlands	Video observation preparation chicken curry salad	71% did not act to prevent cross-contamination; Inadequate hand washing Inadequate washing of boards and knives Undercooking the chicken used in the salad.

Byrd-Bredbenner *et al* 2007	Controlled setting; 154 participants; USA	Observation young adults preparing chicken fajitas	Participants performed 50% of recommended behaviours (cleaning, separating, cooking, chilling and cross-contamination) Males performed less well on the 'cleaning' scale One third did not separate raw chicken from ready-to-eat products. Cooked dish under raw chicken in the refrigerator.

Source	Sample and setting	Nature of study	Results: hygiene behaviours reported that might increase the risk of food borne illness
DeDonder *et al* 2009	Controlled setting; 41 participants; USA	Questionnaire and video observation preparing frozen, breaded chicken products: primary meal preparers and adolescents	Hands not washed on all desirable occasions, especially amongst adolescents, including subsequently touching other produce or surfaces. Microwave cookers sometimes not used properly Conventional ovens often not properly preheated. Questionnaire and observation data contradicted.
Phang & Bruhn 2011	Home; 199 participants; USA	Questionnaire and video observation whilst preparing burgers	22% did not cooked burgers to recommended temperatures. Average hand washing time was 8s. Average of 43 potential cross contamination events recorded per household, with hands the most common vehicle. Many instances of hands not being washed at appropriate occasions. 88% of knives and 81% chopping boards washed in plain water
Scott & Herbold 2010	Home; 30 households; USA	Video study and questionnaire; preparing hamburger sandwich	Many instances of hands not being washed at appropriate occasions. 40% washed their hands for 10s or less. Questionnaire and observation data contradicted.
Borrusso & Quinlan 2013	Home (n= 22); USA	Inspection of homes using audit tool (4 inspections per household) – tool development	Lack of cleaning materials, unclean kitchen sites Lack of hot water. Evidence of pest infestation Pets in food preparation areas. Damaged cutting boards Incorrect storage practices Use of food beyond use by dates Refrigerators operating above 5°C.
Borrusso & Henley 2015	Home (n=100); USA	Inspection of homes using audit tool, 8-9 homes per month (2 inspections per home)	Lack of cleaning materials Unclean kitchen sinks and counter tops. Animals present in kitchens Evidence of pest infestation in 65% Inappropriate storage practices. High risk foods beyond their use by date High risk foods stored at room temperature. Fridges operating >5°C. Some significant differences by ethnicity, income, education level and age.
Anderson *et al* 2004	Home; 99 consumers; USA	Video observation whilst preparing entrée of choice from provided ingredients and salad	727 occasions when hands were not washed Nearly all subjects handled food such that cross contamination could occur
Jay *et al* 1999	Home; 40 kitchens; Australia	Video observation in domestic kitchens	Infrequent and inadequate hand washing. Infrequent and inadequate cleaning of surfaces Contamination of surfaces Interaction with pets.

Redmond *et al* 2004	Model kitchen; focus on older consumers, those with children < 10 years, and young, single men; n=24	Video observation of preparation of chicken and pasta salad; risk scores based on observed malpractice	Up to 86% of unsafe food handling practice linked to cross contamination Suspected route of contamination with *Campylobacter* via handling raw chicken with hands and through contaminated dishcloths, or hand towels.

Appendix XIX

Summary (2) of observation studies of household hygiene behaviours included in systematic review (1990 – 2016)

Source	Hygiene behaviours that may lead to food borne illness identified in relation to:							
	Hand washing	**Boards / Knives**	**Use by date**	**Pets**	**Storage raw meat/ poultry**	**Storage RTE**	**Storage at ambient**	**Cooking**
Wills *et al* 2015				X			X	
Terpstra *et al* 2005			X			X		
Byrd-Bredbenner *et al* 2007	X				X	X		X
DeDonder *et al* 2009	X							X
Phang & Bruhn 2011	X	X						X
Scott & Herbold 2010	X							
Worsfold & Griffith 1997	X	X			X	X	X	
Fischer *et al* 2007	X	X						
Anderson *et al* 2004	X							
Jay *et al* 1999	X	X		X				
Kennedy *et al* 2011	X	X						
Redmond *et al* 2004	X	X						
Borrusso & Quinlan 2013			X		X	X	X	
Borrusso & Henley 2015			X	X	X	X	X	
Clayton *et al* 2003	X	X						
Van Asselt *et al* 2009	X	X						X

