The use of meat thermometers in home kitchens on the island of Ireland

safefood

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ISBN: 978-1-905767-97-7

Publication date: February 2021

Foreword

This research was funded by ***safe***food, who promote awareness and knowledge of food safety on the island of Ireland. The focus of ***safe***food's food safety campaigns is to positively influence food safety behaviours by informing and empowering individuals with knowledge and motivation. A robust evidence base guides ***safefood's*** communications and this scientific background delivers consumer advice that is practical and clear, independent and appropriate. The present research provided an insight into meat thermometer use, ownership and associated attitudes and behaviours on the island of Ireland. A mixed methods approach was employed. Qualitative focus groups produced rich data about subjective experiences and attitudes, while a quantitative consumer survey sampled a representative quota from the island of Ireland and provided a large body of data to allow for the comparison of different demographic, attitudinal and behavioural groups. This research was conducted to provide information on the use of meat thermometers on the island of Ireland. That information will inform possible strategies to encourage the use of meat thermometers.

Acknowledgements

safefood would like to thank all those who contributed to this research project:

Researchers: Dr Samuel Ward, Dr Lynsey Hollywood, Professor Una McMahon-Beattie, Mr Martin Devaney (Ulster University Business School, Department of Hospitality and Tourism Management);

Dr Ruth Price, Dr Adele McElroy (Ulster University, School of Biomedical Sciences, NICHE); and Ms Amanda McCloat and Dr Elaine Mooney (St. Angela's College, Sligo).

Research Advisor: Professor Monique Raats (University of Surrey, Food Consumer Behaviour and Health Research Centre)

Market Research Company: SMR Belfast for the recruitment of focus group participants and the collection of survey data.

All those who participated in the survey, the accompanied practical exercise, and focus group.

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Aim

*safe*food's current advice on how to check whether meat is cooked properly is based on three physical checks; making sure the meat is piping hot, that the juices run clear and that for meats that need to be cooked well done, there is no pink meat. This advice was given priority because of low ownership and use of meat thermometers on the island of Ireland (IoI). However, meat thermometers are the fail-safe way to check that meat is done properly. This project aimed to investigate current perceptions and trends in the use of meat thermometers by consumers on the IoI, and to assess behaviours and attitudes towards meat thermometers and their reported usage. To achieve the project objectives three stages were carried out, a rapid review, focus groups and a consumer survey.

Rapid review

The rapid review of available academic studies and grey literature (e.g., government reports) yielded 44 papers. These papers found that meat thermometer use has steadily increased in the USA and Canada since 1998, from 49% usage in 1998 to 70% in 2010. This may be the result of targeted campaign interventions to encourage usage (the Fight BAC/Thermy campaign in 2000 and the "Is It Done Yet?" campaign in 2004 were both conducted in the USA). Although fewer research studies on meat thermometer use in Europe were identified, three conducted in the UK and Republic of Ireland (RoI) stating a 2-5% usage and two in mainland Europe (Netherlands and Belgium) reporting 0.8-11% meat thermometer usage, the published research would indicate that usage is lower than in the USA and Canada.

Focus Groups

Sixty-five participants (50 female; 15 male) from a wide geographical spread across the IoI were recruited. Results demonstrated that the most commonly reported measure (n=40) of assessing the doneness of meat was to check that there was no pink meat, and that juices ran clear from the meat (this practice was most commonly used when cooking poultry). Potential motivators of meat thermometer use included: social responsibility; as a means of improving the quality of meat; ease of use; and the distribution of meat thermometers without cost. Barriers to use included a perception that meat thermometers were expensive; a lack of exposure to meat thermometers in a domestic setting; the idea that a meat thermometer would be problematic to maintain and contribute to kitchen clutter; and that meat thermometers were used by either highly experienced or inexperienced cooks. Sources of information on the safe cooking of meat used by the participants included family members, butchers, recipe leaflets, internet sources, Home Economics class, and television.

Consumer Survey

A survey was conducted on 1,052 individuals across the island of Ireland to provide a quantitative tool for the assessment of consumers' perceptions and self-reported meat thermometer usage and ownership. The results found that 15.7% (n=165) of participants stated that they used a meat thermometer when cooking meat. 17.4% (n=183) of participants stated that they owned a meat thermometer, meaning there is an ownership-usage gap (those own but do not use) of 1.7%. This percentage is relatively small compared to the USA and Canada. According to the Transtheoretical Model of Change (Shapiro et al, 2011), most participants (86.5%) were in the "pre-contemplation" stage of behavioural change: they had never used a meat thermometer, nor ever thought about doing so. Both meat thermometer owners and non-owners had a poor understanding of meat thermometer insertion methods (ranging from 21.4% accuracy for burgers, 51.7% for roasts), and of the safe end-point temperature of meat which ranged from 30 - 260℃.

"Attitude" (a belief that a meat thermometer prevented food poisoning, and that food poisoning was a risk) significantly predicted meat thermometer use when cooking roasts and small cuts of meat (but no other meat types). Meanwhile, perceived behavioural control (i.e. ease of use) significantly predicted meat thermometer use on whole chicken (but no other meat types). Subjective norms did not significantly influence meat thermometer use on any meat type. This would suggest that effectively communicating the risk of food poisoning from undercooked meat, and that a meat thermometer can prevent food poisoning, might encourage usage levels when cooking roasts and small cuts such as chicken breasts or beef burgers. Effectively communicating the ease with which a meat thermometer might be used may increase levels of use on whole chicken. This could be done via social media networks or informal peer-to-peer networks to promote meat thermometer use. Meat producers could also be encouraged to print recommendations to use a meat thermometer (and how to do so properly) on packaging.

1 Introduction

Both the focus groups and the consumer survey generated valuable insights into how the use of meat thermometers could be promoted during a public communications campaign. The key recommendations that emerged from the analyses suggest that future campaigns could:

1. Encourage people to begin using a meat thermometer, as most were in the pre-contemplation stage of change (never having used a meat thermometer, nor thought about using one, but were open to using one).
2. Educate people regarding the correct insertion method of meat thermometers and of the safe end-point temperature of meat in all cuts of meat.
3. Emphasise that a meat thermometer could be used when cooking any kind of meat, as users report using thermometers more often with larger pieces of meat (whole poultry) than smaller pieces (sausages and burgers).
4. Use social media, TV and radio public service announcements, and poster campaigns to encourage meat thermometer use. These channels should encourage the dissemination of information on meat thermometer use through networks of family, friends, and local butchers.
5. Recommend including instructions on how to cook meat on product packaging. Meat producers could be encouraged to do this on all meat packaging as a voluntary code of practice.
6. Integrate instructions on how to use a meat thermometer into free recipe leaflets. Many participants mentioned getting instructions on how to cook meat from these.
7. Promote the social responsibility of avoiding the causing of food poisoning of others, and emphasise that food poisoning is a serious risk, even when cooking at home.
8. Avoid using famous TV chefs to promote the message. People need to relate to a 'normal' person. This would help to discredit the fallacy that meat thermometers are for professionals or for people who don't know how to cook – they are for everyone.

9. Highlight the fact that using a meat thermometer improves the taste and texture of meat. This was reported as a motivator for use during the focus group study and in other research.
10. Emphasise the affordability of meat thermometers to counteract consumers' frequent overestimation of their cost.
11. Collaborate with Home Economics teachers in schools. This could involve the distribution of a free meat thermometer to each Home Economics kitchen as part of a campaign to educate students on correct meat temperature procedure, along with the correct core temperatures. This will also help to develop good practice among students as future consumers.

2 Introduction and background

An estimated 600 million people become ill, and 420,000 die, after eating contaminated food every year (WHO, 2020). Diarrhoeal diseases are the most common illnesses resulting from the consumption of contaminated food, causing 550 million people to fall ill and 230,000 deaths every year (WHO, 2020). Foodborne illnesses cost the global economy billions of dollars a year – an estimated $450 million from *Escherichia coli* (*E. coli*) alone (Scharff, McDowell, and Medeiros, 2009).

In the UK, a report from the Food Standards Agency (FSA) published in February 2020 (FSA, 2020), identified 2.4 million cases of foodborne illness for 2018, an increase from the figure of one million cases that was reported in 2009 by the FSA. This increase of 1.4 million cases provides a better estimation of the proportion of infectious intestinal disease that is due to foodborne illness, whilst the overall estimate for this type of illness, from all sources, remains the same at around 18 million cases each year in the UK. This means around 13% of all infectious intestinal disease is due to food poisoning, which in turn means food is responsible for more existing cases than previously thought and further suggests that official figures underestimate, through lack of reporting, how many people suffer from food poisoning each year in the UK (FSA, 2020). There is a difference between recorded levels of food poisoning and estimates of total food poisoning due to confirmed laboratory reports, with the latter only making up a fraction of all cases of infectious intestinal disorders (FSA, 2020). Not everyone who has an illness will seek medical help, not everyone who seeks medical help will have a sample taken, and even when a sample is taken, there will not always be a positive result identifying the causal pathogen.

In RoI, the most recent figures for different types of food borne illnesses that were attributed to the pathogens in uncooked meat were recorded between 2017-2018 by the Health Promotion Surveillance Centre (HSPC). The total number recorded in Ireland for this period was around 9,000 cases (HPSC, 2018). However, as explained above, these figures may be higher each year than those reported, for reasons that include people not self-reporting instances of food poisoning. This underlines the importance of

minimising and mitigating the risk of food poisoning in the domestic setting by safe cooking practices, and using aids such as meat thermometers to support these safe cooking practices.

Bacteria are the most frequent cause of foodborne illness. The most common foodborne pathogens in uncooked meat are *Campylobacter jejuni*, *E. coli*, *Listeria monocytogenes*, and *Salmonella* (of which there are 2,300 types) and *Clostridium perfringens*. Meat has been identified as a common source of foodborne disease and a public health concern (WHO, 2020). Harmful bacteria from animal sources are known to contribute to the cause of foodborne illness, especially when meat is undercooked (WHO, 2020). Current government advice on ascertaining the acceptability of meat for consumption varies between regions. In the RoI, recommendations include cutting the meat to check to see if the juices run clear, checking to see if the food is piping hot all the way through, and checking that none of the meat is still pink. In the UK, recommendations include making sure meat is steaming hot and cooked all the way through, and to cut into the thickest part of the meat to check that none of the meat is pink and that any juices run clear (FSA, 2018). These recommendations, in the RoI and the UK, have been found to be unreliable in establishing doneness (Lyon et al, 2000). Given the reported rates of food poisoning on the IoI (RoI and NI), it is important to determine the adequacy of these guidelines and explore the potential for encouraging the use of meat thermometers within a domestic setting.

Meat thermometers provide an easy and accurate means to assess the final core temperature of meat, ensuring a safe cooking temperature has been reached to reduce the presence of bacteria in food, thus minimising the risk of foodborne illnesses. Globally, meat thermometer use remains low; however, meat thermometer use in North America is higher than in Europe (though research on use and ownership in the latter region is sparse – Sampers et al, 2012; Kennedy et al, 2005; Fischer, Frewer, and Nauta, 2006; Mahon et al, 2006; Bates et al, 2017). Since available research began in 1998 (Koeppl, 1998; Unklesbay, Sneed, and Toma, 1998; Lando and Chen, 2012), meat thermometer use in the USA has increased steadily (Cates, Kosa, and Carter-Young, 2002; Lando and Chen, 2012), possibly as a result of several campaign interventions by the United States Department of Agriculture. In the most recent USA study of Lin (2018), it was observed that 25% of 1688 participants reported checking the temperature of burgers as a method to judge when the meat was properly cooked. The study also found that the temperature method of

assessment was more likely to be reported by mid-age participants of 30-44 and 45-59 as compared to older participants.

On the island of Ireland, Kennedy et al (2011) found that 27.1% of consumers reported experiencing food poisoning within the past six months, and that only 30% of consumers followed the ***safe***food meat safety preparation advice (cutting the meat to check to see if the juices run clear, checking to see if the food is piping hot all the way through, and checking that none of the meat is still pink). In an observational component of the same study, the researchers found that 68.9% of chicken samples, which participants had been given to cook, had not reached the optimum cooking temperature of 75°C. Research on the use of meat thermometers on the island of Ireland has been sparse: Kennedy et al (2005) found that only 2% of the population of the island of Ireland stated that they used a meat thermometer to determine the doneness of meat, while Mahon et al (2006) found that 3% of consumers stated that they did so when cooking ground beef.

Kennedy et al's 2005 study focused on knowledge of microbiology, and Mahon et al's 2006 study focused on preparation of beef products. However, there has been no comprehensive study of meat thermometer usage, ownership, and attitudes towards meat thermometers on the island of Ireland.

3 Project aims and objectives

The project aims and objectives were to:

1. Investigate current perceptions and trends in the use of meat thermometers;
2. Assess consumer behaviour and attitudes towards the use of meat thermometers on the island of Ireland;
3. Identify barriers and motivators to using meat thermometers on the island of Ireland; and
4. Develop recommendations for overcoming barriers, raising awareness and promoting the use of meat thermometers.

4 Materials and methods

The four objectives outlined above were met by carrying out a three-stage study design, using both qualitative and quantitative approaches. Each stage of the study helped to inform the structure and interpretation of the research. These stages are as follows:

1. **Rapid review** of academic studies and grey literature (recommendations from food safety authorities and government reports) on meat thermometer usage and attitudes towards meat thermometers.
2. **Focus groups** across the island of Ireland, recruited to reflect a socioeconomic, North/South, urban/rural and East/West split. The purpose of the focus groups was to elicit consumers' attitudes, beliefs and practices on using meat thermometers to cook meat safely at home, in order to inform the development of stage three, the consumer survey.
3. **Consumer survey** across the island of Ireland (with even sampling of Northern Ireland and Republic of Ireland consumers) to assess consumer perceptions towards the use of meat thermometers.

Stage 1: Rapid review

A rapid review of academic studies and recommendations from food safety authorities in six English-speaking territories (the UK, island of Ireland, the USA, Canada, Australia and New Zealand) was conducted to identify trends in the use of meat thermometers. In addition, the rapid review examined consumer perceptions/behaviours towards the adoption of meat thermometer use in the domestic setting. The findings of this review were used to inform the subsequent stages of the methodology.

During the literature search, a number of search terms were identified. These were searched for on an individual basis and in combination with other terms. For instance, meat thermometers have often been termed “food thermometers” and “meat probes”. In this case, all synonyms were listed in the search, using the Boolean operator 'OR', to instruct the search engine to search for articles with any of the

synonymous terms. As this assessment was concerned specifically with the use of meat thermometers (rather than the science or production of meat thermometers, etc.) the Boolean operator 'AND' was employed, to allow searches which search for an exact combination of terms, such as “meat thermometer” and “use” (See page 5 of deliverable 3 report for further details on the search strategy).

Articles were included if they addressed:

1. the use and non-use of meat/food thermometers with specific reference to meat products,
2. meat preparation practices and behaviour change among consumers,
3. previous interventions to improve meat preparation practices among consumers,
4. meat preparation practices and risk perception among consumers,
5. public and consumer perceptions of meat thermometers,
6. barriers and/or motivators to safe(r) meat preparation practices.

Articles were excluded if they:

1. were non-English language studies,
2. took place before 1980,
3. were published before 1980,
4. were not in a peer-reviewed journal (apart from the grey literature sources mentioned above).

A total of 121 different academic databases were searched using USearch (see http://library.ulster.ac.uk/electronic/index.php for a full list). Despite the extent of the search, only 19 databases yielded results, of which only 12 were deemed relevant (Business Source Complete, Science Citation Index, Hospitality and Tourism Complete, MEDLINE, SPORTDiscus, Scopus, Social Sciences Citation Index, CINAHL Plus, Cochrane Database of Systematic Reviews, ERIC, Directory of Open Access Journals, Emerald Insight).

Ad hoc searches were also carried out on reference lists of those papers already identified through the database search. The websites of food authority bodies in six English-speaking countries (UK, island of Ireland, New Zealand, Australia, USA, and Canada) were also examined to find existing advice and research on meat thermometer use. Further details of these searches may be found in project deliverable 3.

From the 12 databases that were deemed suitable, in addition to the searching of grey literature and ad hoc searches, a total of 43 papers were identified to be included in this review (see Tables 3 & 4). Each paper included was critiqued by extrapolating relevant data for comparisons including methods, geographical location, sample and pertinent results.

Stage 2: Focus groups

During the second stage of the study, an in-depth qualitative exploration of the barriers and motivators relating to the adoption and use of meat thermometers was carried out using focus groups. These groups were used to determine consumers' attitudes, beliefs and practices in relation to using meat thermometers to cook meat safely at home.

Six focus groups were undertaken across the island of Ireland. Participants were recruited by a market research company using purposive sampling in that they were recruited to represent both ABC1 and C2DE socioeconomic groups. The ABC1 (n = 20) bracket included people employed in higher, intermediate and junior managerial, supervisory, administrative, clerical and professional occupations. The C2DE (n = 23) bracket included people employed in skilled, semi-skilled & unskilled manual occupations, and unemployed and lowest grade occupations. Recruitment was also split between urban and rural participants and ensured a geographical spread across the island of Ireland (Belfast, Coleraine, Dublin, Galway and Sligo). All participants were required to meet the following inclusion/exclusion criteria:

- Be aged 18 years or over,
- Have primary responsibility for the cooking of food in their household, and
- At least occasionally cook meat.

Focus groups took place between 16/10/19 and 23/10/19. In total, 65 participants took part (mean = 10.8$\pm$1.32/6, range 10-13). The length of the focus groups ranged from 60 to 90 minutes, with a mean running time of 67$\pm$9.58 minutes. Results from the rapid review, alongside discussions within the research team, informed the development of the focus group discussion guide (see Appendix 1). A semi-structured approach was used within the groups, which followed the guide but also allowed additional relevant questions and follow-up on salient responses.

In order to supplement and support the analysis of the focus group transcripts, a field note taker helped to set up the focus groups, welcomed the participants, ensured that the focus groups were being recorded effectively, and took detailed notes on the focus group discussion.

All focus groups were audio recorded. The recordings were subsequently transcribed by a professional transcription service. Following transcription, the qualitative analysis software Nvivo (v11) was used to conduct a thematic analysis of the data. In this approach to coding qualitative data, themes are allowed to emerge in a relatively organic manner from the dataset, rather than imposing pre-conceived themes upon it (Braun and Clarke, 2003). However, the structured nature of the focus groups (informed by the existing literature and pre-determined research questions) resulted in certain themes being inherent within the data.

Both the research associate and a research assistant coded the data using a three-step process.

Stage 1: the research associate and the research assistant separately read and re-read the focus group transcripts, to develop a familiarity with the data, and patterns that existed within it.

Stage 2: the research associate and research assistant separately generated "codes": patterns or phrases within the dataset that grouped different parts of the discussion together. During this stage, codes that appeared to be synonymous were collapsed into a single code.

Stage 3: the research associate and research assistant shared the codes they had generated separately, along with a detailed description of what each code entailed. After agreeing upon the suitability of each code and to which passages of the transcript they applied, the research associate and research assistant began to categorise groups of codes into overarching themes, which accurately depicted broader concepts that emerged in the data.

All themes identified in this stage of the study were presented to the team at a research meeting, and were discussed and verified (intercoder reliability 74%).

Stage 3: Consumer survey

Thirdly, a quantitative tool for assessment of consumer perceptions of the use of meat thermometers was developed. This was based on learning derived from both the rapid review and the focus groups. The survey (n=1,052) included questions on the following in relation to using meat thermometers:

- perceptions
- barriers/motivators
- meat safety knowledge
- meat handling practices
- decision-making regarding the pros and cons of using a food thermometer
- frequency of use
- measures of behavioural change (including the theory of planned behaviour, trans theoretical Model of Change)
- Socio-demographic indicators.

The quantitative research provided a cross-sectional view of the current level of understanding on meat thermometers.

Before deployment in the field, the consumer survey was piloted (n=14) and appropriate alterations to the survey were made. The recruitment of survey participants was facilitated by the market research company Social Market Research (SMR) using a purposive sampling approach to ensure the sample was representative across the island of Ireland (accounting for a ROI / NI, male/female, urban/rural split). Respondents were also required to meet the following inclusion/exclusion criteria:

- To permanently live at the address where the interview took place
- Be aged 18 years or over
- Have primary responsibility for the cooking of food in their household
- At least occasionally cook meat.

A total of 1,052 participants (n=513 NI; n=539 RoI) from across 107 different geographical locations across the IoI completed the survey between 4/12/19 and 13/01/20. The survey was administered on a face-to-

face basis by SMR, lasting between 15 – 20mins, and responses were recorded on a tablet in real time. A table outlining the demographics of consumer survey respondents can be seen below.

Table 1: Characteristics of survey respondents

	Overall sample	RoI	NI
%(n)*	1,052	51.2%$ (539)	48.8%$ (513)
Female **Male**	67.6% (712) 32.4% (340)	67.7% (364) 32.3% (175)	67.4% (346) 32.6% (167)
Mean age (years) ± SD	48.71±16.74	48.75±16.05	48.66±85
Socioeconomic class **ABC1** **C2DE** **F (farmers)**	 45.2% (476) 51.1% (538) 3.6% (38)	 46.4% (251) 46.8% (252) 6.9% (37)	 44.1% (226) 55.8% (286) 0.2% (1)
Highest educational attainment Primary Junior cert/GCSE Leaving cert/A level Undergraduate degree Postgraduate degree No response	 6.8% (72) 31.1% (327) 27.5% (289) 29.8% (314) 3.6% (38) 1.1% (12)	 5.4% (29) 29.9% (161) 32.1% (173) 27.6% (149) 3.5% (19) 1.5% (8)	 8.4% (43) 32.4% (166) 22.6% (116) 32.2% (165) 3.7% (19) 0.8% (4)
Co habitation with at risk individuals Children under 5 Children aged 5 10 Adult aged 55+ Individual with a weakened immune system Pregnant individual (or has been in the past 12 months) Does not co habit with a vulnerable individual	 14.2% (149) 17.9% (188) 36.6% (385) 1.3% (14) 1% (10) 36.5% (384)	 13.0% (70) 13.0% (70) 34.7% (187) 1.1% (6) 0.7% (4) 40.3% (217)	 15.4% (79) 23% (118) 38.6% (198) 1.6% (8) 1.2% (6) 32.6% (167)
Limitation due to disability Limited a lot Limited a little Not limited Prefer not to say	 3.4% (36) 10.8% (114) 83.4% (877) 2.4% (25)	 2% (11) 10.6% (57) 85.5% (461) 1.9% (10)	 4.9% (25) 11.1% (57) 81.1% (416) 2.9% (15)

**unless otherwise specified$ % of total sample*

The survey was divided into five sections:

Section A: Meat cooking behaviour and knowledge

Section B: Ownership and Use of Meat Thermometers

Section C: Visual Task

Section D: Behaviour Assessment Changes

Section E: Background Characteristics

All data from the survey was uploaded into the Statistical Package for Social Sciences (SPSS, version 22 for Windows, Inc., IBM). Basic frequencies and cross-tabulations were used to determine data characteristics. Pearson's chi-square tests were performed to assess differences between categorical data. Significance was considered at the $p = \leq 0.05$ level.

Participants of the focus group were offered a gift card as an incentive for their participation in the research.

5 Results: rapid review

The rapid review aimed to extrapolate from all the current literature data on meat thermometer usage trends, attitudes and perceptions of individuals.

Current safety advice on cooking meat from food authority bodies

The majority of food authorities do not have formal recommendations for the safe cooking of meat (Table 2). Six countries were included in this review, as they are English speaking. Of those who have formal recommendations, most recommend that a meat thermometer be used in at least some instances. However, only the Canadian Government and the United States Department of Agriculture/Food Safety Inspection Service (USDA/FSIS) encourage cooking meat to a specific temperature, and assessing this temperature using a meat thermometer, as the only reliable option for assessing the doneness of meat.

Table 2: Current international meat cooking safety advice

Country	Food safety body	Meat thermometer advice	Recommended end point temperature	Other meat cooking advice	Campaign interventions?
UK	Food Safety Standards Agency (2018a, 20218b)*	Only recommendation for meat thermometer use is for Christmas turkeys	• Turkey - 70°C for two minutes	Cook meat until it is steaming hot, cut into the thickest part of the meat to ensure that it is not pink, and that any juices run clear	No
Island of Ireland	*safe*food, Food Safety Authority of Ireland and Food Standards Agency in NI (UK)	Meat thermometers are presented as an alternative, but not the only method	• Ground meat (including sausages and burgers) – 75°C • All poultry – 75°C • Whole fish – to preference • Minced fish products (such as fish burgers) - 75°C	Cook meat until it is steaming hot, cut into the thickest part of the meat to ensure that it is not pink, and that any juices run clear	No
Australia	Food Standards Australia New Zealand	A meat thermometer is recommended explicitly by Food Standards Australia New Zealand only in advice pertaining to cooling and reheating food	• Beef, veal, and lamb – 63°C (medium rate), 71°C (medium rare), 77°C (well done) • Ground meat – 71°C • Whole poultry – 74°C • Poultry pieces – 74°C • Leftovers – 75°C • Fish – 63°C	Food Standards Australia New Zealand recommends cooking beef, sausages, and chicken until the juices run clear. Steaks to preference	No

	New South Wales Food Authority (2019)*	However, New South Wales Food Authority recommends that meat be cooked to a specific temperature. Consumers are encouraged to "invest in a thermometer" to do so	• Ham – 71°C (from raw) • 60°C (reheating if pre-cooked)		
New Zealand	New Zealand Food Safety (2019)*	New Zealand food safety recommends meat thermometers are used to assess end-point temperature, though it also recommends other methods	• Chicken/poultry - 75°C • Mince - 75°C • Sausages - 75°C • Pork - 75°C	Recommends consumers cook chicken, mince, and sausages "right through". Juices from poultry dishes should run clear	No
Canada	Government of Canada (2019)*	Meat thermometers are recommended as the only safe way to assess the doneness of meat	• Beef, veal, and lamb – 63 • (medium rate), 71 (medium rare), 77 (well done) • Ground meat – 71°C • Whole poultry – 74°C • Poultry pieces – 74°C • Leftovers – 75°C • Fish – 63°C • Ham – 71 (from raw), 60°C (reheating if pre-cooked)	N/A	No

USA	US Department of Agriculture/Food Safety and Inspection Service (2019)*	Meat thermometers are recommended as the only safe way to assess the doneness of meat.	• Beef, veal, and lamb – 62.8°C* • Pork – 62.8°C • Ground meat – 71°C • Whole poultry – 73.9°C • Poultry pieces – 73.9°C • Fish – 62.8°C * temperatures in ºC after conversion from ºF	N/A	Yes – Fight BAC/Thermy, Is It Done Yet?, and a USDSA public service video - see also Cates, Cosa, and Carter-Young, 2002; Lando and Chen, 2012)

**Note: these dates indicate the date the respective web pages were last edited. They do not represent the date the advice was published, but rather serve to direct the reader to the appropriate sources in the reference list*

Meat thermometer ownership and use

A summary of the empirical findings of the academic and government research on meat thermometer ownership, self-reported use, self-reported ownership and observed use is found below in Tables 3 and 4. A total of 44 studies were identified. Thirty-three studies were conducted in America, five in Canada, three in Europe, one in the UK, and two in Ireland.

Research conducted or published prior to 2009 shows most self-reported general usage in the USA was approximately 6% (Unklesbay, Sneed, and Toma, 1998; Cates and Carter-Young, 2000). However, a large variation in range of 5-57% is observed across self-reported and observed usage depending on meat type (see Tables 3 & 4). After 2009, there appears to have been a rise in the general use of meat thermometers in the USA to between 20% and 29% (DeDonder et al, 2009; Shapiro et al, 2011; Parra et al, 2014; Mazengia et al, 2015). In Canada, reported use ranges from 13.7% to 29%, though no available data for general thermometer use could be found prior to 2009 (Nesbitt, 2009; Ekos Research Associates Inc, 2010; Murray et al, 2017). There is a very clear ownership-usage gap across studies, as evidenced in Tables 3 and 4 below. For example, prior to 2009, American studies demonstrate ownership ranges from 30-73%, whilst post-2009 studies in the US demonstrate an ownership range of 43-73%. These percentages are significantly higher than usage percentages discussed above. However, the self-reported and observed usage figures documented are very dependent on meat type.

Only five research studies on thermometer use in Europe were identified indicating lower use than in North America (0.8-11% usage). There is limited data available, preventing any real trend over time (2-11% usage pre-2009 (Kennedy et al. 2005, Mahlon et al. 2006, Fischer et al. 2006), or cross-national (0.8-11% usage in mainland Europe (Sampers et al. 2012, Fischer et al. 2006) *vs* 2-4% usage in UK/Ireland (Kennedy et al. 2005, Mahlon et al. 2006, FSA Food and You Programme, 2010-2016) comparison within Europe. The data that is available, however, indicates that meat thermometer use in Europe is at around the same level (or indeed below) as that of the USA in the late 1990's and early 2000's. Although other factors should be considered, this may indicate the influence of interventions

to encourage meat thermometer use in the USA, whereas there has been no recorded public interventions to encourage meat thermometer use in any European country.

Concerning social norms, Koeppl (1998) conducted focus groups that found that most US consumers only used a meat thermometer during holidays such as Thanksgiving and Christmas, while relatively few used them for grills and barbecues. This correlates with much of the research presented in Table 3, which found higher rates of thermometer use for meats traditionally cooked during holidays (roasts and whole poultry) than for meats cooked at other times. This may lead to the establishment of habits, and potentially indicates social norms (cooking is possibly a more public spectacle during holiday periods), both of which have a significant influence over cooking practices, including the use of meat thermometers (McIntosh, Christensen, and Acuff, 1994; Shapiro et al, 2011; Young and Waddell, 2016; Murray et al, 2017).

Meat thermometer use varies according to meat type

Several reviewed papers (n=11) analysed self-reported meat thermometer use according to specific meat type. With only a few exceptions (Mahon et al, 2006; Murray et al, 2017), these papers used US consumers for their sample. Findings indicated unequal use of meat thermometers according to meat type (higher use for whole poultry, lower use for smaller cuts such as burgers).

Overall, participants were more likely to self-report using a meat thermometer on larger pieces of meat than smaller pieces. This may be the result of the ease of use of a meat thermometer on larger pieces of meat, such as whole poultry and roasts, compared to smaller pieces, on which using a meat thermometer might feel difficult (Takeuchi et al, 2005). Kosa et al (2017) reported that consumers felt that chicken parts were too small to easily insert a meat thermometer into. In North American research, no study found thermometer use on burgers to be above 20%, with a range of 3.9 - 25% (1998-2003) and 6 - 42.6% (2006-2017) reported for meats such as burgers and sausages.

For larger pieces of meat, no study reported the use of thermometers on roasts to be below 21%, with a range of 21-50% (2006-2017) and 25.5-73% (2006-2017) being observed. Many consumers rely on

visual cues to test whether meat is cooked, often relying on internal colour (Cates and Carter-Young, 2000; Sampers et al, 2012; Parra et al, 2014; Murray et al, 2017). As the centre of roasts and whole poultry may be difficult to access, meat thermometers may be perceived as an easier alternative, which may explain the higher usage in larger cuts.

Demographics and self-reported meat thermometer ownership and use

Just as meat thermometer use varies according to meat type, it is also subject to change according to demographic factors. Those with higher levels of education were more likely to own a meat thermometer than those who had a high school education or less, and those with a higher income were more likely to reporting owning a thermometer (Anderson et al, 2011; Lando and Chen, 2012). Participants who lived outside of metropolitan areas were more likely to report owning a meat thermometer, a result replicated in Nesbitt et al, 2009 and Kosa et al, 2017). However, Takeuchi et al (2005, 2006) found that demographic variables had no significant influence on the effectiveness of communications to encourage meat thermometer use.

Table 3: Self-reported meat thermometer ownership and use

Source	Year of data collection*	Country	Self reported ownership (% of sample)	Self reported use (%)	Meat type	Sample size (and sampling method)
Food Safety Survey, 1998 cited in Lando and Chen, 2012						1,699 (stratified sampling)
Unklesbay, Sneed, and Toma, 1998	Date not given	USA	-	6.3[mc]	General	824 (convenience sampling – university students)
Cates and Carter Young, 2000	Date not given	USA	-	6[fr]	General	67 (stratified sampling)
Food Safety Survey, 2001 cited in Lando and Chen, 2012	2001	USA	63	13[fr] 25[fr] 50[fr]	Burgers Chicken parts Roasts	3,882 (random telephone sampling)
Cates, Kosa, and Carter Young, 2002	2002	USA	-	6[fr] 12[fr]	Burgers Small cuts of meat	63 (random telephone sampling)
Mahon et al, 2006	2002	Island of Ireland	-	3[mc]	Ground beef	485 (sampling method not disclosed)
McCurdy, 2003 (unpublished) cited in McCurdy et al, 2006	2003	USA	-	3[nr]	Burgers and small cuts of meat	100 (sampling disclosed – Idaho consumers)

Anderson et al, 2000	Date not given	USA	30	5[fr]	General	99 (convenience sampling)
Kennedy et al, 2005	Date not given	Island of Ireland	-	2[t]	General	1,020 (stratified sampling)
Nesbitt et al, 2009	2005-2006	Canada	-	13.7[b] (12.2 - urban population) (21.8 – Suburban population)	General	2,332 (stratified sampling)
Food Safety Survey, 2006 cited in Lando, A.M. and Chen, 2012	2006	USA	72	14[fr] 34[fr] 57[fr]	Burgers Chicken parts Roasts	3,745 (169 (stratified sampling)
Fischer, Frewer, and Nauta, 2006	Date not given	Netherlands	-	11[b]	General	1,044 (stratified sampling)
Sampers et al, 2012	2007-2008	Belgium	-	0.8[b]	General	1,618 (snowball sampling)
McArthur, Holbert, and Forsythe, 2007	Date not given	USA	23	-	-	786 (convenience sampling – university students)
DeDonder et al, 2009	Date not given	USA	73	20[fr]	Breaded poultry	41 (convenience sampling - adolescents and their parents)

Anding and Scott, 2009	Date not given	USA	-	7[b] 6[b]	Burgers Chicken breasts	713 (convenience sampling – low income women)
Cates et al, 2009	Date not given	USA	-	3.9[lt]	Small cuts of meat	1,329 (stratified sampling – adults aged 60+)
Food Safety Survey, 2010 cited in Lando and Chen, 2012	2010	USA	70	16[fr] 37[fr] 57[fr]	Burgers Chicken parts Roasts	3,769 (stratified sampling)
EKOS Research Associates Inc, 2010	Date not given	Canada	-	29[fr]	General	1,536 (stratified sampling, five target groups)
Shapiro et al, 2011	Date not given	USA	-	27[li]	General	544 (convenience sampling)
Phang and Bruhn, 2011	Date not given	USA	53	-	-	199 (convenience sampling)
Anderson et al, 2011	Date not given	USA	-	76[fr] (Caucasians) 54[fr] (Non-Caucasians) 79[fr] (High-education participants) 69[fr] (Low-education participants)	General	1,317 (stratified sampling)

Henley, Stein, and Quinlan, 2015						
Parra et al, 2014	2010-2011	USA	47	21[fr]	General	78 (random online sampling – Mexican-Americans)
Mazengia et al, 2015	2011-2012	USA	43	25[fr]	Whole poultry	56 (convenience and snowball sampling)
Bruhn, 2014	2013	USA	48	-	-	120 (stratified sampling)
Kosa et al, 2015	2013	USA	62	-	-	1,504 (stratified sampling)
Kosa et al, 2017	2013	USA	-	11.7[lt] 42.6[lt] 26.3[lt] 56[lt] 73[lt]	Patties Turkey breasts Chicken breasts and other parts Whole chickens Whole turkeys	4,531 (random online sampling)
Maughan, 2015	2014	USA	63	20[fr] 30[fr]	Turkey patties Chicken breasts	155 (convenience sampling)
Murray et al, 2017	2014-2015	Canada	-	29[b] 33[b]	General Chicken	2,474 (stratified sampling)

Food Safety Survey 2016	2016	USA	67	10[fr] 19[fr] 38[fr]	Burgers Chicken parts Roasts	4,169 (stratified sampling)
Bates et al, 2017	2016	UK	-	4[mc]	General	110 (stratified sampling)
Lin, 2018	2016	USA	16	3[mc]	Burgers	1,688 (random sample oversampled Hispanics)

**Note: if date of research was not made available, date of publication is treated as a proxy to order the data chronologically.*
[fr] Use level determined by frequency of use (use is here defined as using a thermometer "always" or "often").
[lt] Use determined by whether consumer used a thermometer the "last time" they cooked.
[mc] Use determined by whether consumer indicated thermometer use as a way of determining doneness, on a multiple-choice question.
[bi] Use determined by response to a binary choice (yes/no).
[t] Use determined by whether the participant referred to "temperature" as the main way of assessing the doneness of meat.
[li] Use determined by responses to a five-point Likert scale (use is here defined as responding "agree" or "strongly agree" to the statement "it is very likely that I will use a food thermometer the next time I prepare raw meat or chicken").
[nr] Paper does not report how self-reported use is determined.