APPENDIX XX

Foodborne illness contribution arising from the domestic setting – workshop responses

From the 'evidence' presented in the systematic review does this suggest a measure of the contribution to foodborne illness arising from the domestic setting? *If so, which of the sources, should be considered reliable enough to base conclusions on?*
• All attendees agreed that the findings demonstrated that foodborne illness can arise from the domestic setting but that it was virtually impossible to arrive at an evidence-based estimate of a specific percentage from the information gathered in the Systematic Review. • It was accepted that food preparation practices in the home are one of a series of control points along the food chain. If food enters the home pathogen free then it is reasonable to conclude that any subsequent contamination and/or survival of harmful bacteria, leading to foodborne illness, is a result of failure to follow good hygienic practice within the domestic setting. • A degree of variation was noted in evidence from papers set in different countries but the reasons for this could only be surmised e.g. different surveillance systems, reporting requirements and diagnostic practices; different climate and temperature; different retail and food consumption patterns; variations in food choices and in storage, preparation and cooking practices. • It was considered that studies reporting on a large proportion of sporadic (unlinked) cases should be considered unreliable unless there was a clear and convincing description of how attribution to exposures or practices was determined. • Given the variations noted it was suggested that UK based papers might offer the most reliable information however some were "dated" and might not reflect the current situation e.g. Evans et al;1998. It was recognised that in selecting relevant material consideration would need to be given to factors beyond the date of writing alone e.g. currency of pathogen and prevalence trends. Concerns were also expressed about papers where the sample size was small e.g. Fitzgerald 2016. • Whilst UK papers were likely to be most applicable it was suggested that papers from other countries should not be ignored as they might give confirmation (or otherwise) of findings about factors influencing foodborne disease in the home. • It was recognised that the UK surveillance system(s) were not designed to focus on domestic kitchen practice. For example, data on household outbreaks, collected by Public Health England, relates only to dinner parties and similar events i.e. it does not link to every day household food preparation and consumption. Consequently, the surveillance systems could not be relied upon to properly recognise issues in the home. • Looking further at UK focused studies it was noted that often the same datasets were used in several the studies identified e.g. Evans at al 1998 and O'Brien et al 2002. This, it was suggested, might lead to "double counting". Subsequent discussion recognised such potential however there was no clear resolution or agreement on the likely extent of the issue. • It was noted that most of the information was based on outbreaks but attendees believed that most cases arising from the home were likely to be sporadic. This would indicate that basing action on outbreak data could be seriously flawed, as certain factors that result in infection in commercial kitchens are likely to be qualitatively different to those occurring in domestic kitchens e.g. pooling eggs and poor temperature control. • Similarly, little of the outbreak data collected would relate to factors likely to result in *Campylobacter* being transferred from chicken in the domestic kitchen. As this latter is the single issue with the greatest impact on the community it exemplifies the need to treat the information gained from outbreak surveillance with caution. It was agreed that, due to its systematic collection, outbreak data was more reliable than data on sporadic cases.

How can we combine the results from the different studies together?
• Given the variations noted and the lack of information on sporadic cases it was considered that it would be difficult to draw conclusions by combining results. However, considering the general lack of data some attendees suggested that there might be value in exploring opportunities for further interpretation of the data. This would need to recognise that outbreak data can provide epidemiological links to a common food source whereas sporadic cases do not. As such further analysis, might best consider outbreak and sporadic data separately.
Would any of the approaches outlined in the table be worthwhile conducting in the UK?
• No specific approaches were identified that would be worth replicating in the UK. Though it was considered that a focus on "causation" might provide useful information. Such an approach would require a directly observes study with careful section of cases to exclude illness that may have resulted from exposure outside the home.
Are the group aware of any other approaches which might provide estimates?
• The studies identified, through the systematic review, did not have a direct focus on home hygiene practice, rather the information had been drawn out from more general studies. • Studies with a clear focus on foodborne illness arising from the home would be required to permit a reasonable estimation of the disease burden from this setting. They would need to include a focus on sporadic cases linked to food preparation/consumption. It was suggested that the first stage of future research should be descriptive studies to test hypotheses, with a second stage involving case control studies, perhaps focused on individual pathogens. Alongside these observational studies might provide valuable insights into practices. • Whilst such approaches were supported it was agreed that their design would be complicated. • As a starting point, to provide data on sporadic cases, some attendees suggested that an online epidemiological study might be set up, involving people reporting diarrhoea and vomiting to their General Practitioner. • Stratification of studies by various factors was also suggested as an approach that could yield data of interest in defining policy and strategy. This would require initial consideration of the factors of "greatest importance" e.g. age, socio-economic status, ethnicity, gender etc. • There was general agreement that new technologies such as Whole Genome Sequencing might provide further insight into the food sources of illness but without proper epidemiological investigation they would not address the key issue of causation e.g. identify the common route of transmission and relevant food handling practices.