Observational studies of meat thermometer use

Self-report measures tend to over-report safe food behaviours (Anderson et al, 2004; Diplock et al, 2018), with a social desirability bias or priming effect leading to more participants reporting that they engage in safe behaviours. Though the majority of papers found in the rapid review relied on self-report measures, Table 4 highlights 11 papers that at least partially employed observational measures of consumer behaviour (Anderson et al, 2004; Kendall et al 2004; Byrd-Bredbenner et al, 2007; DeDonder et al, 2009; Phang and Bruhn, 2011; Hoelzl et al, 2013; Bruhn, 2014; Mazengia et al, 2015; Maughan, 2015; Murray et al, 2017; Diplock et al, 2018). All but one of these recruited North American consumers as participants (Hoelzl et al, 2013), and all but three recruited US consumers (Hoelzl et al, 2013; Murray et al, 2017; Diplock et al, 2018). Unlike the research on general use of meat thermometers, and on their use for specific meat types, there is no apparent increase over time in the percentage of consumers using meat thermometers in these observational research papers. Excluding research that included proximate educational interventions, such as including advice to use a thermometer on meat packaging (DeDonder, 2012), taking part in a Fight BAC educational programme (Diplock et al, 2018), or taking part in a nutrition education programme (Kendall et al, 2004), only one study (Maughan, 2015) observed usage at levels higher than 5% (ranging from 3-5% - Anderson et al, 2004; Byrd-Bredbenner et al, 2007; Phang and Bruhn 2011; Bruhn, 2014; Mazengia et al, 2015).

These studies suggest that meat thermometer use may be lower than indicated in research that relies on self-report data. This may also call into question the accuracy of the reported increase in meat thermometer use. However, observational data does not necessarily represent actual behaviour in the domestic setting more accurately: the observational research summarised in Table 4 generally gathered data on meat cooking technique using cameras in participant homes or were based on observed cooking practices in test kitchens of some form. Although these examples are attempts to replicate naturalistic conditions, in both cases participants were aware of being observed, which may have influenced behaviours. For instance, as discussed below, there may exist social norms which deter meat thermometer use, such as the belief that able chefs do not need to use a thermometer.

Observational studies may therefore create a social desirability bias in participants, discouraging their use of meat thermometers.

Of the 11 available observational studies, two broad methodologies were employed: observations in the home, in which cameras were used to observe cooking practices, and observations of cooking in community, school or university kitchens, or university test kitchens, in which researchers observed behaviours and coded them appropriately. The mean observed use in home kitchens was 4.4% (4.5% when research conducted by non-US participants is excluded – Hoelzl, 2013), while in community/school/university kitchens the mean observed use was 14.66%. This may indicate that the presence of an observer may bias consumers towards using a meat thermometer. Though this study will not employ any observational measures of meat thermometer use, the difference between results derived from different methodology should be taken into account in any future studies, and attempts should be made to mitigate any unintended side effects of the observational methodology.

Many of the reviewed observational studies relied on convenience sampling. Only one study (Bruhn, 2014) attempted to recruit a representative sample. Therefore, it should not be assumed that the results presented here are necessarily reflective of the general population. Though the observational studies present a less optimistic assessment of meat thermometer usage than self-report methodologies, they may indicate the efficacy of educational interventions: the data presented by Diplock et al (2004) and Diplock (2018) are of observed use levels following educational interventions, and display higher levels of use than studies that did not include any interventional element. A summary of the observational studies may be found below in Table 4. It is reported in chronological order, according to date of research.

Table 4: Observational studies of meat thermometer use

Source	Year of research*	Country	Self reported ownership (%)	Self reported use (%)	Observed use (%)	Meat type	Location of observation	Sample size (and sampling method)
Anderson et al, 2004								99 (Convenience sampling)
Kendall et al, 2004	Date not given	USA	-	-	16	Burgers and chicken breasts	Community kitchens	79 (convenience sampling - graduates of a nutrition education programme)
Byrd Bredbenner et al, 2007	2005	USA	-	-	3	Small cuts of chicken	University kitchen	432 (convenience sampling – university students)
DeDonder et al, 2009	Date not given	USA	73	20	12	Breaded poultry	University kitchen	41 (convenience sample - adolescents and their parents)
Phang and Bruhn, 2011		USA	53	-	4	Burgers	Participants' home	199 (convenience sample)

Hoelzl, 2013	2011	Austria	-	-	3	Chicken pieces	Participants' home	40 (convenience sampling)
Mazengia et al, 2015	2011-2012	USA	43	25	5	Poultry	Participants' home	56 (convenience sample/snowball sampling)
Bruhn, 2014	2013	USA	48	-	5	Whole chicken or chicken parts – participants' choice (though only 3.6% of the sample chose to cook whole chicken)	Participants' home	120 (representative sample)
Maughan, 2015	2014	USA	63	20 53	22 30	Turkey patties Chicken breasts	University test kitchens	155 (convenience sample – University students)
	2014-2015	Canada	-	29	-	Chicken		2474 (representative sample)

Murray et al, 2017								
Diplock, 2018	2015	Canada	-	-	5 (pre-intervention) 36 (post-intervention) 30 (follow up study)	Chicken breasts	School kitchens	218 (Convenience sampling – high school students)

**Note: if date of research was not made available, date of publication is treated as a proxy to order the data chronologically.*

Barriers and motivators to meat thermometer use

All reviewed research (n = 13) on motivators and barriers to thermometer use was conducted with North American participants, and only two of these were focused on Canadian data (for more information, see table 9 in appendix 2).

Barriers to meat thermometer use included:

1. The use of alternative methods of assessing meat doneness were thought to be more effective, i.e., relying on time, checking the colour, checking if juices ran clear (Kosa et al, 2017).
2. Meat thermometers were thought to be a nuisance, and inconvenient to use (Takeuchi et al, 2005, 2006).
3. Meat thermometers were perceived as difficult to use (Koeppl, 1998, Shapiro et al, 2011), especially on smaller pieces of meat (Takeuchi et al, 2005), such as chicken parts (Kosa et al, 2017).
4. A lack of social norms, which encourage meat thermometer use. For example, how a person perceives the way their social group views meat thermometer use, and their desire to comply with these views (Shapiro et al, 2011; Young and Waddell, 2016; Murray et al, 2017). Alternatively, there may indeed be social norms that actively discourage meat thermometer use, such as recipes and cookbooks suggesting subjective indicators as the method to assess doneness (time frame, colour and/or texture) (Clayton et al, 2003, Mathiasen et al, 2004, Singh, Walia, and Farber, 2019).
5. A perceived lack of instructions on how to use a meat thermometer, with instructions not easily accessed, and
6. Meat thermometers are viewed as expensive (Scheule, 2004, Porticella et al, 2008).

Motivators to meat thermometer use included:

1. Meat thermometers being demonstrated as easy to use (Takeuchi et al, 2005);

2. Meat thermometers being shown to reduce the risk of foodborne illness (Takeuchi et al, 2005, McCurdy et al, 2006), especially if they assured the safety of children (Koeppl, 1998); and
3. Meat thermometers being shown to improve the taste and texture of the meat (Koeppl, 1998).

Related behavioural theories

Proposed interventions to improve both food safety behaviours in general, and specifically meat thermometer use, have grounded themselves in theories regarding behavioural change. These theoretical models provide a framework in which to analyse the resulting data from this project and provide potential items to include in the consumer survey, and further provide guidelines for conducting the focus groups.

Health Belief Model (HBM)

The HBM (Rosenstock, 1990; Janz, 2002) posits that individuals will adopt a health behaviour when they believe the benefits outweigh the personal cost, believe themselves to be susceptible to risk, and consider the risk to be serious. The model also considers cues to action, such as education or media, which are hypothesised to influence perceived threat (Strecher and Rosenstock, 1997). Several exploratory research projects recommend that, in order to encourage meat thermometer use and food safety generally, interventions should emphasise the severity of foodborne illnesses, and communicate the susceptibility of the target audience (Cates et al, 2009; Patten, Sneed, and Nwadike, 2018). Three of the included studies in this review found that HBM-based interventions have effectively encouraged meat thermometer use (Kendall et al, 2004; Medeiros et al, 2006; Winn et al, 2008).

The Theory of Planned Behaviour (TPB)

TPB holds that behavioural intention is a good predictor of actual behaviour (Ajzen, 1991). In this model, it is posited that behavioural intention is determined by *attitude* towards a behaviour, *subjective norms* regarding said behaviour, and *perceived behavioural control* (the degree to which an individual believes they are able to influence an outcome). Shapiro et al (2011) found that the

subjective norms (how a person perceives the way their social group views meat thermometer use, and their desire to comply with these views) and *perceived behavioural control* (such as ease of use of the thermometer) correlated more significantly with meat thermometer use than *attitude* (beliefs about the risks of not using a meat thermometer, such as food poisoning).

Trans-theoretical Model of change (TTM)

TTM (also known as the Stages of Change model) proposes that behaviour change is a process with five stages: pre-contemplation, contemplation, preparation, action, and maintenance. TTM has been applied to the use of meat thermometers in four of the included studies in the review (Edwards et al, 2005; McCurdy et al, 2006; Takeuchi et al, 2005 & 2006), which have broadly defined *pre-contemplation* as the stage in which individuals have not considered change (e.g., individuals who have never thought of using a meat thermometer), and *contemplation* as the stage in which individuals have considered taking an action, but have made no attempts yet to act, or have planned to act in the long term. This would include individuals planning to use a thermometer within the next six months. *Preparation* refers to individuals who have made the initial steps towards adopting a change in behaviour, for example, planning to use a thermometer in the next 30 days. *Action* refers to individuals who have begun, relatively recently, to enact a behavioural change, i.e., having used a thermometer for approximately six months. *Maintenance* refers to those individuals who have been routinely enacting the desired changed behaviour for a period of time, i.e., have used a thermometer for more than six months (Prochaska, DiClemente, and Norcross, 1992; Skinner, Stretcher, and Hospers, 1994).

Identification of Stage of Change, according to specific demographics and the population at large, allows tailored interventions (Prochaska, DiClemente, and Norcross, 1992; Skinner, Stretcher, and Hospers, 1994). For instance, Takeuchi et al (2005) found that those in the pre-contemplation and contemplation stage found an educational brochure the most motivating and useful source of information on meat thermometers, while those in the action and maintenance stages found educational videos the most useful and motivating.

Previous campaign interventions

All food authority bodies in the English-speaking world recommend meat thermometer use in at least some circumstances (see Table 2). However, large-scale campaign interventions which attempt to encourage meat thermometer use appear to have only been conducted in the USA. A review of these, based on academic research (Cates, Cosa, and Carter-Young, 2002; Lando and Chen, 2012) and the grey literature (US Department of Agriculture/Food Safety and Inspection Service (2019), is presented in Table 10 (see Appendix 3). It is important to note that no studies on the effectiveness of campaigns in relation to meat thermometer use were identified in Europe, the United Kingdom or the Republic of Ireland. This presents a knowledge gap in the literature.

Conclusion

The findings of this review have several implications for the development of this study. These include the measures that are employed to investigate current thermometer use, a framework with which to analyse both qualitative and quantitative data, and several survey items which may be useful in identifying barriers and motivators to use, and in designing future interventions to encourage thermometer use.

The findings of this rapid review suggest that, in the USA at least, interventions based on behavioural theories increase the levels of meat thermometer use. The remaining two stages of the current research project will provide a better understanding of consumer behaviour and attitudes towards meat thermometer use on the IoI. This may in turn provide the basis for effective interventions that will encourage thermometer use.

6 Results: focus groups

Using the question schedule outlined in Appendix 1, focus groups consisting of individuals from various socioeconomic backgrounds and geographical areas on the island of Ireland (n=65) were carried out. The findings provided a wealth of information surrounding perceptions of, and attitudes to, meat thermometers. The themes that developed from these focus groups are discussed in detail below.

Common methods of assessing doneness

Results revealed that one-sixth of consumers (n=11) at least occasionally used a thermometer to assess the doneness of the meat, and more commonly employed a meat thermometer on larger pieces (e.g., whole poultry and roasts) than smaller pieces (e.g., sausages, burgers, thighs). Further results highlighted two consumer practices relating to assessing the doneness of meat. Both practices placed emphasis on the how consumers used either visual cues or cooking time to assess the doneness of meat. These results will be discussed further under two broad themes: (1) *If it looks OK then it's done!* and; (2) *If I overcook it'll be OK!*

Theme 1: If it looks OK then it's done!

Results highlighted that people used two visual cues to assess the doneness of meat: (1) colour/browning; (2) juices running clear. The most commonly reported method of assessing the doneness of meat was to check the colour (checking for no red or pink meat). The majority of participants (n=40) discussed how using colour or browning on the meat provided reassurance that it was safe to eat:

> "Mainly the colour, the juices too, if I'm cooking a chicken... I'd take it out and put a skewer into it just to check."
>
> (focus group 1 – Belfast/female/ABC1)

"[*I'd check] the colour in the middle of the meat to make sure it's cooked properly in the middle.*"

(focus group 2 – Coleraine/male/C2DE)

"*No pink… you don't want pink.*"

(focus group 4 – Dublin#2/female/C2DE)

"*I'd just wait until I can't see any more redness.*"

(focus group 5 – Galway/female/ABC1)

Using colour as an indicator was most commonly expressed in discussions regarding light-coloured meats, such as chicken, turkey and other forms of poultry. Though visual indicators were not discussed much in relation to other meats, one participant stated that they would assess whether steak was ready to eat if it had turned from red to "*slightly pink in the middle*" (focus group 2 – Coleraine/female/C2DE). Some participants also stated that they checked the doneness of roasts by slicing the meat: "*Maybe just throw the first slice off [roast ham] and once you've cut into that you're seeing how pink it is.*" (focus group 1 – Belfast/male/ABC1). Some participants also employed colour as a visual cue when checking the doneness of smaller cuts: "*You can sort of open a smaller cut, just make a slice and you can see automatically.*" (focus group 1 – Belfast/female/ABC1). However, when discussing non-poultry meats,

participants were more likely to refer to timing/overcooking as the preferred method of assessing doneness. See theme 2: *If I overcook it, it will be OK!*

A second visual cue participants used to assess doneness was to check whether juices run clear from the meat:

"*I normally stick a knife in to it to make sure the juices are clear and run out of it.*"

(focus group 1 – Belfast/female/ABC1)

"*I would just use a fork to make sure the juices are clear rather than blood.*"

(focus group 2– Coleraine/female/C2DE)

"*… the juice runs clear, generally it's supposed to be cooked.*"

(focus group 3 – Dublin#1/female/ABC1)

"*when the water comes out it's cooked*"

(focus group 6 – Sligo/female/C2DE)

Again, this method was often used when discussing cooking safety regarding poultry, especially chicken and turkey. Both these cues were frequently used in conjunction, with participants often listing one before quickly stating that they also used the other: "*mainly the colour... the juices too*" (focus group 1 – Belfast/female/ABC1). These are only two of the three cues, currently recommended by ***safe***food.

Interestingly, one of the 65 participants, who stated, "I just stick a knife in and if it comes out steaming it's cooked, and if it doesn't ... it's not", only reported the third visual cue recommended by ***safe***food – checking to see whether meat is "piping hot". (focus group 3-Dublin#1/female/ABC1).

In addition, results highlighted that no other visual cues (e.g., texture, blood, etc.) were identified or discussed across the focus groups.

Theme 2: If I overcook it, it will be OK!

In the second theme, results indicated two methods that participants used to overcook the meat to ensure its doneness*:* (1) extending cooking time and (2) burning meat*.* Almost half of all participants (n=31) stated that they would intentionally overcook meat to ensure safety. Professions of overcooking in some form occurred in all of the focus groups, although discussions of burning meat occurred more frequently in C2DE focus groups. In several instances, participants would simply state that they "overcook" without elaborating upon how they would do so. However, overcooking mainly consisted of participants stating that they intentionally left meat in the oven for longer than a recipe or packaging called for, with comments such as, *"If it said an hour and a half I'd give it two hours."* (focus group 1 – Belfast/female/ABC1) and *"I always go by the cooking time they recommend and a wee bit more. I always do a wee bit more."* (focus group 4 – Dublin#2/female/C2DE).

Another tendency within the theme of overcooking was burning meat. This was less common than overcooking by leaving meat in the oven longer, but it was stated by at least one participant in four focus groups, including all of the C2DE focus groups (and in the Galway focus group): *"I do [burgers] on each side, burn them up."* (focus group 6 – Sligo/female/C2DE), *"I cremate my food."* (focus group 5 – Galway/female/ABC1). Though some participants did prefer the taste of burnt meat, there was a general

sentiment that this was poor practice; one participant in the Galway focus group exclaiming, *"I'm making these delicacies of leather!"* (focus group 5 – Galway/female/ABC1). Burning was more commonly reported when discussing smaller cuts of meat, such as sausages, burgers and bacon rashers, although some participants also referred to burning steak, chicken and meat in general.

Current meat thermometer use

Though 11 of the 65 participants reported using meat thermometers on at least some occasions, only five of these participants stated that they used a meat thermometer when initially discussing meat-cooking practices. Results showed that the vast majority of participants ($n = 54$) did not own or use a meat thermometer. Our results were used to identify three consumer groups based on participants' perceptions, ownership and usage of meat thermometers: the *cautious meat preparers, carefree cooks*, and the *thermometer curious*. These three consumer groups are a good representation of the possible target audience for a campaign or intervention to increase meat thermometer usage.

The cautious meat preparers

Eleven participants stated that they used a meat thermometer, at least occasionally. Most of these participants owned a dial rather than a digital meat thermometer, and no participants owned a liquid-filled meat thermometer. Three of those who owned and used a meat thermometer (one in the Dublin ABC1 focus group, two in Galway ABC1) used a meat thermometer every time they cooked: one of these was a chef, while another suffered with a chronic condition which put her at higher risk from food poisoning, something which caused her to be very vigilant when cooking meat: "My immune system is already severely compromised… it takes two or three times longer to recover from something like that [food poisoning]… *I'm someone that would be hyper-vigilant… it's a whole other ball game.*" (focus group 5 – Galway/female/ABC1). The third participant used a thermometer regularly, as she was concerned that she was a poor cook who might give food poisoning to her partner, for whom she cooked three nights a week: "*I've to use it quite regularly because I'm in fear… I wouldn't be the most confident, so I'd be using one just to be cautious… It wouldn't be because I'm a great cook.*" (focus group 3 – Dublin#1/female/ABC1).

However, the majority (n= 9) of participants who used meat thermometers reported using them infrequently and only for particular cuts of meat. This group reported using them more on larger cuts of meat than on smaller cuts and burgers/sausages. Likewise, participants were more likely to use thermometers on poultry (chicken and turkey) than on roasts. This appeared to be motivated by two factors: (a) meat quantity/weight and (b) meat type.

Meat quantity

Larger cuts were more likely to be cooked for groups rather than immediate family or oneself. For instance, one participant stated: "*If it was a big roast and you were cooking for maybe 10 or 12 people, I would definitely use it.*" (focus group 5 – Galway/female/ABC1). This may provide an explanation as to why use was greatest on turkey, which is primarily cooked for groups at Christmas. One user explained his using a meat thermometer on turkey (but not on smaller cuts) as follows: "*If you've five or six people it could be something big so, say turkey at Christmas, then it would be used.*" (focus group 1 – Belfast/male/ABC1). Social responsibility to others (especially those outside of the immediate family) was a strong motivator to use a meat thermometer, and this responsibility was accentuated when cooking for more individuals: "*There's a certain responsibility, that's why it comes out occasionally, it's not there all the time but if you're doing Christmas dinner and you have seven people and they're all eating turkey then that's when it would be used.*" (focus group 2 – Coleraine/male/C2DE).

Meat type

Participants found it difficult to check the colour at the centre of large pieces of meat, such as whole poultry or large roasts or joints, while smaller items such as burgers could easily be cut to see the colour of the very centre of the meat. A common justification for using a thermometer on larger cuts, but not smaller, can be summarised as follows: "*You can sort of open a smaller cut, just make a slice and you can see automatically, but you can't see into the centre of the large piece of meat.*" (focus group 1 – Belfast/female/ABC1). One participant reported using a meat thermometer when cooking casseroles, where the sauce prevents colour being employed as an indicator of doneness: "*I think that's a visual thing [cooking burgers and sausages]... whereas to put something in a dish with chicken breasts and a cream sauce... it's difficult to gauge by*

looking at it." (focus group 2 – Coleraine/male/C2DE). Another participant was concerned that cutting a large, stuffed piece of meat to check for colour would damage the structural integrity of the food: "*You don't want it falling apart on you, so you just automatically use a probe.*" (focus group 5 – Galway/female/ABC1). In these instances, a meat thermometer was not employed as the best means to assess doneness, but rather as a substitute for visual cues (primarily colour).

Both motivating factors (meat quality and meat type) were influenced by season and occasion. The most apparent example of this was meat thermometer use at Christmas, primarily on turkeys: "*At Christmas time… this comes out [pointing to a meat thermometer] to test the turkey and stuff like that.*" (focus group 1 – Belfast/male/ABC1). "*There's a certain responsibility… it's not there all the time, but if you're doing Christmas dinner and you have seven people and they're all eating turkey then that's when it would be used.*" (focus group 1 – Belfast/male/ABC1). "*Christmas with the turkey… you want to make sure it's cooked right through.*" (focus group 2 – Coleraine/male/C2DE).

Although usage was reported as less frequent at other times, several participants stated that they used a meat thermometer on barbecues during the summer. This was often motivated by a fear of potentially giving guests food poisoning: "*if I were having a summer barbecue or something like that, definitely [would use a meat thermometer]. Nobody wants to be remembered for the dinner at their house and you're like oh by the way, I was sick for 48 hours.*" (focus group 5 – Galway/female/ABC1). "*If I was doing a barbecue… because if you have our friends over you don't want to sicken them.*" (focus group 5 – Galway/female/ABC1). Others were more inclined to use a meat thermometer because a barbecue was not something they were used to cooking on: "*I have used it on a barbecue, and the reason being that you don't use the barbecue as often as you're used to your own oven and stuff.*" (focus group 2 – Coleraine/female/C2DE). "*I've gotten a bit braver [using a barbecue]… so I just wanted to gauge it properly.*" (focus group 3 – Dublin#1/female/ABC1).

The thermometer-curious

Most participants (n=54) did not own or use a meat thermometer. When questioned as to why, most participants stated that they had not ever thought of doing so. These participants might be described as being in the "pre-contemplation" stage of change, according to the Transtheoretical Model change (Takeuchi et al, 2005, 2006). Responses as to why participants did not use meat thermometers was far more likely to be, "*I've never really thought about it.*" (focus group 1 – Belfast/female/ABC1), or "*I haven't even thought about buying one.*" (focus group 3 – Dublin#1/female/ABC1). Although participants were aware of what a meat thermometer was, it was generally associated with professional cooks and not with domestic cooking.

The majority of participants stated a willingness to buy and use a meat thermometer having participated in a focus group discussion regarding them, with one participant exclaiming, "*I'll probably get one after this!*" (focus group 4 – Dublin#2/male/C2DE). During the de-brief (during which participants were handed gift cards), several participants stated that they might even spend their remuneration on a meat thermometer. This highlights how this group of participants were largely unaware of meat thermometers prior to the focus, and how that lack of awareness changed to curiosity after completing the focus group discussion.

The carefree cooks

Some participants were resistant to ever using a meat thermometer (n=8). This was found in all focus groups but was primarily articulated by older and exclusively female participants. Resistance was more commonly articulated among participants in the Republic of Ireland. A frequent refrain from those unwilling to ever use a meat thermometer was, "*I haven't killed anyone yet.*" (focus group 4 – Dublin#2/female/C2DE). The general sentiment in this group was that years of experience had ensured that their cooking practices were safe, the proof of which was that they had not given their family food poisoning (as far as they were aware).

One participant owned a meat thermometer but did not use it, responding to the question of ownership with, "*Yes, but it's in the drawer.*" (focus group 3 – Dublin#1/female/ABC1). This participant felt that a thermometer was a nuisance to clean and maintain and felt that it contributed to kitchen clutter.

In summary, these results indicated similarities in the behaviour of consumers who did not use a meat thermometer to test if meat was cooked. On analysis, those behaviours could be grouped into three types: the *cautious meat preparers*, the *thermometer-curious*, and the *carefree cooks*.

Results of the practical task

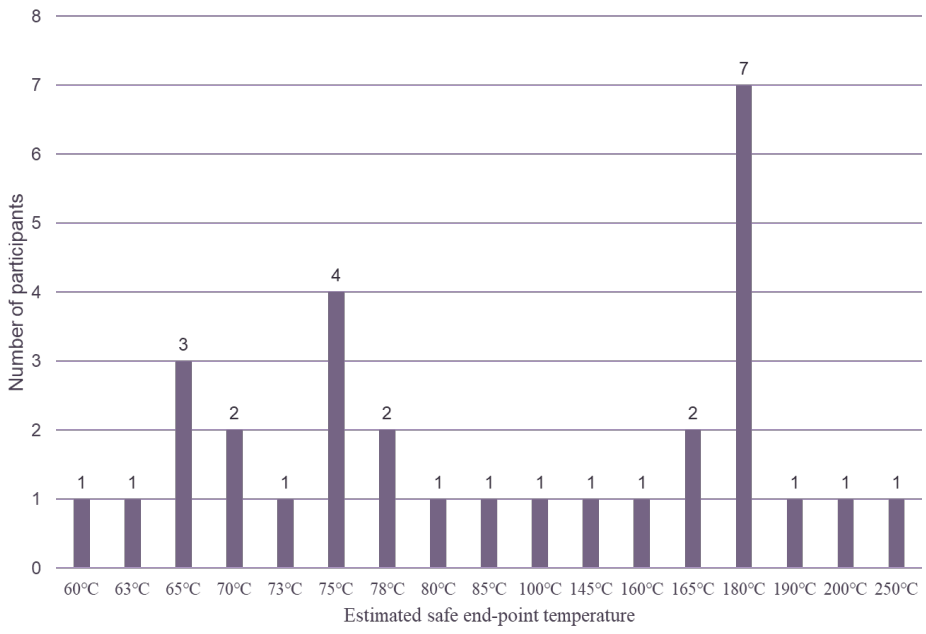
Responses to the visual tasks are displayed in Table 5. Participants were asked to identify the correct insertion method for a meat thermometer into four different meat types: a whole chicken, a burger, a roast, and a chicken thigh. They were also asked what temperature they believed meat should be cooked to, in order to ensure that it was safe to eat. The majority of participants in the focus groups were able to identify the correct insertion points of a meat thermometer on images of roasts (69.2% accuracy), while 57.8% were able to identify the correct insertion method of chicken thighs. Only a minority were correctly able to identify the correct insertion method on whole chicken (29.7%) and burgers (29.2%). Participants in the Republic of Ireland focus groups were more likely to identify the correction insertion method for every meat type than participants in Northern Ireland, with the exception of images of whole chicken (NI = 40%, RoI = 25%).

Table 5: Correct identification of probe insertion points in meat types

Meat type	Total sample *N*	Overall correct sample *N* (%)
Roast		45 (69.2%)
Chicken thigh	64	37 (57.8%)
Whole chicken	64	19 (29.7%)
Burger	64	19 (29.7%)

Responses to the question "*What temperature should meat be cooked to, to ensure that is safe to eat?*" may be found in Figure 1. Participants had a poor understanding of the appropriate end-point temperature of meat (the ***safe*food** recommended safe end-point temperature of meat is 75°C). A total of 34 participants stated that they did not know the correct end-point temperature of meat. Of the 31 volunteered responses, there was a range of temperatures from 60°C to 250°C.

Figure 1: Estimations of safe end-point temperature of meat (°C)



Barriers and Motivators

This section will address the barriers to, and motivators of, meat thermometer usage. Results identified four barriers and four motivators.

Barriers to use

Both spontaneously and through prompting, several barriers to meat thermometer use in the domestic setting were identified in the focus groups. The themes that emerged as barriers were: *high cost hindrance, not a home habit, troublesome tools,* and *purely for pros and newbies.*

High cost hindrance

Participants estimated that meat thermometers would be particularly expensive, many believing them to be outside of their price range. When asked, all participants across all focus groups (with the exception of one participant in the Coleraine focus group) estimated that a meat thermometer would cost in excess of £12/€14. The moderator brought a meat thermometer that retailed at £6 to each of the focus groups. When the focus groups were informed of the price, it was generally met with surprise. Concern regarding the price was often due to a feeling that a meat thermometer would not be frequently used, or was not an essential kitchen item; these participants often responding in the vein of, "*I don't know if I'd want to pay any more than 10 to 15 quid for something that I don't necessarily need or would use all the time*" (focus group 3 – Dublin#1/female/ABC1). Although not the most frequently expressed barrier to use, over-estimation of the price of a meat thermometer was widespread and did not differ according to the socioeconomic makeup of a focus group, nor location.

Not a home habit

The absence of social norms also provided a barrier to meat thermometer use. Overwhelmingly, participants stated that they had not seen their parents, grandparents or friends ever use a meat thermometer. It was this lack of exposure, especially when growing up and learning to cook, which was attributed by participants as being responsible for the lack of social norm: "*If you're taught cooking from your parents or grandparents and they've never used one you're not inclined to go and buy one and use.*"

(focus group 2 – Coleraine/female/C2DE) and "*I don't think that you see it often enough being used so you don't feel the need to use it.*" (focus group 1 – Belfast/female/ABC1). Though no tradition of using meat thermometers was apparent in Northern Ireland, volunteering the absence of a social norm as a barrier, with special reference to its absence within families and during formative years, was exclusive to the Republic of Ireland.

To an extent, there was even a social norm that actively discouraged meat thermometer use. In both C2DE focus groups in the Republic of Ireland (one in Dublin, one in Sligo); some participants (largely older individuals) seemed to view meat thermometer use as an indication of being a poor cook. One individual in the Dublin C2DE focus group commented: "*Like that chap there [points to a man who had stated that he used a meat thermometer] I could give him a lesson in cooking!"* (focus group 4 – Dublin#2/female/C2DE).

A troublesome tool

A common theme was that meat thermometers were perceived to be a nuisance. They were regarded as difficult to maintain, and likely to contribute to kitchen clutter. It was suggested that a meat thermometer would be one extra complication when trying to prepare dinner.

The difficulty of maintaining a meat thermometer was primarily in relation to batteries and to cleaning the thermometer, with one participant stating: "*It seems lazy, but the hassle of having to replace the batteries as well, I would see people forgetting the batteries.*" (focus group 1 – Belfast/male/ABC1), to which another responded, "*It's the cleaning of it… you couldn't just stick it in the dishwasher.*" (focus group 1 – Belfast/female/ABC1). None of the participants had any concerns about the need to recalibrate meat thermometers, which may be attributable to an overall lack of awareness about meat thermometer usage amongst much of the IoI population. Meat thermometers should be recalibrated at least once every two years.

The most common feature of the *troublesome tool* theme was the sentiment that a meat thermometer would add excess clutter to a kitchen, with a representative response being: "*I have enough stuff; I don't*

want another thing thrown in the drawer." (focus group 5 – Galway/female/ABC1), and "*It's just another gadget… among spatulas and prongs and the rolling pin.*" (focus group 3 – Dublin#1/female/ABC1), to which another participant exclaimed, "*And you can never find the one you want!"* (focus group 3 – Dublin#1/female/ABC1). This theme was often accompanied by a sentiment that meat thermometers were surplus to requirements: "*You don't want to add in any more [to the kitchen], no. If it's not something I'm going to use and if it's not something I feel I need.*" (focus group 5 – Galway/female/ABC1).

There was also a feeling in some focus groups that inserting a meat thermometer into a piece of meat would add another level of complexity to preparing food, something that they felt should be as simple as possible. Many who expressed this latter concern were parents: "*By the time I start taking that out and start digging the thing into the meat to see if it's done and the whole lot, sure the kids would be screaming.*" (focus group 4 – Dublin#2/female/C2DE).

Purely for pros and newbies

There was also a widespread sentiment, apparent in all focus groups, that a meat thermometer was a primarily a professional item. "*Chefs use them, they have to use them.*" (focus group 4 – Dublin#2/female/C2DE) was a frequent remark. Professional chefs were believed to use meat thermometers primarily for insurance purposes, and due to a heightened social responsibility (preparing food for large numbers of others).

There was also a common perception that meat thermometers were either the preserve of experienced cooks or inexperienced cooks. The belief that experienced cooks primarily used meat thermometers was apparent in every focus group other than Coleraine (C2DE), and the belief that inexperienced cooks primarily used meat thermometers was found in every focus group other than Galway (ABC1).

In addition to the perception that meat thermometers were primarily used by professional chefs, many participants felt that meat thermometers were mostly used by very experienced or frequent cooks ("*Someone who likes to do a lot of cooking.*" (focus group 3 – Dublin#1/female/ABC1)), very able cooks ("*Someone who's a really good cook.*" (focus group 5 – Galway/male/ABC1)), those who took a great deal

of pride in their cooking ("*It would be someone who takes pride… cooking fabulous meals each day.*" (focus group 4 – Dublin#2/female/C2DE) and those who were particularly adventurous in what they cooked ("*If you're cooking for friends on a regular basis… you're more likely to have that [a meat thermometer] because you're trying new dishes.*" (focus group 5 – Galway/male/ABC1); "*An avid cook might use it more often if they were more adventurous in trying different cuts of meat.*" (focus group 3 – Dublin#1/female/ABC1)).

By way of contrast, many participants felt it likely that an inexperienced cook would use a meat thermometer. An inexperienced cook might be someone who cooks infrequently ("*People that don't cook often.*" (focus group 2 – Coleraine/female/C2DE)), those who did not feel confident preparing meat ("*Maybe they've got confidence issues with cooking.*" (focus group 4 – Dublin#2/female/C2DE)), and those who were only learning to cook ("*You would use it when you're learning to cook.*" (focus group 1 – Belfast/male/ABC1)). Among some participants, there was a belief that this latter group would largely be made up of the young, partly because they had not learned traditional cooking techniques from parents: "*A lot of younger people don't stand beside mammy watching what she's doing… so they'd use something like that [a meat thermometer]."* (focus group 4 – Dublin#2/male/C2DE). This belief was also based on an assumption that meat thermometers were taught in Home Economics class: "*Younger people [would use meat thermometers] because they're probably more educated about it… in school and Home Economics they all learn about these things.*" (focus group 3 – Dublin#1/male/ABC1).

The belief that meat thermometers are exclusively used by cooks who are accomplished or inadequate may be a barrier to use, as few participants in the focus groups identified as being either poor or excellent cooks. A meat thermometer was not seen as necessary as they did not see themselves as significantly at risk from food poisoning (as inexperienced cooks were seen to be), or likely to cook new and adventurous dishes or need to be especially meticulous (as experienced cooks were seen to be).

Motivators of use

Four motivators for meat thermometer usage were identified, and are discussed below: *a socially responsible aid, an implement for improvement, a foolproof appliance,* and *a freebie.*

A socially responsible aid

A sense of duty to prepare food safely was commonplace among participants. This was equally true of meat thermometer owners and those who did not use a meat thermometer. It became apparent that this sentiment was widespread among non-users when the topic of conversation turned to factors that might motivate them to use a meat thermometer in future, and when discussing food poisoning as a risk more generally. The sense of duty was most acute in relation to guests, with many participants stating that they would feel guilt and perceive a damage to their reputation if they gave guests food poisoning: ("*You don't want to be remembered as that person who made everyone sick.*" (focus group 5 – Galway/female/ABC1)). This responsibility was diminished the closer the consumer of meat was to the self: "*You'd feel more guilty if you [food] poison someone else rather than yourself.*" (focus group 4 – Dublin#2/female/C2DE). More responsibility was felt for guests than immediate family, and more responsibility was felt for immediate family members (especially children) than for the self.