APPENDIX XXI

Proportion of foodborne disease cases caused by specific pathogens – workshop responses

Which considers the contribution made by pathogens, to what extent are the findings sufficiently reliable to draw conclusions in the final report?
• Many of the concerns expressed about the findings contained in the summarised review data indicating the proportion of foodborne disease arising from the home (section 3.3.1 main report) applied to the information from the studies included in the summary of studies investigating different organisms and the relative proportion of cases occurring in the home and in commercial food settings, e.g. it appears that forms used for data collection varied and not all studies were categorised by organism. • Information was mainly derived from outbreaks. Attendees noted that certain pathogens appeared more frequently in the reported outbreaks than others. *Salmonella* spp. featured frequently although food vehicle and setting were not always attributed (although some links were made to eggs and poultry). • The relative absence of *Campylobacter* outbreaks was noted. It was suggested that this might be due to failure to identify outbreaks, as exposure, through chicken alone, was likely to be high. Attendees noted that a good typing scheme for campylobacter was lacking, contributing to the difficulties in identifying outbreaks. It was also suggested that most *Campylobacter* cases were likely to be sporadic. • Other issues raised included impacts on precise recall where pathogens had longer incubation periods, which might be a factor in the apparent "under representation" of *Listeria* in outbreaks. More specifically a longer incubation period might make it harder to identify common foods consumed by cases in an outbreak. • Lack of clarity was a further concern e.g. although the Sockett *et al.* study focused on household outbreaks there was no information about where illness was acquired i.e. it might have been brought in from a commercial source.

APPENDIX XXII

Potential for foodborne disease in the home resulting from failure to implement recommended practices – workshop responses

To what extent can conclusions be drawn about the potential to render food 'unsafe' through poor practices (malpractices) in the home? Specifically, cross contamination, poor transportation conditions, inadequate storage, inappropriate handling and inadequate preparation (including cooking).
• It was noted that the UK surveillance system utilised five categories for common risk factors in outbreaks, but it was suggested that practices might be better considered under the; following (group) headings: cross-contamination; heat treatment; time-temperature control; infected food handler and other. • It was suggested that there was an inbuilt bias in published peer reviewed papers as these tended to focus on newer (more interesting) cases rather than the better-known issues. • Some concerns were expressed about the potential for confusion from the use of various definitions to identify outbreaks arising from the home i.e. "household outbreak" (household residents only) and "general outbreak" (household residents plus visitors e.g. a dinner party with friends). However, whilst there might be some degree of ambiguity, these definitions have been in place since 1992 and are accepted by FSA, ACMSF and international experts. Making changes would risk further confusion. Workshop stimulus: case report • The evidence to directly link illness to causation was limited (6 case reports). Apart from the paper by Ryan et al (an older study), which considered a number outbreaks involving home catered events, there was no indication of the relative risk of foodborne disease arising from failures to follow recommended hygiene practice. • Attendees pointed out that the Ryan et al paper was a review of available surveillance data and thus might be repeated using more recent UK and EU data. It was also acknowledged that home catered events did not reflect normal household practice e.g. volumes of food were likely to be higher and this would need to be considered in drawing any conclusions about "risky" practices. • It was reiterated that the UK surveillance system was not designed to consider household outbreaks. Workshop stimulus: Case control studies • The case control studies were a better source of information on foodborne disease risk factors than the case reports. The range of factors considered was broad (though it was suggested these might not cover all factors of interest in the UK currently) and some studies appeared methodologically strong. • It was suggested that there could be merit in identifying the number of studies featuring each risk factor, the effect size and the statistical support. This might provide stronger information. Similarly, it was suggested that better information might be extracted by considering findings by individual pathogen. • Whilst analysing the studies in different ways might increase the value of the information on risk factors, it was noted that the focus of the studies appeared to be on identification of the food vehicles involved. This could affect the reliability of any hypotheses generated about food handling practices. • Several foods were identified as linked to illness, with eggs being specifically linked to *Salmonella* outbreaks. Given that eggs (at the time of the studies) were known to be contaminated with *Salmonella* it was suggested that there could be over attribution to this pathogen as other factors might not have been properly considered. • It was pointed out that the date of studies must be considered especially in the case of *Salmonella* and eggs, where "at source" interventions had now significantly decreased the risks of illness occurring. • UK papers produced within the last 10 years including surveillance data were identified as being most relevant. Variation in data production from different countries was also highlighted.