However, food poisoning of the self also figured prominently as a theme in all focus groups. This often arose as a response to what might motivate participants to purchase a meat thermometer: "*If I were to food poison myself, then I would rush out and buy one straight away.*" (focus group 5 – Galway/female/ABC1). It was also a common response as to how future campaigns might communicate the importance of using a meat thermometer, with numerous participants making such statements as, "*I would sell it on the health and safety reasons really, if people are undercooking meat, getting food poisoning or something.*" (focus group 1 – Belfast/female/ABC1).

An implement for improvement

In two ABC1 focus groups, participants stated that they might be motivated to use a meat thermometer to improve the taste and/or texture of meat, with responses such as, "*You'd cook it better… rather than*

overcooking and spoiling it. You could learn a better way of cooking." (focus group 5 – Galway/male/ABC1). This sentiment was absent from C2DE focus groups. When participants were asked whether they would be more likely to use a meat thermometer based on risks (such as food poisoning) or potential benefits (such as improving taste and flavour), the risks of food poisoning were most frequently cited.

A foolproof appliance

Though not motivators per se, many participants said that they thought a thermometer would be easy to use and stated a curiosity or willingness to try. This is particularly relevant to future interventions. According to the Theory of Planned Behaviour (Ajzen, 1991), a crucial predictor of adopting a behaviour (including meat thermometer use - York et al, 2009, Shapiro et al, 2011) is "perceived behavioural control", which fundamentally equates to ease of use.

When asked whether they thought a meat thermometer would be difficult to use, most participants across all focus groups said no, albeit this response was in part conditional: "*If there were instructions on the packaging [that the thermometer came in]."* (focus group 1 – Belfast/male/ABC1) or "*As long as I was taught how to use it.*" (focus group 2 – Coleraine/female/C2DE).

In two ABC1 focus groups (Belfast and Dublin), some participants even felt that a meat thermometer might make the cooking of meat easier. One participant explained their reasoning in the following manner: "*The oven mightn't be what it used to be with the temperature, but with the thermometer you don't have to do any more testing.*" (focus group 3 – Dublin#1/male/ABC1).

A freebie

In all C2DE focus groups (but only in one ABC1 group - Galway), participants stated that they would be more likely to use a meat thermometer if they were freely distributed. A common topic of conversation within the groups was whether participants would use a thermometer if it were a gift, a common response being "*If you give me a present of it I'll use it.*" (focus group 5 – Galway/female/ABC1). Several

participants who used meat thermometers had themselves received them free of charge, for example: "*Some relatives brought it me home from America for Christmas time.*" (focus group 5 – Galway/female/ABC1), and "*My wife got it for free, or some kind of special offer.*" (focus group 4 – Dublin#2/male/C2DE). It was also suggested that if a meat thermometer were already in a kitchen, it would be used more frequently: "*If you had it in the house anyway, you'd pick it up.*" (focus group 2 – Coleraine/female/C2DE).

Current sources of information

The focus group consumers were asked to discuss their preferences for finding out more about the safe preparation of meat. Results revealed that the three most widely reported sources of information included:

1. personal communications, specifically family members through word-of-mouth,
2. customer service advice from the butcher, and
3. instructional material such as recipe leaflets.

To a lesser degree, participants reported:

1. advertising, more specifically using search engines and social media,
2. personal communications, specifically, Home Economics classes, and
3. personal communications from a celebrity chef.

Personal communications – family members

Participants in all focus groups stated that they learned to cook meat from their parents, primarily through "helping and watching". Some participants, generally of a younger generation, had learnt to cook meat from their fathers, or from both parents, though most had learnt from their mothers: "*It was just watching and then experiencing doing it yourself, and you could just get her to check it along the way and say, is this OK now.*" (focus group 5 – Galway/female/ABC1). In one focus group (Dublin, C2DE), the question of whether anyone had learnt to cook meat from their father was met with prolonged laughter. Some participants had learnt how to cook from their grandparents, but was primarily baked goods rather

than meat. While parents were the most common source of information, many participants stated that they continued to alter their cooking practices according to their circumstances as they aged, such as when acquiring new recipes: "*Watching mummy over the years [is how I learned to cook meat safely]... I've adapted mine just myself because mummy would have made dishes which I don't make anymore.*" (focus group 1 – Belfast/female/ABC1). These responses confirm findings in the behavioural sciences, which have found that long-lasting habits, including food behaviours, are established by imitating immediate peers within the family (Duncker, 1938; Birch et al, 1982, 1984).

Customer service advice - butchers

In all focus groups, participants stated that they got information on how to cook meat from a butcher. This was primarily in the form of leaflets and recipes, which were made available at butcher's shop counters. However, some participants stated that they would ask the butchers themselves for advice on how to cook meat, making statements such as, "*A good butcher says how you're going to cook this chicken and give you some advice.*" (focus group 6 – Sligo/male/C2DE). This was a particularly popular source of information on how to prepare meat safely, especially in the RoI, where many participants stated that they had a local butcher they felt they could rely on for good produce and sound advice: "*I've a butchers back at home that I trust.*" (focus group 5 – Galway/female/ABC1).

Instructional materials – recipe leaflets

Recipe leaflets were also a popular source of information on how to cook meat. These were discussed in all focus groups, except those in Dublin. Participants generally stated that they were unlikely to pick up leaflets regarding the safe preparation of meat specifically (such as one, which discussed the risks of food poisoning): "*If I saw it in the doctors [an informational leaflet on the risk of food poisoning] I'd just leave it.*" (Focus group 6 – Sligo/female/C2DE). However, they were inclined to pick up leaflets produced by supermarkets and butchers, which contained instructions on how to cook meat: "*I've several of those wee recipe cards; they're very, very good.*" (focus group 1 – Belfast/female/ABC1). Slimming World was a popular source of recipe leaflets in the Belfast (ABC1) focus group, where seven participants stated that

they used this source. Participants who made responses in this vein were overwhelmingly female, even when accounting for the higher female-to-male sampling ratio.

Media communications - Internet, search engines, and social media

Participants in the NI focus groups and the first (ABC1) Dublin focus group reported using search engines and the internet as a source of meat cooking information. This was normally to double-check what temperature an oven should be heated to. One participant stated: "*Sure if I wasn't certain I'll google it.*" (focus group 3 – Dublin#1/male/ABC1), while another participant said, "*You can ask Alexa.*" (focus group 1 – Belfast/male/ABC1). Some younger participants said that they got recipes on social media platforms such as Instagram and YouTube. Two participants in the Galway focus group (focus group 5 – ABC1) said that they got their cooking information from a YouTube Influencer*: "*The cooking shows I watch are on YouTube so if I was watching a YouTuber and they were saying, "Oh, this is really important," then I'd take it on board.*" (female). Upon hearing this statement, an older male participant responded: "*I've discovered YouTube lately, it's so simple now.*" A separate participant in Galway stated that their approach to gathering information of how to cook meat safely was "*mother and YouTube*" (female).

**A You Tube Influencer is someone who has built a substantial following on the You Tube video platform providing information on a specific subject, e.g., cooking. (Please note, this person may get paid to promote certain products or services or receive free samples in exchange for a review).*

Formal education - Home Economics class

In all focus groups, with the exception of the Belfast group, participants reported Home Economics (or other school food classes) as their source of how to cook meat safely. However, this was mainly among the older participants, many of whom could not recall specific advice, and who further stated that they only learnt basic cooking instructions in Home Economics: "*We did learn to cook but we would have learned the basic safety and cooking food and temperature.*" (focus group 3 – Dublin#1/female/ABC1).

Media communications - Television

Some participants (*n* = 30) stated that they watch cookery programmes on television. However, many do not watch cookery programmes regularly, a common statement being: "*I wouldn't watch it religiously*" (focus group 1 - Belfast/male/ABC1). In all focus groups except the Sligo group (C2DE), at least some participants said that they noticed TV chefs using a method to check doneness, although only a few said that they had acquired doneness-checking behaviours from TV chefs, with one participant stating: "*I got that from [a] Jamie Oliver show a few years ago, making sure the juices running clear.*" (focus group 1 – Belfast/male/ABC1). However, there was a common observation that chefs used a number of different methods, and that different chefs employed different techniques, which led to some confusion: "*You would get extra tips over the years [from cookery shows] but there's an awful lot of the cookery programmes on now.*" (focus group 3 – Dublin#1/female/ABC1).

Participants had reservations about following the recommendations of TV chefs, who were seen as cooking food far too quickly to ensure safety: "*This fella [on TV] does scrambled eggs in 28 seconds, I think it would be dodgy to do eggs in that time!"* (focus group 1 – Belfast/male/ABC1). Likewise, the highly skilled nature of TV chefs resulted in their behaviour being seen as inaccessible to the average person, with several participants stating that they would not be willing to employ the same methods, such as touching meat to see if it was fully cooked. In general, cookery programmes were consumed mainly for entertainment or for inspiration, with one participant commenting: "*I just watch them but I don't really, I wouldn't take anything from them, I wouldn't go in and make something in a particular way [that a TV chef had]. I'd maybe get ideas of what I'd like to cook and things.*" (focus group 1 - Belfast/female/ABC1). When the moderator asked the Coleraine focus group (focus group 2) whether they would follow the procedures demonstrated on TV at home, he was met with bemusement and laughter, before one participant replied, "*More the recipes than the procedure*,"(focus group 2 female/C2DE) which was followed by another participant saying, "*It's stuff that you wouldn't be making at home.*" (focus group 2 - female/C2DE).

Consumer preference for communication of meat safety advice

In addition to being asked to identify the source from which they learn about cooking meat safely, participants were also asked to identify the communication source they would be more likely to take heed of in relation to the safe cooking of meat. Four main communication sources were identified:

1. personal communication via advice from the butcher;
2. personal communication via direct selling at meat counters;
3. television advertising; and
4. instructional material on food packaging.

Butchers, either in shops or at supermarket meat counters, were a popular source of advice on cooking meat safely, and many participants said that they would like to see communications coming from a butcher who could provide additional advice on how to cook the meat: "*It might be a good idea… if they're buying meat, and the butcher would add some advice in, and say, well, you need a meat thermometer.*" (focus group 1 – Belfast/female/ABC1). Additionally, participants stated that they would be more likely to use a meat thermometer if they were on display at meat counters or at a butcher's shop: "*If butchers or supermarkets had them beside the counter and explained what they were.*" (focus group 6 – Sligo/male/C2DE).

In all focus groups, except the Galway group (ABC1), participants stated that they would be more likely to use a meat thermometer if they were instructed to do so on the packaging of meat: "*Maybe a wee bit on the packaging… just like something highlighting it, the importance of cooking it with a probe.*" (focus group 4 – Dublin#2/female/C2DE). It was also suggested that meat packaging could include information on the correct end-point temperature of meat: "*Just say you were getting a steak, and there was a sticker on the side telling them exactly what it should be cooked at… rules of chicken, beef, bacon, whatever it is.*" (focus group 6 – Sligo/male/C2DE).

Conclusion

The focus group research provided substantial information on the attitudes and perceptions of people on the Island of Ireland who have the primary responsibility of cooking meat in the domestic setting. It also provided a basic understanding of the motivations of those who use meat thermometers, the meat types the thermometers are used with, and the occasions on which they are employed. This information provided practical insights for the consumer survey (Table 6) and for possible future interventions (see the Recommendations section for Themes and Their Implications for Campaign Communications).

Table 6: Focus group themes and their implications for the consumer survey

Theme	
Many participants in the focus groups stated that they knowingly overcooked meat to ensure safety.	The consumer survey should include a question assessing whether participants overcooked meat to ensure safety, to establish whether this is a common practice.
Participants provided a wide range of sources from which they acquired information on the safe cooking of meat.	The consumer survey should include a question assessing what sources of information consumers use for information on how to cook meat safely, to provide a quantitative measure of source popularity.
A potential barrier to use was identified in many participants stating that they thought meat thermometer use was typical of a very experienced and/or a very inexperienced cook, with	The consumer survey should include two questions, assessing whether meat thermometer use is perceived as typical of experienced and/or experienced cooks.

neither group being commonly identified with.	
The focus groups suggested that the perceived cost of meat thermometers was a barrier to use.	The consumer survey should include two questions, one to assess the estimated cost of a meat thermometer, and one to assess the amount consumers would be willing to pay for a meat thermometer.

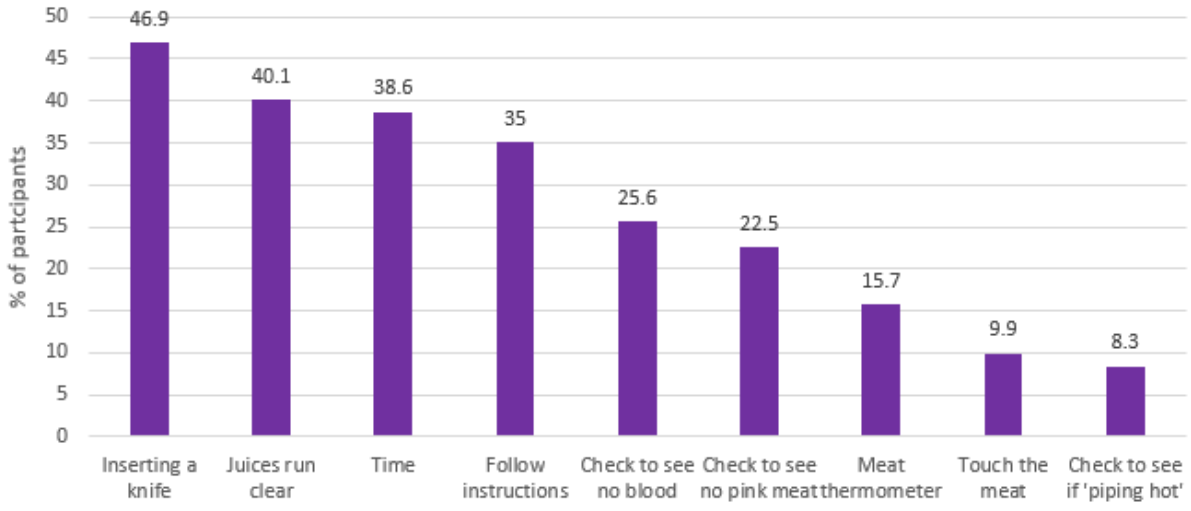
7 Results: consumer survey

The purpose of the consumer survey was to assess perceptions relating to the use of meat thermometers. It examined their general attitudes towards the cooking of meat and then focused more specifically on meat thermometers concerning the likelihood of usage, barriers to usage, and motivators to usage. The information collected from stage one and two of the project was used to inform this stage of the research.

Measures of checking doneness

The most commonly employed measures of checking the doneness of meat (see Figure 2) were 'inserting a knife into the meat' (46.9 %), followed by 'juices running clear' (40.1%), 'timing' (38.6%), and 'following instructions on packaging' (35.0%). Only a small minority of respondents (15.7%) reported 'using a meat thermometer'. Only 1.9% of the sample followed the ***safe***food recommendation of combining the three methods of: (1) checking to see if juices run clear from meat, (2) checking to see if any pink meat is present, and (3) checking to see if meat is piping hot.

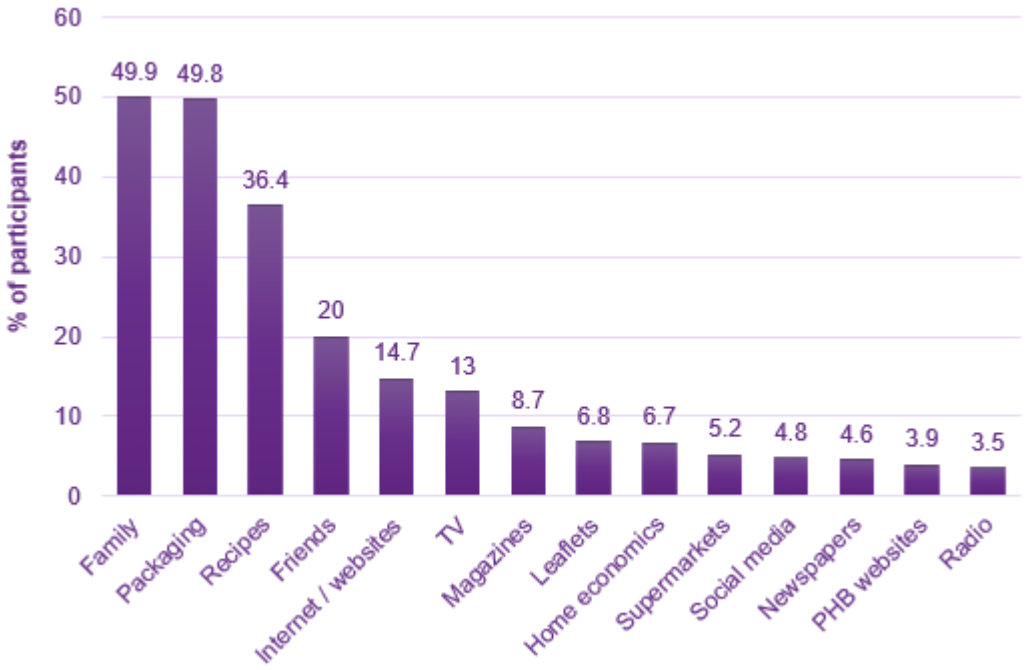
Figure 2: Reported measures of checking doneness



Sources of information on the safe preparation of meat

The three most commonly stated sources of information on how to safely prepare meat were: 'family' (49.9%), 'the packaging on meat' (49.8%), and 'recipes' (36.5%) (Figures 3-5). The popularity of sources on how to check the doneness of meat differed according to country. Family, friends, 'internet/websites', 'newspapers' and 'TV' were more popular in the Republic of Ireland while following the 'instructions on the packaging of meat' was more popular in Northern Ireland. Participants differed in their stated sources of information according to their "stage of change" (e.g., *pre-contemplation, contemplation, preparation, action, and maintenance*). Note: most participants (86%) belonged either to the pre-contemplation stage of never having used a meat thermometer, nor having thought about buying or using one (72.5%) or the maintenance stage of regularly using a meat thermometer for six months or more (14%).

Figure 3: Sources of information on the safe preparation of meat



Perceived safe end-point temperature of meat

Participants had a poor understanding of what core temperature meat should reach for food safety. Results revealed that 55% (n=579) of participants said that they did not know what temperature meat should be cooked to. Responses ranged from 30 - 260°C. This was true both when "correct" was coded as 75°C (the standard advice), or as ranging from 60-75°C (i.e., the lowest possible safe end-point temperature to the highest, according to all the food safety authorities reviewed in the rapid review).

Figure 4: Accuracy of estimates of safe end-point temperature of meat (where "correct" = 75°C)

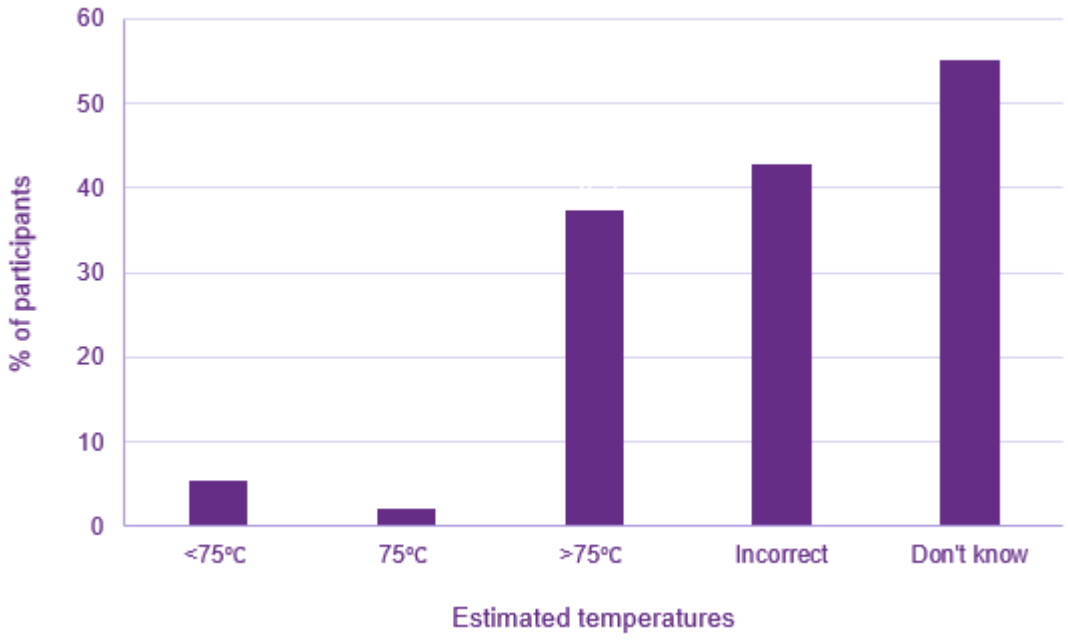
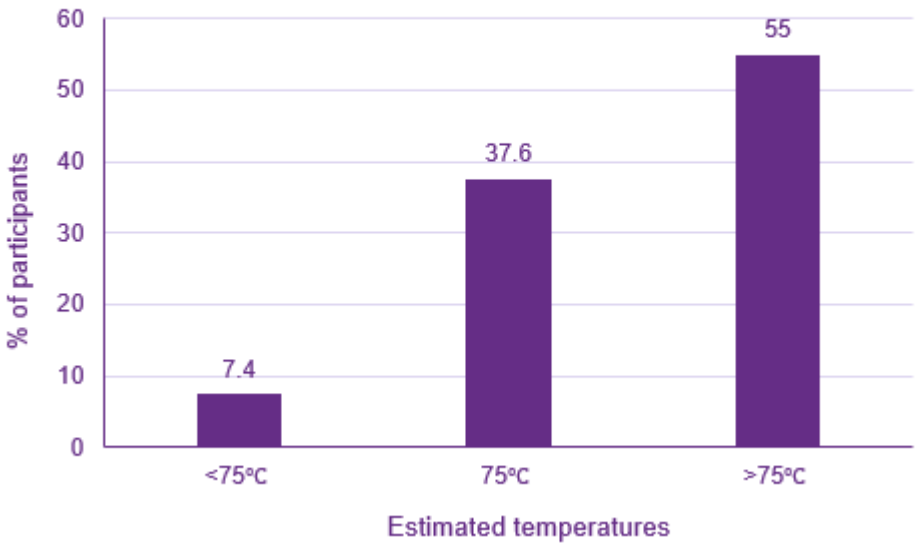


Figure 5: Accuracy of estimates of safe end-point temperature of meat (where "correct" = 60 - 75°C)



Ensuring the safe cooking of meat

Around half of participants (50.8%) at least occasionally overcooked meat to ensure it was safe to consume. This differed according to location (56.6% vs. 44.6% for RoI and NI respectively), socioeconomic bracket (ABC1 = 48.2%, C2DE = 51.75), and stage of change (51.1% vs. 41.5% for pre-contemplation vs maintenance stage respectively).

Meat thermometer users vs non-users

A total of 17.4% of the sample stated that they owned a meat thermometer. 57.9% of these owned a digital thermometer, 21.9% a dial thermometer, and 5.5% a liquid-filled thermometer. An assessment of how owners and non-owners of meat thermometers differed on different metrics may be found in Table 7. Ownership differed significantly according to stage of change and educational attainment. Participants with higher levels of educational attainment being more likely to own a meat thermometer). Participants in the RoI demonstrated a trend towards being more likely to own a meat thermometer than those in NI but this was not significant and participants in the socioeconomic bracket ABC1 were more likely to own a meat thermometer than those in the C2DE socioeconomic bracket. When compared to

non-users, current meat thermometer users were more likely to agree, "*A meat thermometer is a necessary tool when cooking in a restaurant/deli counter.*" "*A meat thermometer is a necessary tool when cooking at home.*", and "*Food poisoning poses a risk to me.*".

Table 7: A comparison of meat thermometers owners and non-owners on key metrics (%(n))

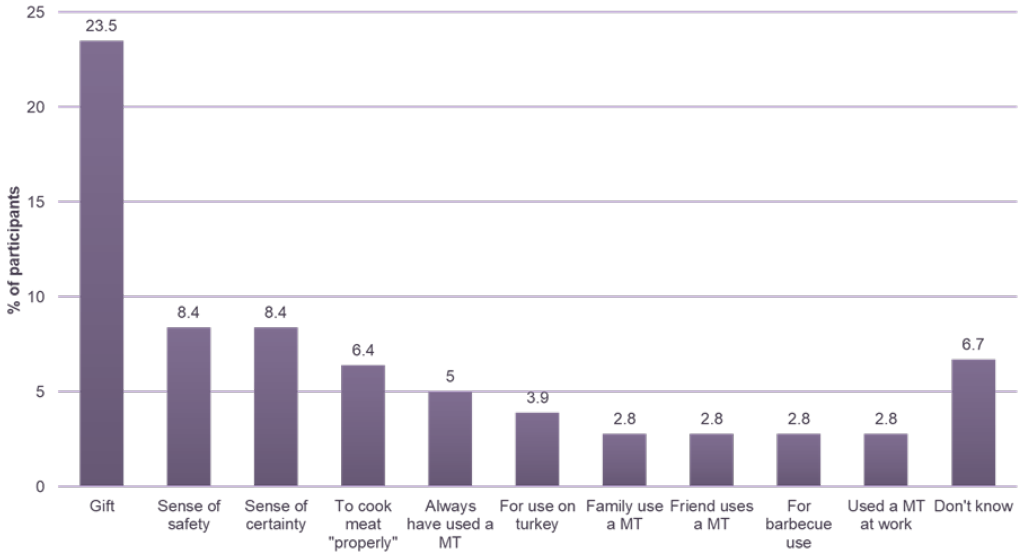
Variables	Owners	Non owners
Gender Male Female		 84.3% (284) 81.5% (574)
Age (years)*	48.73±14.30	48.66±17.13
Location RoI NI	 19.8% (106) 15.2% (77)	 80.2% (429) 84.8% (429)
Stage of change[1] Pre contemplation Contemplation Preparation Action Maintenance	 2.2% (4) 0% 0.5% (1) 6.6% (12) 80.3% (147)	 88.9% (763) 0% 0% 0% 0%
Educational attainment Primary Junior cert/GCSE Leaving cert/A level Undergraduate degree Postgraduate degree	 5.5% (10) 32.8% (60) 27.9% (51) 27.9% (51) 3.3% (6)	 7.2% (62) 30.7% (263) 27.5% (236) 30.2% (259) 3.6% (31)
Socioeconomic status *ABC1* *C2DE*	 59% (108) 38.2% (70)	 42.4% (364) 53.8% (462)
A meat thermometer is a necessary tool when cooking in a restaurant/deli counter"*[L]	1.43 ± 0.682	1.91 ± 0.950
A meat thermometer is a necessary tool when cooking at home*[L]	1.98 ± 1.061	3.03 ± 1.122
"Food poisoning poses a risk to me"*[L]	2.08 ± 1.270	2.68 ± 1.102

[1] 11.9% of participants who did not own a meat thermometer, and 10.4% of those who did, failed to respond to at least one of the Stage of Change assessment questions, and therefore a stage could not be calculated.; [L] Likert scale: 1 "strongly agree" – 5 "strongly disagree".

Motivation to own a meat thermometer

The number of participants who owned a meat thermometer was 17.5%, which supports the number (17%) of meat thermometer users documented in the focus group research. However, when asked what motivated them to purchase a meat thermometer, the participants' reasons differed from those stated in the focus group. Responses are shown in Figure 6. The three most commonly reported motivations were that their meat thermometer was 'a gift' (23.5%), that it 'provided a sense of safety' (8.4%), and that it 'provided a sense of certainty' (8.4%).

Figure 6: Stated motivation to purchase a meat thermometer



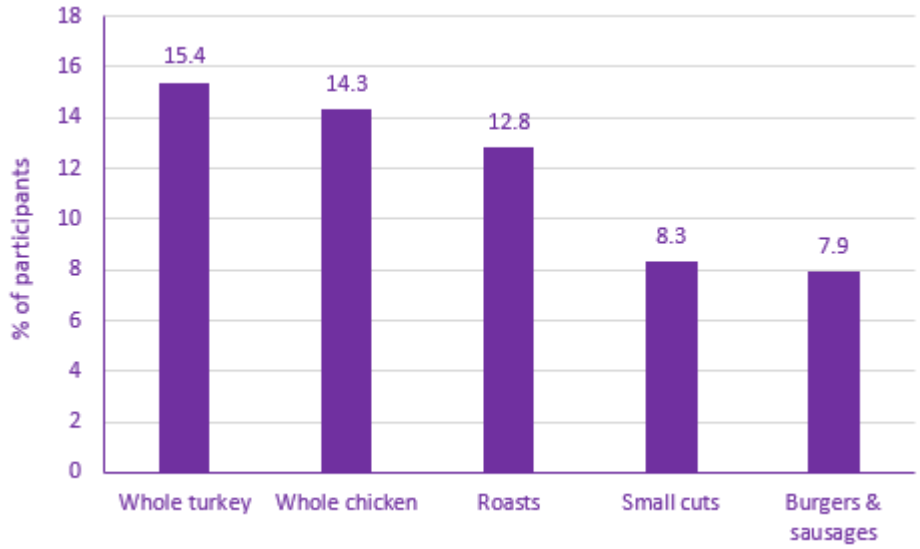
Meat thermometer use and ownership-usage gap

A total of 17.4% of participants said that they owned a meat thermometer and 15.7% of the respondents stated that they used meat thermometers. This meant there was an ownership-usage gap (those who owned a meat thermometer but did not use one) of 1.7%. This is comparatively low compared to previous studies in North America, where the ownership-usage gap ranges from 18% (Mazengia et al, 2015) to 45% (Food Safety Survey, 2016).

Meat thermometer use according to meat type

In keeping with previous work on meat thermometer use, "use" according to specific meat types was defined as using a meat thermometer "always" or "often" when cooking that meat type (Food Safety Survey, 1998, 2001, 2006, 2012, 2016; Lando and Chen, 2012; Maughan, 2015). Figure 7 illustrates that participants stated that they used meat thermometers "always" or "often" on whole turkeys (15.4%), followed by whole chicken (14.3%) and roasts (12.8%), and were less likely to use it on small cuts (8.3%) such as chicken thighs and chicken drumsticks, and burgers and sausages (7.9%).

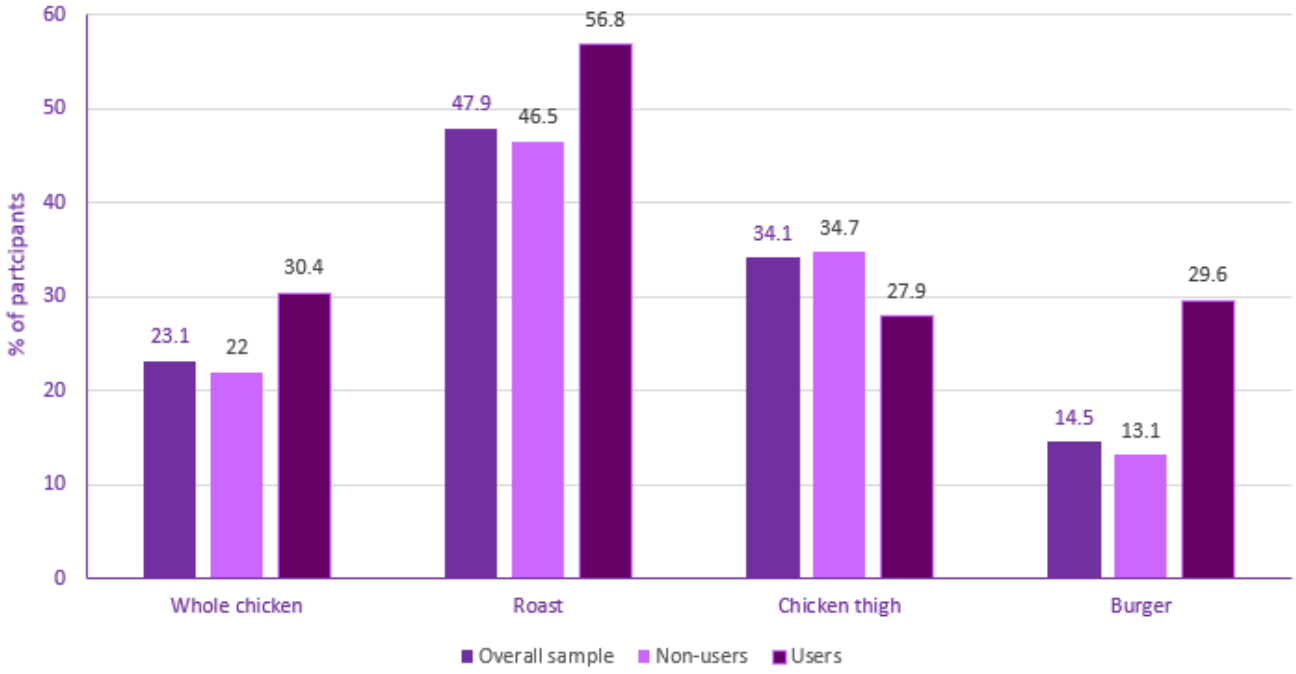
Figure 7: Meat thermometer use "always" and "often" according to meat type



Results from the visual materials

Images were presented to participants that demonstrated both correct and incorrect insertion points for meat thermometers in various meat types. They were then asked to select those that were correct. Most participants were unable to identify images that accurately displayed the correct insertion of a meat thermometer into different meats (52.1-85.5%). This was true of both users and non-users, as demonstrated in Figure 8, although users identified the correct answer more consistently than non-users. The most frequently correctly identified insertion point was seen in the images of the roast (47.9%), with the least frequently correct being the burger (14.5%).

Figure 8: Correct identification of meat thermometer insertion image, according to usage level

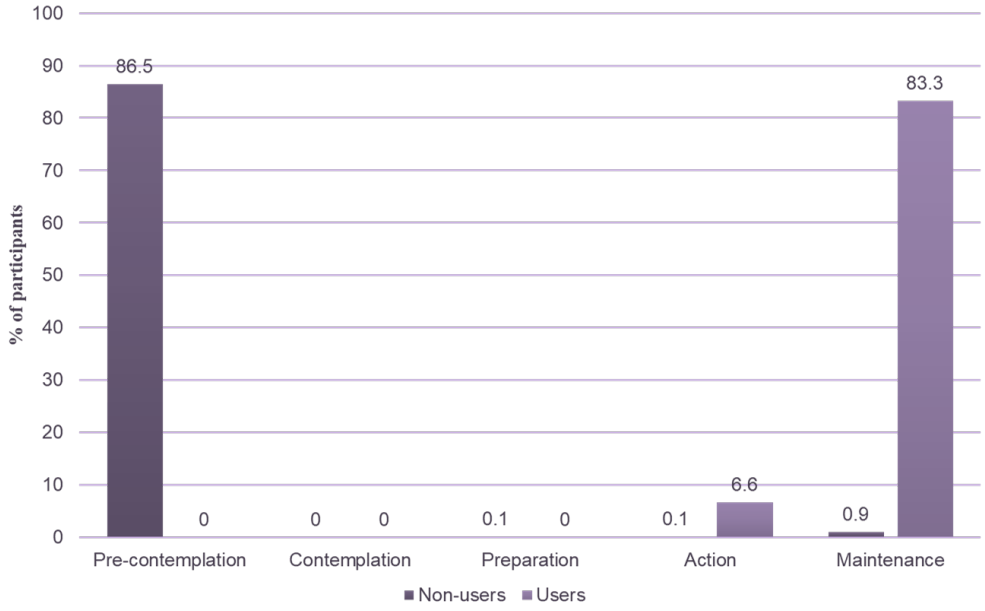


Stages of Change

Transtheoretical Model of Change

The majority of participants who were not meat thermometer users (86.5% of non-users, 72.9% of the overall sample) were categorised according to the "Stage of Change" model as "pre-contemplation": they did not use meat thermometers and had never considered using them. By contrast, the majority of meat thermometer users (83.3%, 14% of the overall sample) were categorised as being in the "maintenance" stage: having used meat thermometers to cook meat and had done for six months or longer (see Figure 9).

Figure 9: Respondent Stage of Change in respect to meat thermometer usage*



** non users n184; users n866*

Theory of Planned Behaviour

A series of multi-level linear regressions were performed to assess how well the model predicted the use of meat thermometers on different meat types. Overall, the theory of planned behaviour model appeared to have little influence on meat thermometer use among sampled participants.