APPENDIX XXIII

Risk factors attributed to practices and behaviours in the home associated with incidence of foodborne disease in the domestic setting – workshop responses

Is there sufficient justification to surmise that the factors attributed to practices and behaviours in the home are causal to the risk posed to human health? *And is it reasonable to conclude that they are responsible for the incidence of foodborne disease in the domestic setting?*
• Whilst observational studies will provide a degree of insight into practices, they might be considered "slightly artificial" in that the food preparation has been pre-determined by the researchers and the fact that practices are actively observed. These circumstances would be expected to influence behaviours; However, such studies may still produce useful insights. It should also be recognised that such studies may have a different impact on different groups as biases may not be uniform across ages/ genders/socio economic groups etc. Refrigerator studies • For the fridge studies, it was suggested that the temperature of the external environment can impact on results e.g. depending on location the Italian study (Catellani *et al.*) might have taken place in a much warmer environment than UK studies. • Further degrees of uncertainty are created by the age of some studies and the lack of information about the refrigeration equipment i.e. refrigeration technology has improved over time. Similarly, refrigeration practices have changed over time and findings in papers could be influenced by the age of study participants. • As in previous questions it was highlighted that the pathogen and levels of contamination subjected to poor temperature control (and its extent) would be expected to change the potential seriousness of the poor practice. For example, predictive modelling shows that *Listeria* will grow twice as fast at 8^{o}C compared to 5^{o}C. • Given the caveats about the variations in circumstances of malpractice i.e. food type, pathogen, extent of malpractice and vulnerability of consumer it is problematic to conclude that poor refrigeration practice will cause foodborne illness. However, some pathogens can grow at refrigeration temperatures, potentially increasing the risk of foodborne disease. Microbiological investigations in the home (or in realistic settings) • Evidence shows that suggests the potential for cross contamination exists. The studies indicate that this might be from a contaminated food to ready to eat food but also highlight the lack of handwashing which can cause direct contamination. • Even the observations of "infrequent" transmission in e.g. video reviews of practice must be considered in the light of approximately 50,000,000,000 person meals consumed in England per year, many prepared or partly prepared in the home. • So, although not demonstrating cause, the studies suggest that it is reasonable to assume that food borne disease may result from cross contamination, given the prevalence of contamination in the kitchen environment, the number of events at which cross contamination could occur (provided there is a breakdown in hygiene practices) and the clear evidence of intermittent breaks in good hygiene practices.

- However, the existence of a “persistent and frequent” level of cross contamination in the home environment does not match the pattern and incidence of foodborne infection i.e. a predominance of apparently sporadic cases of infection. This raises questions about the transmission pathways and suggests that they may be more complex than the studies indicate.

Observation studies

- It was noted that some of the observational studies took place in the home and others in “controlled settings”. As such differences in observations might be expected. Some three studies also reported differences in practices linked to age and gender. However, they were not UK based and the effects differed. Consequently, the findings would need to be considered cautiously and examined for relevance and significance. Workshop attendees at suggested that there could be a range of factors that affected behaviours including nationality and culture; age; gender; ethnicity, education etc.

APPENDIX XXIV

Assessment of the relative likelihood of a specific 'practice' or groups of 'practices' to cause foodborne illness: expert responses

- There was general agreement that all the different practices listed in the Exercise template could lead to foodborne illness but in general illness resulted from "a series of unfortunate events (practices)". It was reiterated that variation in study design would undermine any attempt to aggregate findings from the published papers included in the Systematic Review. Consequently, views on relative importance of different practices would need to be considered on "pragmatic grounds" i.e. likelihood of greatest impact.

- Expert members pointed out that whilst it was useful to consider the relative importance of various domestic practices, health impacts would vary according to factors such as the pathogen present; its infectious dose; the food type and the vulnerability of the consumer. A "worst case" example might be the presence of *Listeria* on a ready to eat food with inappropriate cold holding and consumption beyond "Use by date" by a vulnerable person.