However, perceived behavioural control (the ease with which participants felt they could use a meat thermometer) did significantly predict frequency of use when cooking whole chicken. The easier a participant thought a meat thermometer was to use, the more likely they were to use one when cooking a whole chicken. Likewise, attitude predicted the use of a meat thermometer on small cuts, such as chicken thighs, chicken drumsticks and roasts. The perception of food poisoning as a threat, and the perception of a meat thermometer as a safeguard against food poisoning, influenced the frequency of meat thermometer usage on whole chicken.

Related beliefs

Participants were asked a series of attitudinal questions which related to meat thermometers, and to food preparation and safety more generally. Most respondents believed themselves to be '*confident cooks*' (76.5%) and *'felt responsible for the food safety of others'* (78.7%). More people agreed that a meat thermometer was a necessary tool in a restaurant/deli counter than in a domestic setting (78.6% for necessary in a restaurant/deli vs 38% in a home environment). In general, however, respondents thought that an inexperienced cook was more likely to use a meat thermometer than an experienced one (60.4% disagreed that *'an experienced cook would use a meat thermometer' vs.* 16.4% who agreed that *'an experienced cook would use a meat thermometer*'), although approximately one quarter (23.2%) were not sure.

When compared to non-users, current meat thermometer users were more likely to agree with the statements "I am a confident cook.", "I feel responsible for the food safety of others.", "A meat thermometer is a necessary tool when cooking in a restaurant/deli counter.", and "A meat thermometer is a necessary tool when cooking at home". Current users of meat thermometers were also more likely to think, "A meat thermometer would be used by an experienced cook." Users and non-users of meat thermometers did not differ in their opinions of how likely an inexperienced cook would be to use a meat thermometer. Responses to each of these attitudinal measures did not differ according to socioeconomic bracket, based on their employment type.

Estimated cost of a food thermometer and willingness to spend

The estimated cost of a meat thermometer among participants in NI was £5-10 (Figure 10), which was also the mode willingness to pay (Figure 11). Likewise, in the RoI, the estimation of cost and willingness to pay was €10-20 (Figures 10 & 11). Around a third of participants said that they did not know how much a meat thermometer would cost (RoI = 33.2%, NI = 26.9%). A total of 15.4% of participants stated that they would not be willing to pay for a meat thermometer. This figure differed according to location: RoI = 19.7%, NI = 11.1%.

Those who stated that they would not be willing to pay for a meat thermometer were unlikely to own a meat thermometer (6.7%), and were significantly more likely to disagree with statements that 'a meat thermometer was necessary in a professional setting' or in a 'domestic setting', and were significantly more likely to disagree with the statement that 'food poisoning was a serious risk to them'. This would suggest that those in this group were not resistant to purchasing a meat thermometer because they already owned one, but because they were resistant to meat thermometer use, and were less concerned about food poisoning

Figure 10: Estimated cost of a meat thermometer

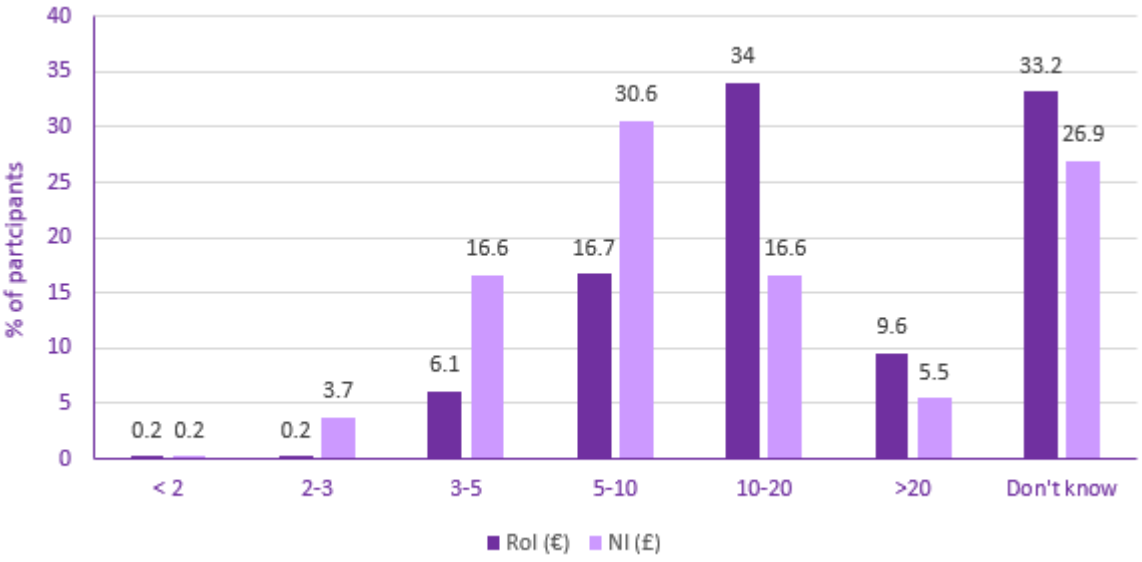
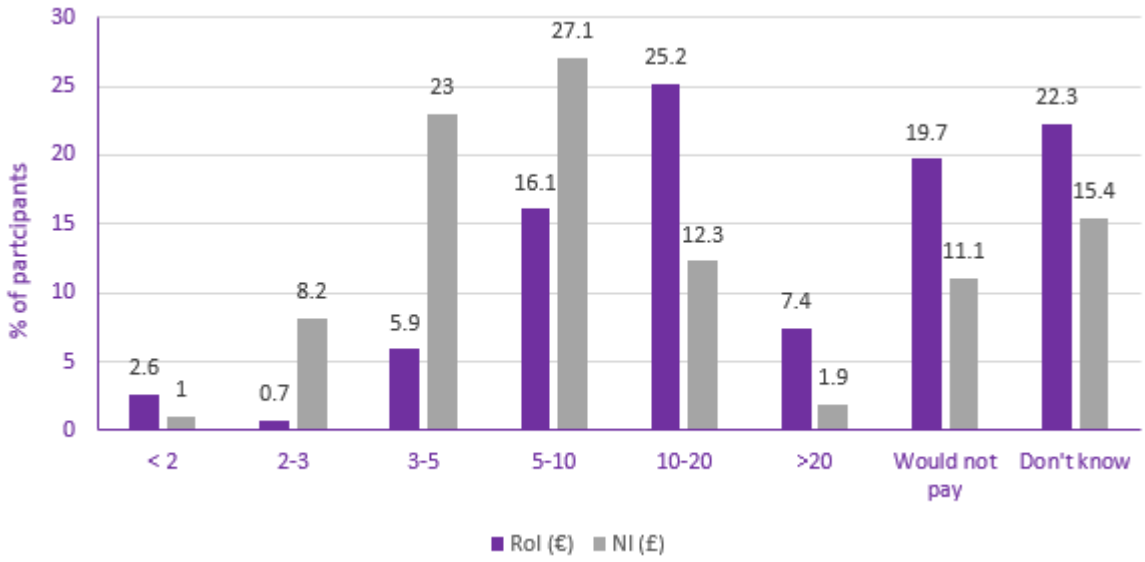


Figure 11: Willingness to spend on a meat thermometer



Conclusion

The consumer survey research provided substantial information on the behaviours, attitudes and perceptions of people on the IoI in relation to meat thermometers. It also provided a basic understanding of why those who use meat thermometers on the IoI do so, and on what meat types. It further highlighted the high level of misunderstanding of safe-end point temperatures and insertion points for checking temperatures. These results provided practical insights for possible future interventions (see Recommendations section for relevant themes and recommendations for future interventions/campaign communications). It is notable that the findings from the consumer survey unequivocally supported the findings from the earlier focus group research.

8 Project discussion & key findings

In global terms, meat thermometer use remains low. However, thermometer use in North America is higher than Europe (though research on use and ownership in the latter region is sparse – Sampers et al, 2012; Kennedy et al, 2005; Fischer, Frewer, and Nauta, 2006; Mahon et al, 2006; Bates et al, 2017). Since available research began in 1998 (Koeppl, 1998; Unklesbay, Sneed, and Toma, 1998; Lando and Chen, 2012), meat thermometer use in the USA has increased steadily (Cates, Kosa, and Carter-Young, 2002; Lando and Chen, 2012; Elshahat, Woodside, and McKinley, 2019), potentially as a result of several campaign interventions by the United States Department of Agriculture. Although food authorities in the UK, IoI, New Zealand and Australia recommend meat thermometer use in some instances, thermometers are not recommended as the only reliable option to assess doneness; only the USA and Canada recommend thermometers as the primary means of assessing the doneness of meat. While most research on current meat thermometer use has been conducted in North America (USA and Canada), a comparison with the small amount of research conducted on European populations would suggest that thermometer ownership and use is higher in North America than in Europe. It is likely that this is the result of government recommendations and active interventions to encourage use.

Consumers have been slow to adopt thermometers when cooking meat, and research indicates that there are more barriers to usage than there are motivators. However, there is evidence that interventions to encourage use have been successful, with self-reported use of thermometers increasing steadily in the US after the implementation of interventions, although other, undetected causal factors may have also played a role, for example, obtaining a thermometer as a gift. While growth in self-reported use occurred after 2000, when the Fight BAC/Thermy campaign was implemented, the largest growth occurred after 2004, the year in which the "Is It Done Yet?" campaign was introduced. "Fight BAC/Thermy" employed the Health Belief Model (HBM) and was aimed at the general population, though the message was tailored

to children, who were thought to be the best means by which to influence families directly. “Is It Done Yet?” employed the Transtheoretical Model, targeting a specific demographic with high levels of cultural influence. While the two approaches are not directly comparable, the relative success of the latter approach may indicate that a campaign targeted at a specific demographic with significant influence over social norms, and tailoring a campaign based on their Stage of Change (according to the Transtheoretical Model), may have an advantage over a HBM-based campaign aimed at the population at large.

The results of both Stage 2 and Stage 3 of this project have resulted in a number of key findings and actionable insights that could be employed in a campaign based on the Transtheoretical Model to increase meat thermometer usage across Europe, the UK and Ireland. The key findings from Stages 1 – 3 are discussed below.

Key Findings

- Government guidance on meat thermometer use differs across countries, with thermometers being explicitly recommended in USA, Canada, Australia and New Zealand. In the UK, meat thermometers are recommended for use at Christmas when cooking a turkey, and in Ireland they are presented as one of a number of methods of assessing the doneness of meat. Across all the countries, guidance indicated that the acceptable end-point temperature of meat ranged from 62.8-75%.
- Most research has been completed in North America (n=33) /Canada (n=5), providing trend data from 1998. There is a lack of research as regards meat thermometer usage in Europe (n=3).
- Self-reported meat thermometer ownership was highest in the US, with reported ownership ranging from 43-73% and self-reported usage of 20-29%. Canada had a lower self-reported usage of 13.7-29%, while in research studies carried out in Europe had a self-reported usage of around 11%.

- Most meat thermometer ownership/usage data collected was self-reported (n=33) and therefore subjective. Observational studies (n=11) identified lower usage levels than self-reported studies, meaning that the data available may well be based on overestimates.
- Only two government campaigns to encourage meat thermometer usage were identified, both in the US: ‘‘Fight BAC/Thermy campaign in 2000 and the “Is It Done Yet?” campaign in 2004. No meat thermometer campaigns were identified in the EU.
- US campaigns by the Department of Agriculture saw steady increases in thermometer usage, with the biggest increase occurring from 2004 onwards due to the 'Is It Done Yet?' campaign. Reasons:
    - The campaign was aimed at a specific demographic with high level of influence on social norms and employed the Transtheoretical Model, which was tailored to the demographic's stage of change.
    - The campaign was more targeted than the (Fight BAC/Thermy campaign), which was aimed at the general population and used the Health Beliefs Model.

- Research in general suggests that there are more barriers to meat thermometer usage than motivators and in the UK and Ireland. Barriers included the perceived high cost of a meat thermometer, the lack of exposure to meat thermometer usage in the domestic environment, the perception that meat thermometers would be difficult to maintain and/or would contribute to kitchen clutter, and that meat thermometers were only for the highly experienced or highly inexperienced cook. Motivators included a sense of social responsibility not to give food poisoning to others, to improve the taste and/or texture of meat, the potential ease of use of a meat thermometer, and the free distribution of meat thermometers.
- Thermometer use is not recommended as the only reliable option to assess meat doneness in the UK and Ireland.

Current behaviours in relation to cooking of meat

The most frequently reported measures for checking doneness was *'checking whether there was any pink meat'* (focus group respondents) *'inserting a knife into meat'* (survey respondents, most frequently reported in RoI), and *'checking to see if juices run clear'* (focus group and survey respondents, and most frequently reported in NI). Relying on '*timing'* was more frequently reported in C2DE: "*If I overcook it, it will be ok!"* was the theme that emerged from the focus group respondents.

There is a low level of adherence to ***safe***food's recommended methods of checking doneness. Only 1.9% of the survey sample reported combining the three methods of checking to see that there is no pink meat that juices run clear from the meat and that meat is piping hot. Only one focus group participant said that they checked to see whether meat was piping hot.

Many focus group (n=31) and survey participants (50.8%) stated that they at least occasionally overcook meat to ensure it's safe to eat. Predominantly, this was in the form of leaving meat in the oven for longer than specified on instructions. However, some participants stated that they intentionally burned meat.

Meat thermometer use across the IoI is low compared to levels documented in the USA and Canada.

- 16.9% (11/65) focus group participants stated that they use a meat thermometer at least occasionally.
- 17.4% of survey participants reported owning a meat thermometer, while 15.7% reported using a meat thermometer, an ownership-usage gap of 1.7%. This is a smaller gap than reported in North American studies (Elshahat, Woodside, and McKinley, 2019)

Consumer types

Analysis of the focus groups revealed three consumer types: '*cautious meat preparers', 'carefree cooks or indifferent meat preparers', 'the thermometer curious'*. These groups were also evident and further explored / characterised within the survey. The emergence of these three groups was based on exploratory

analysis during this project. Further analysis would be required to determine if these groupings are definitive.

(1) ***Cautious meat preparers***: consumers who use a meat thermometer, generally to avoid giving food poisoning to themselves or those they are cooking for.

Survey data showed that meat thermometer owners were most likely to:

- Have obtained the thermometer as a gift (23.5%) or have purchased it to provide a sense of safety or certainty (16.8%)
- Own the thermometer for longer than 5 years (32.8%)
- Know someone else who has a meat thermometer (60.5%)
- Use it on whole poultry (turkey 88%, chicken 82%) and roasts (74%), and less likely to use it on small cuts (48%)
- Belong to socioeconomic bracket ABC1 (22.9% vs. 13.2%)
- Be in the *maintenance* stage according to the Transtheoretical Model of behavioural change (83.3%), where use has been established as habitual
- Be more likely to agree that:
  - a meat thermometer is necessary in a professional (92.7%) and domestic setting (76.4%), and
  - food safety poses a risk to them (72.7%).

From the focus groups, the more frequent use of meat thermometers on larger pieces of meat appeared to be motivated by two factors:

- Larger pieces of meat are more likely to be cooked for guests and groups of people, to whom meat thermometer users felt a sense of social responsibility to prevent food poisoning (more so than for themselves).

- Larger pieces of meat were perceived as more difficult in terms of gauging the colour of the meat at its centre.

(2) ***Carefree cooks***: consumers who do not believe they need to use a meat thermometer and are resistant to doing so. Generally, the carefree cooks did not perceive food poisoning to be likely, or to be a threat to them or those they cooked for.

- The survey showed that the 15.4% of respondents who were unwilling to pay for a meat thermometer were more likely to:
  - Consider it unnecessary in a professional or domestic setting, and
  - Believe food poisoning was not a risk to them.

(3) ***The thermometer curious***: consumers who had never used a meat thermometer, nor had thought about doing so, yet were willing and indeed curious to try cooking with one. These participants might be classified as being *pre-contemplation*, according to the Transtheoretical Model of behavioural change. Findings from both the focus groups and survey found that the majority of respondents were likely to fall into this consumer group.

- The vast majority (86.5%) of non-users of meat thermometers were in the *pre-contemplation* stage of change, i.e., they had never used a meat thermometer, nor thought of acquiring or using one.
- The majority of the survey sample stated that they were willing to pay for a meat thermometer (65.75%) and the amount that they were willing to pay matched their perceived cost of a meat thermometer (£5-10 and €10-20, for NI and RoI respectively).
- An overall majority of participants believed that a meat thermometer was necessary in a professional environment (78.5%). A slight majority stated that a meat thermometer was necessary in a domestic cooking environment (38% agree vs 28.7% disagree – 33.2% don't know).

Barriers and motivators

Barriers reported by participants to meat thermometer use were very similar to those reported by US consumers summarised in the rapid review, and included:

The perceived high cost of a meat thermometer,

1. a lack of exposure to meat thermometer usage in the domestic environment (especially during childhood),
2. the perception that meat thermometers would be difficult to maintain and/or would contribute to kitchen clutter,
3. that meat thermometers were only for the highly experienced or highly inexperienced cook, and
4. lack of knowledge.

- Despite the perceived high cost of a meat thermometer being noted as a barrier to use, our survey found that 65.7% of respondents would be willing to pay for a meat thermometer, matching their perceived cost of a thermometer, between £5 - 10 among NI respondents and €10-20 for RoI respondents.
- Both meat thermometer users and non-users had a poor understanding of meat thermometer insertion method. Only 26.2% of survey respondents obtained the correct method for whole poultry, 31.30% for chicken thighs, 21.35% for burgers, and 51.65% for roasts). There was also a poor understanding of the correct core cooking temperature for meat, with 7.2% of survey respondents reporting the correct temperature. The response range was 30-260°C and 30-250°C for survey and focus group participants, respectively; the 'don't know' response was 52.3% (n=34) and 52.7% (m=579), respectively. Most participants overestimated the correct core cooking temperature for meat, which may be indicative of a confusion with oven temperature.

Motivators of meat thermometer use included:

1. a sense of social responsibility in preventing food poisoning in others,

2. to improve the taste and/or texture of meat (although this was reported exclusively among ABC1 participants),
3. the ease of use of a meat thermometer, and
4. the free distribution of meat thermometers.
    - While the Theory of Planned Behaviour model had a limited influence on the use of meat thermometers on specific meat types, "attitude" (belief that a meat thermometer prevented food poisoning, and that food poisoning was a risk) significantly influenced usage on roasts and small cuts of meat. Likewise, "perceived behavioural control" (essentially the ease of use) significantly influenced use on whole chicken.
    - Again, motivators reported by participants are very similar to those reported by US consumers summarised in the rapid review.