- Attendees also queried the relative validity of "self-reported" behaviours against "observed behaviours" and the extent to which these were likely to be replicated in the home. Failure to adjust for design bias could impact on the effectiveness of any future intervention (though the difficulty in adjusting for such bias was fully recognised).

- Concerns were expressed about linking domestic practices to illness i.e. whilst it was reasonable to suspect linkage, causation was difficult to demonstrate. It was suggested that the relative importance of different practices should be considered based on whether they involved a food safety Critical Control Point (CCP).

APPENDIX XXV

Pathogen Specific Theoretical frameworks

Food related activities to point of consumption	Action identified in systematic review as possibly linked to hazard	Hazard	Potentially leading to food borne disease as a result of consumption of:	Key
Purchase [a]		Contaminated →	Ready to eat food; eaten immediately	→ Literature points to a possible link, but not a proven causal link ➔ Definite link; extended time will increase risk of hazard occurring, represented by heavier line [a] contamination could be exacerbated through prolonged transport out of chill [c] Contamination may also be through dirty cloths [d] infected other relates to another individual in the home with symptoms of food borne disease Highlighted text indicates key hazardous practices
Storage			Ready to eat food, or prepared, uncooked, food after further storage	
Preparation	**Infected other** [d] **Inadequate handwashing** **Inadequate cleaning, including reuse equipment** [c] →	Contamination/cross contamination →	Prepared food, no cooking	
	Pets in household →	Contamination/cross contamination →		
Cooking	**Inadequate cooking – temp/time/both** →	Survival of pathogens →	Cooked food eaten immediately	
Storage after cooking/service			Cooked food stored for later use – without reheating	
Reheat/hot holding	**Inadequate heating – time/temp/both** →	Survival of pathogens →	Cooked food stored for later use – with reheating	
Serve	**Infected other** [d] **Inadequate handwashing** **Inadequate cleaning, including reuse equipment** [c] →	**Contamination/cross contamination** →	Hot or cold food, could be ready to eat, may be subsequently stored for later use	
	Pets in household →	**Contamination/cross contamination** →		

Theoretical framework for potential influences in the home leading to foodborne disease from *Campylobacter,* based on Systematic Review and Expert Workshops (2016)

Food related activities to point of consumption	Action identified in systematic review as possibly linked to hazard	Hazard	Potentially leading to food borne disease as a result of consumption of:	Key
Purchase [a]		**Contaminated**	Ready to eat food; eaten immediately	
Storage	**Inadequate chilling/ Extended storage time** [b]	**Bacterial growth**	**Ready to eat food, or prepared, uncooked, food after further storage**	
Preparation	Infected other [d] Inadequate handwashing Inadequate cleaning, including reuse equipment [c]	Contamination/cross contamination	Prepared food, no cooking	
Cooking	Inadequate cooking – temp/time/both	Survival of pathogens	Cooked food eaten immediately	
Storage after cooking/service	**Inadequate chilling/ Extended storage time** [b]	Bacterial growth	Cooked food stored for later use – without reheating	
Reheat/hot holding	Inadequate heating – time/temp/both	Survival of pathogens	Cooked food stored for later use – with reheating	
Serve	Infected other [d] Inadequate handwashing Inadequate cleaning, including reuse equipment [c] **Inadequate chilling/ extended storage time** [b]	Contamination/cross contamination **Bacterial growth**	Hot or cold food, could be ready to eat, may be subsequently stored for later use	

Literature points to a possible link, but not a proven causal link

Definite link; extended time will increase risk of hazard occurring, represented by heavier line

[a] contamination could be exacerbated through prolonged transport out of chill

[b] including exceeding use by dates

[c] Contamination may also be through dirty cloths

[d] infected other relates to another individual in the home with symptoms of food borne disease

Highlighted text indicates key hazardous practices

Theoretical framework for potential influences in the home leading to foodborne disease from *Listeria,* based on Systematic Review and Expert Workshops (2016)

Food related activities to point of consumption	Action identified in systematic review as possibly linked to hazard	Hazard	Potentially leading to food borne disease as a result of consumption of:	Key
Purchase		Contaminated →	Ready to eat food; eaten immediately	→ Literature points to a possible link, but not a proven causal link [c] Contamination may also be through dirty cloths [d] infected other relates to another individual in the home with symptoms of food borne disease Highlighted text indicates key hazardous practices
Storage ←			Ready to eat food or prepared, uncooked, food after further storage	
Preparation ←	**Infected other** [d] → **Inadequate handwashing** **Inadequate cleaning, including reuse equipment** [c]	Contamination/cross contamination →	Prepared food, no cooking	
Cooking	**Inadequate cooking – temp/time/both** →	Survival of pathogens →	Cooked food eaten immediately	
Storage After cooking/service ←			Cooked food stored for later use – without reheating	
Reheat/hot holding	**Inadequate heating – time/temp/both** →	Survival of pathogens →	Cooked food stored for later use – with reheating	
Serve ←	**Infected other** [d] → **Inadequate handwashing** **Inadequate cleaning, including reuse equipment** [c]	Contamination/cross contamination →	Hot or cold food, could be ready to eat, may be subsequently stored for later use	

Theoretical framework for potential influences in the home leading to foodborne disease from *norovirus,* based on Systematic Review and Expert Workshops (2016)

Food related activities to point of consumption	Action identified in systematic review as possibly linked to hazard	Hazard	Potentially leading to food borne disease as a result of consumption of:	Key
Purchase [a]		Contaminated	Ready to eat food; eaten immediately	→ Literature points to a possible link, but not a proven causal link ➔ Definite link; extended time will increase risk of hazard occurring, represented by heavier line [a] contamination could be exacerbated through prolonged transport out of chill [b] including exceeding use by dates [c] Contamination may also be through dirty cloths [d] infected other relates to another individual in the home with symptoms of food borne disease Highlighted text indicates key hazardous practices
Storage	**Inadequate chilling/extended storage time** [b]	Bacterial growth	Ready to eat food or prepared, uncooked, food after further storage	
Preparation	Infected other [d] Inadequate handwashing Inadequate cleaning, including reuse equipment [c] Pets in household	Contamination/cross contamination	Prepared food, no cooking	
Cooking	**Inadequate cooking – temp/time/both**	Survival of pathogens	Cooked food eaten immediately	
Storage after cooking/service	**Inadequate chilling/extended storage time** [b]	Bacterial growth	Cooked food stored for later use – without reheating	
Reheat /hot holding	**Inadequate heating – time/temp/both**	Survival of pathogens	Cooked food stored for later use – with reheating	
Serve	Infected other [d] Inadequate handwashing Inadequate cleaning, including reuse equipment [c] Pets in household **Inadequate chilling/extended time out of chill** [b]	Contamination/cross contamination Bacterial growth	Hot or cold food, could be ready to eat, may be subsequently stored for later use	

Theoretical framework for potential influences in the home leading to foodborne disease from *Salmonella,* based on Systematic Review and Expert Workshops (2016)

Food related activities to point of consumption	Action identified in systematic review as possibly linked to hazard	Hazard	Potentially leading to food borne disease as a result of consumption of:	Key
Purchase [a]		Contaminated	Ready to eat food; eaten immediately	→ Literature points to a possible link, but not a proven causal link ➡ Definite link; extended time will increase risk of hazard occurring, represented by heavier line [a] contamination could be exacerbated through prolonged transport out of chill [b] including exceeding use by dates [c] Contamination may also be through dirty cloths [d] infected other relates to another individual in the home with symptoms of food borne disease Highlighted text indicates key hazardous practices
Storage	**Inadequate chilling/ Extended storage time** [b]	Bacterial growth	Ready to eat food or prepared, uncooked, food after further storage	
Preparation	**Infected other** [d] **Inadequate handwashing** Inadequate cleaning, including reuse equipment [c]	Contamination/cross contamination	Prepared food, no cooking	
Cooking	Inadequate cooking – temp/time/both	Survival of pathogens	Cooked food eaten immediately	
Storage after cooking/service	**Inadequate chilling/ Extended storage time** [b]	Bacterial growth	Cooked food stored for later use – without reheating	
Reheat/hot holding	Inadequate heating – time/temp/both	Survival of pathogens	Cooked food stored for later use – with reheating	
Serve	**Infected other** [d] **Inadequate handwashing** Inadequate cleaning, including reuse equipment [c]	Contamination/cross contamination	Hot or cold food, could be ready to eat, may be subsequently stored for later use	
	Inadequate chilling/ Extended storage time [b]	Bacterial growth		

Theoretical framework for potential influences in the home leading to foodborne disease from *Staphylococcus aureus,* based on Systematic Review and Expert Workshops (2016)