Sources for information

Preferences (focus group and survey participants) for future communications regarding meat thermometers, and the safe preparation of meat, included:

- advice from butchers / meat counter workers,
- meat packaging,
- recipes, and
- television advertisements.

Within the survey, 'family' was significantly more commonly reported as a source of information for those in the *pre-contemplation* stage of change (a group that future interventions would likely aim to target), while websites were significantly more commonly reported as a source of information for those in the *maintenance* stage.

Project Conclusions

This mixed methods study provided a substantial body of data and insight into meat thermometer usage, ownership, associated attitudes, and self-reported behaviours. Focus groups allowed for an in-depth exploration and analysis of attitudes and behaviours in relation to the use of meat thermometers, while the consumer surveys allowed for a large sample of comparative measures across the island of Ireland. The insights gained through this research provide an understanding of contemporary meat thermometer use (and dispositions towards use), a pathway to potentially encouraging meat thermometer use through communication campaigns, and a resource for future research into meat preparation, health behaviours and attitudes on the island of Ireland.

Added Value & Anticipated Benefits of research

Failing to thoroughly cook meat and poultry can lead to serious foodborne illness and even death. 'Fully cooked' means cooking to a temperature of 75°C in the core (i.e., thickest part) of the food, or to an equivalent temperature-time combination. It is recognised that colour alone is not a reliable indicator of thorough cooking, as the colour of cooked meat depends on several factors, such as the feed of the animal, its pH and fat content, and the freezing and thawing methods of the meat (King and Whyte, 2006). Since the 1980s, the USDA has been advising consumers to use meat thermometers to accurately achieve the correct cooking temperature for meat and poultry. This recommendation was extended to burgers in 1997.

This research provides the first comprehensive analysis of meat thermometer usage, and related attitudes and behaviours, on the island of Ireland. The research has generated several actionable insights, which may be employed to encourage meat thermometer use in the general population, and thus reduce the occurrence of foodborne illnesses. This project has highlighted the reasons why food safety authorities should change their advice on cooking meat to include meat thermometer use. It has also provided a rationale for implementing a campaign to promote this new advice, in addition to revealing a clear picture of the target population and how receptive they would be to this campaign. The study design

employed resulted in the provision of specific information on how such a campaign might be configured, as well as providing baseline data for evaluating the campaign.

Limitations of the Research

During stage one of the research; the decision was made to include only English language studies. In addition to this, only the websites of food authority bodies in six English-speaking countries (the UK, the island of Ireland, New Zealand, Australia, the USA and Canada) were examined to obtain current advice. This may have resulted in research studies, campaigns and food authority advice on the use of meat thermometers from non-English speaking countries not being included in the current review.

Although the focus groups provided a rich body of data, there were several limitations inherent in the method. Focus groups allow the moderator to observe emergent themes, which arise organically within a group. However, the nature of social groups will often lead to particular individuals dominating the conversation. While the research assistant in these focus groups attempted to encourage other individuals to participate, and all participants made at least some contribution in each of these groups, more assertive participants may have expressed their opinion more so than the less vocal.

Focus groups took place in the early evening. This time was specifically chosen so that a wider demographic base could be reached and the timings not clash with normal working hours. However, this might have presented a barrier to the participation of some potential participants, who may have had caring duties for elderly relatives or children, which required them to be at home during the evenings.

Focus groups relied on self-reported data in relation to cooking behaviours. Previous research has found that, both generally and in relation to meat thermometers, individuals tend to over-report meat thermometer use (DeDonder et al, 2009; Mazengia et al, 2015; Maughan, 2015). This may be due to the social desirability of meat thermometer use. While such a social norm is not apparent on the IoI, participants may have overstated other desirable behaviours, such as underreporting instances of undercooking meat. Likewise, in some focus groups (such as Focus group 4 – Dublin#2, in which a

participant lightly mocked a meat thermometer user as not being a good enough cook), resistance to meat thermometer use may have suppressed reporting of meat thermometer use.

Though the qualitative nature of the focus groups allowed a detailed understanding of subjective experiences, and attitudes and beliefs towards meat thermometer use, it did not allow for a large-scale comparison of key metrics. Some of these limitations may partly be compensated for in the quantitative consumer survey.

The consumer survey allowed for a large-scale quantitative measure of self-reported cooking behaviours, meat thermometer use and related attitudes. In combination with the focus groups, it provided a useful resource in contributing recommendations for future interventions to encourage meat thermometer use on the island of Ireland. However, there were certain limitations inherent in the design.

The consumer survey relied on the accuracy of self-reported data. However, both generally and in specific relation to meat thermometers (DeDonder et al, 2009; Mazengia et al, 2015; Maughan, 2015), self-reported behaviour often deviates from behaviour found in observational studies. Observational studies have found that participants' meat thermometer use tends to be over reported when compared with their observed behaviour.

Surveys were conducted on a face-to-face basis. This may have influenced responses on certain items through a social desirability effect. For example, an unwillingness to discuss food poisoning may have led to an underreporting of gastrointestinal complaints.

While the structured nature of the consumer survey allowed for the comparison of different groups within a large sample, it did not allow for follow-up questions. This resulted in certain pieces of data being difficult to interpret. For example, the most common method of checking doneness reported by participants was “inserting a knife”. This did not make clear precisely what participants were attempting to assess by inserting a knife (colour, firmness, juices running clear, etc.).

Furthermore, while the quantitative measures employed here allowed for the identification of correlations – such as identifying a relationship between perceiving food poisoning as a risk and using a meat thermometer – it was not possible to make causal inferences. For instance, the methods employed could not assess whether increasing an individual's perception of food poisoning, as a risk would encourage meat thermometer use.

Future research

The first stage of this three-step research project highlighted a lack of research in this area in Europe, and more specifically in the UK and on the island of Ireland. There has been no comprehensive study of meat thermometer usage, ownership and attitudes towards meat thermometers on the island of Ireland. Kennedy et al.'s 2005 study focused on knowledge of microbiology, and Mahon et al.'s 2006 study focused on the preparation of beef products broadly, whereas the current project utilised a mixed method approach based on previous literature suggestions. This mixed methods research design should be utilised to fill the research gap in this area.

Both the qualitative and quantitative results of this study highlighted the opportunity for further research regarding the efficacy of Front of Pack (FOP) cooking instructions versus in-store demonstrations and advice from butchers, by evaluating the potential these approaches offer in conducting novel and applied research in the area of food safety.

If a communications campaign were to be rolled out with the updated advice, as suggested by this project, a study to assess its impact on increased usage would be highly beneficial.

In summary, this project has provided a base for future research by identifying additional areas where further research may be warranted - notably, cooking skills relating to meat, and packaging design (e.g., cooking information and guidelines) - and further provides a baseline for evaluating the effectiveness of a campaign on meat thermometer usage.

9 Recommendations

A summary of the project's key recommendations is given at the beginning of this report on page 3. The outcome of this research, based on the review, focus group work and consumer survey, has highlighted a need for more research in Europe, the UK and Ireland, and has provided a rationale for a campaign to address a specific demographic on the island of Ireland based on the Transtheoretical Model of behaviour that targets a person's stage of change.

Below are the recommendations made for a communications campaign, which are derived from the results of stage two and three of this research project. It is worth noting the overlap in key findings, and therefore recommendations, between the focus group work and the consumer survey.

Table 8: Focus group & consumer survey findings and their implications for a communication campaign

Theme	Implication for Communications
During the focus group study, most participants did not use a meat thermometer, nor had they ever thought about using one. However, many participants stated a willingness to use a meat thermometer in the future (the *thermometer-curious* consumers). Furthermore, the majority of participants across focus groups stated that they felt a meat thermometer would be easy to use (though often on the condition that they had instruction on how to do so), a perceived difficulty of use being one of the three barriers to usage, according to the Theory of Planned Behaviour.	A campaign may prove effective in encouraging meat thermometer use on the island of Ireland. However, such a campaign should assume minimal awareness of meat thermometers as a domestic tool.
The survey revealed the majority of meat thermometer users were in the "maintenance" stage of change, in which use is established and habitual. A majority of non-users (and a majority of the sample overall) were in the "pre-contemplation" stage, in which meat thermometer use had not been considered. Though only 15.8% of participants used a meat thermometer, 84.6% stated that they were willing to purchase a meat thermometer.	Any future interventions should focus upon non-users. Further, future interventions should assume no prior knowledge regarding meat thermometers. Campaign interventions to encourage meat thermometer use may prove fruitful, as current opinion is not actively resistant to meat thermometer use at home.
Focus group findings revealed that meat thermometers were used primarily on larger cuts of meat, often as a substitute for checking the internal colour of the meat.	Campaigns should emphasise that meat thermometers should be used on all meat types, and that using a meat thermometer is the best way to check the doneness of meat.

The “attitude” component of the Theory of Planned Behaviour significantly influenced use of meat thermometers on small cuts and roasts during the consumer survey.	Any interventions specifically designed to encourage meat thermometer use on small cuts and roasts should aim to communicate that meat thermometers reduce the risk of foodborne illness, and that home cooked foods can present a risk of food poisoning (any proposed intervention should address the **“**attitude toward the behaviour**", e.g.,** the desire to prevent food poisoning. It is recommended that the Theory of Planned Behaviour Model underpins such an intervention).
38% participants in the consumer study agreed that a meat thermometer was necessary when cooking at home (higher than the current actual reported usage), while only 28.7% disagreed (33.3% 'don’t know')	Future interventions should consider the use of the Behaviour Change Taxonomy to identify appropriate interventions that support behavioural practices around habit formation, e.g., supporting consumers to adopt new positive habits on meat thermometer usage.
Most participants in the focus group who used a meat thermometer did so for large groups and for those outside their immediate family (and rarely for themselves). The stated reason for this was frequently a sense of social responsibility (to prevent food poisoning).	Future communications could emphasise social responsibility as a motivator to encourage meat thermometer usage.
One of the most common reasons for purchasing a meat thermometer in the consumer study was to provide safety and certainty during food preparation.	Campaign interventions may resonate with consumers if they emphasise that meat thermometers will promote confidence and certainty during the provision of safe food to family and friends.

The focus group work highlighted a widespread confusion over the temperature meat should be cooked to. A slight majority stated they did not know the correct temperature, while most of those who volunteered a response-overestimated temperature.	Campaign communications should emphasise the correct end-point temperature. Campaigns could imitate those in the USA, which simplified communications by creating a single, standard temperature (160°F). A campaign could be developed in partnership with Home Economics teachers in schools. This could involve the distribution of a free meat thermometer to each Home Economics kitchen. This would accompany a campaign educating students on the correct procedure, along with the correct core temperatures, which would be key take-home messages.
Participants in the consumer study also had a poor understanding of the safe core end-point temperature of meat.	Future interventions should state a single correct temperature to which meat should be cooked to (as is ***safe*food**'s existing approach) in order to simplify communications.
Few participants in the consumer survey, including current meat thermometer users, could identify the correct insertion method of meat thermometers.	Future interventions should communicate the correct insertion method of a meat thermometer.
Several participants stated that they would like to receive future communications from butchers or those who work at meat counters in supermarkets.	Information on meat thermometers could be presented in butchers' shops, at meat counters and in meat aisles. Butchers and meat counter workers could be encouraged to recommend the use of a meat thermometer.
Results from the focus groups and survey identified that a common source of information on how to cook meat came from recipes and recipe leaflets distributed by supermarkets. Participants in the consumer survey revealed they were more likely to state that they used recipe leaflets than informational leaflets as a source of information on preparing meat.	Campaign communications could employ recipe leaflets, in which the leaflets recommend meat thermometer use and highlight how their use would improve the taste. If interventions employ printed materials, an effective form of communication may be to integrate meat thermometer use into recipe leaflets. This same method has been applied in the USA to promote meat thermometer use

A common theme in focus groups was the importance of meat packaging as a source of preparation information, and as a preferred method of safe meat preparation.	Producers of meat products could be encouraged to include instructions on how to use a meat thermometer on their packaging, including recommended end-point temperature.
The consumer survey also revealed that instructions on meat packaging were a commonly reported source of information on how to cook meat safely, although significantly more so in NI than the RoI.	Interventions (especially in NI) could attempt to encourage meat producers to print recommendations to use a meat thermometer (and how to do so properly) on packaging.
The consumer study identified friends and family as two of the most commonly reported sources of information of how to cook meat safely. These sources were significantly more popular in the Republic of Ireland than Northern Ireland. Further, those in the "pre-contemplation" stage of change are significantly more likely to use family as a source of information than those in the "maintenance" stage.	Interventions (especially in RoI) should attempt to employ peer-to-peer networks to promote meat thermometer use, such as encouraging individuals to tell their friends and family about the necessity of a meat thermometer.
During the focus groups, participants felt that meat thermometer use was typical of low-skilled cooks, yet also typical of high-skilled cooks (especially professional chefs). Neither of these groups were considered relatable, with the latter being viewed as inaccessible. Likewise, TV/celebrity chefs were seen as unrelatable in terms of cooking practices.	Campaigns should avoid employing “spokesperson/s” perceived as unrelatable, even if they are a high-prestige cook, such as a celebrity chef.
The “perceived behavioural control” (essentially ease of use) component of the Theory of Planned Behaviour significantly influenced use of meat thermometers on whole chicken.	Any interventions that aim to specifically encourage meat thermometer use on whole chicken should communicate that meat thermometers are easy to use.
Many participants in the focus groups overestimated the cost of a meat thermometer.	Campaigns should communicate the affordability of meat thermometers.

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Publications

At the time of writing, the Principle Contractor has produced one academic publication from this project. This have been submitted to Food *Quality and Preference* for peer review.

11 Appendices

Appendix 1 Discussion guide for focus group (page 12)

1. When cooking meat at home do you normally check that it is fully cooked?
2. Where did you get this information?
3. Do you use a meat thermometer:
    a. when cooking whole poultry? (chicken/turkey – if responses differ on poultry type, follow up);
    b. when cooking roasts? (pork/beef/lamb etc. – if responses differ on roast type, follow up);
    c. when cooking chicken pieces? (chicken thighs, chicken drumsticks, chicken wings);
    d. when cooking burgers and sausages (if responses differ, follow up).
4. Investigate if meat thermometer usage is seasonal – e.g., Do you use meat thermometers at certain times of the year only? Why?
5. Do you have a meat thermometer as an accessory in your oven?
6. PRACTICAL TASK: participants were asked to identify the correct insertion method for a meat thermometer into four different meat types: a whole chicken, a burger, a roast, and a chicken thigh. They were also asked what temperature they believed meat should be cooked to, in order to ensure that it was safe to eat. (See Appendix 3)
7. Do you know anyone who uses a meat thermometer at home?
8. Why do people use meat thermometers?
9. Why do people not use meat thermometers?
10. For those who have a meat thermometer but don't use it – why?
11. For those who do use a meat thermometer – why?
12. What would make it easier for you to use a meat thermometer? What would prevent you from using one?

13. Where would you like to get information in the future on cooking meat safely?

14. Have you ever seen a meat thermometer for sale in a shop?

Appendix 2

Table 9: Motivators and barriers to meat thermometer use (page 34)

Source	Reported barrier	Reported motivator	Sample (and sampling method)	Methodology
Koeppl, 1998				Six focus groups
Clayton, Griffith, and Price, 2003	There exist social norms which discourage thermometer use	-	40 (convenience sample)	Telephone interviews
Mathiasen et al, 2004	Role models (i.e., celebrity chefs) do not use thermometers	-	60 hours of TV cooking show content (recorded 2002-2003)	Content analysis of cooking shows
Schedule, 2004	Thermometers are too expensive for low-income individuals to access	-	249 (convenience sample – expert review)	Surveys
Takeuchi et al, 2005	Thermometers felt to be inconvenient to use	If thermometers could guarantee food safety, and if they could be	Sample size and recruitment method not specified	Focus groups

Takeuchi et al, 2006	Thermometers felt to be inconvenient to use	-	552 (convenience sample)	Survey
McCurdy, 2006	-	Avoidance of foodborne pathogens	35-41 (exact number not specified – convenience sample)	Four focus groups
Porticella et al, 2008	Thermometers are seen as too expensive to access	-	45 (recruitment method not specified)	Four focus groups
Shapiro et al, 2011	Thermometers felt to be inconvenient to use There is no social norm encouraging thermometer use	-	544 (convenience sampling, recruited at three shopping malls and an airport)	Survey
Young and Waddell, 2016	There is no social norm encouraging thermometer use	-	39 relevant articles	Systematic review of available qualitative research
Murray et al, 2017	There is no social norm encouraging thermometer use	-	2,474 (stratified sampling)	Survey
Kosa et al, 2017	Use of alternative methods Chicken parts felt to be too small to use a thermometer on	-	4,531 (stratified sampling)	Survey
Singh, Walia, and Farber, 2019	Cookbooks do not recommend thermometer use – this is a barrier to thermometers becoming a social norm	-	The 30 bestselling cookbooks in Canada, 2015-2017	Study was a review of Canadian cookbooks

Appendix 3

Table 10: Summary of previously employed campaign interventions (page 37)

Intervention	Description	Behavioural theory employed	Year of introduction	Evaluation	Target audience
Fight BAC and Thermy					All USA consumers – though children were specially targeted as a means to relate messages to parents
Is It Done Yet?		Transtheoretical Model	2005 (piloted in 2004)		

				(Lando and Chen, 2012; see also Table 3)	
USDA public service announcement video The importance of cooking to a safe internal temperature and how to use a food thermometer"	TV and YouTube video Advised against relying on changes in colour or juices running clear as a measure of doneness	Not specified	Released in 2015	Video found to increase thermometer use immediately after viewing, in a test kitchen (Cates et al, 2009)	Not specified – assumed to be all USA consumers

Table 11: Differences between meat thermometer 'users' and 'non-users' in their ability to correctly identify the correct technique for using a meat thermometer (page 72).

Meat type	Users / Non users	Accuracy (% correct) [a]
Chicken thigh		27.9%
	Non-users	34.7%
Roasts	Users	56.8%
	Non-users	46.5%
Whole chicken	Users	30.4%
	Non-users	22%
Whole chicken	Users	28.3%
	Non-users	22%
Burgers	Users	29.6%
	Non-users	13.1%

[a] *Users defined as those who report using a meat thermometer "always" or "often"*

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