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Abstract

Purpose – The International Scientific Forum on Home Hygiene's (IFH) approach to infectious disease prevention is "targeted hygiene", which means identifying the routes of transmission of infection in the home and community, and targeting hygiene measures at "critical points" (CPs) to break the chain of transmission. This paper aims to identify and prioritise CPs in the home kitchen environment during food preparation in order to inform food safety campaigns.

Design/methodology/approach – This study involved: filming participants ($n = 60$) while they prepared a meal according to a specified recipe (30 beef/salad burgers and 30 chicken salads); swabbing key potential contamination sites in the participant's kitchen for microbiological testing; sampling the meat and salad components of the cooked meal for microbiological testing; visual inspection and temperature check of the meat after cooking; and administering a survey of knowledge, attitudes and demographic factors.

Findings – This study has identified the critical points (CPs) during domestic food preparation as: CP1: correct cooking practices; CP2: prevention of cross-contamination; and CP3: correct food storage practices. Statistically significant links were found between food safety knowledge and behaviour as well as between food safety attitudes and demographic factors.

Originality/value – This is the first study to link all aspects of observed consumer food safety practices in the home to food safety knowledge, attitudes, perceptions, psychosocial and demographic factors to identify these CPs.

Keywords Diseases, Food products, Contamination, Food safety, Microbiology, Ireland

Paper type Research paper

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1. Introduction

The home is the final control location of food safety hazards. All food business operators are required by law to take responsibility for the safety of the food that they handle (Regulation EC, 178/2002) and use some form of a Hazard Analysis Critical Control Point (HACCP) system, however, HACCP is not appropriate for the home and consumers may handle food as they see fit. In 2007, 22 European Member States and two other European countries submitted information on food-borne outbreaks to the European Food Safety Authority (EFSA). The most common setting of exposure for verified outbreaks was the private household (37.0 per cent) (EFSA, 2009). However, many consumers do not accept the role of the home in food borne infections (Eurobarometer, 2006; Beumer and Kusumaningrum, 2003). Such failure to accept personal responsibility for food safety, a prerequisite for implementation of appropriate food safety behaviours (Unklesbay *et al.*, 1998) means that they neglect the relatively simple but necessary precautions, to reduce microbiological risks (Redmond and Griffith, 2003a; Hoorens and Harris, 1998).

The International Scientific Forum on Home Hygiene's (IFH) approach to intestinal disease prevention is "targeted hygiene", which means identifying the routes of transmission of infection in the home and community, and targeting hygiene measures at "critical points" (CPs) to break the chain of transmission (IFH, 2009). This paper aims to identify and prioritise CPs in the home kitchen environment during food preparation in order to inform food safety campaigns.

It has previously been reported that due to the likelihood of managed responding when questioned about personal food safety practices it is important to carry out observational studies in the domestic environment (Fischer *et al.*, 2006; Redmond and Griffith, 2003b). It is also valuable to use a transdisciplinary team that includes social and natural sciences when researching consumer food safety practices (Nauta *et al.*, 2008; Fischer *et al.*, 2007). This study includes observations during home food preparation and it involves expertise from the fields of food safety, consumer science, microbiology, communications, psychology, sociology and medicine.

2. Methods

A total of 60 participants were recruited by Amarach (Ballsbridge, Dublin, Ireland), a marketing research agency. A quota control was used so that the participants chosen were representative of main food shoppers in terms of age and gender[1]. The recruited participants were then contacted by post and given instructions regarding the ingredients to purchase for either beef burgers (lean steak mince, iceberg lettuce, tomato, garlic, onion, eggs, flour, burger bun, ground black pepper, salt and olive oil or warm chicken salad (garlic, onions, iceberg lettuce, chicken breast fillets, lemon juice, ground black pepper, salt and olive oil). The participants were later contacted by telephone and arrangements were made for the researcher to visit at a day and time that suited the participant. The participants were reimbursed for the expenses involved in taking part in the study.

The meal preparation and cooking was recorded by a webcam. A researcher observed the preparation and cooking and used a checklist to score hygienic performance. The checklist was later verified by two independent researchers, who watched the webcams. Before and after food preparation and cooking, microbiological swabs were taken (as described by Kennedy *et al.*, 2011) from four kitchen areas (sink drainers, taps, work tops, refrigerator handles) and two kitchen utensils (knife blades, chopping boards). After the food preparation, swabs were taken from participants' hands and samples (25 g) were taken of cooked beef burgers, cooked poultry, and accompanying salad vegetables from each dish. Analysis included tests for the presence of total viable counts (TVCs), total coliform counts (TCCs), *C. jejuni, E. coli, S. aureus*.

Swabs and samples were stored below 5°C in plug-in cool boxes, transported to the laboratory, stomached and enriched in Preston Selective Enrichment Broth (SEB) (Oxoid, Basingstoke, UK) and Buffered Peptone Water (BPW) (Oxoid). Then 1 ml aliquots from the stomached swabs was serial diluted to 10^{-2} dilution were spread plated (100 μl) onto Baird Parker medium (Baird Parker agar base with egg yolk tellurite emulsion, Oxoid), Chromocult coliform agar (Chromocult, Merck, UK) and plate count agar (tryptone glucose yeast agar, Oxoid) in duplicate. All plates incubated at 37°C for 24 to 48 h. Selective enrichment broths were incubated at 37°C for 24 h. Aliquots (100 μl) of SEB were spread plated onto either Preston agar or Chromocult agar in duplicate. Preston agar plates were incubated microaerophilically at 37°C for 48 h, Chromocult plates were incubated for 24 h at 37°C. To confirm, *S. aureus* were confirmed by indentifying typical colony morphology, namely 2 mm black shiny colony with zone of clearing. Two presumptive colonies per sample were sub-cultured onto nutrient agar (Oxoid) for 24 h at 37°C and confirmed as positive using Staphyloslide latex. All typical growth on Preston agar plates was Gram stained, and tested for presence of *Campylobacter* spp using *Campylobacter* latex kit (Oxoid). The TCC was made by enumerating all colonies on Chromocult that showed typical colouration (pink/salmon/blue). *E. coli* was identified by typical colony colouration on Chromocult (blue). Presumptive colonies were confirmed as *E. coli* by API 20E.

All batches of media passed quality control. Preston SEB, Preston Agar: using wild type *Campylobacter* (CK4, University College Dublin, Ireland), Chromocult, BPW: using *E. coli* NCTC 1093, BP: using *S. aureus* NCTC 8325. The quality control of isolation procedure: *Campylobacter* (CK4, 10^8 CFU approx.); *E. coli* (NCTC 1093, approx 10^5 CFU) applied to environmental sampling swabs, retained at 4°C for 6 h, then processed as above. *Campylobacter* and *E. coli* were both detected on selective agar plates following selective enrichment.

A self-reported questionnaire was designed containing questions on level of conscious effort to ensure safe food, importance of correct food handling and preparation practices, perceived risk of food poisoning based on situational vignettes, food safety practices, food safety knowledge, and past-experience of food borne illness as well as socio-demographic information. After preparation and cooking of the food, the participants were given the questionnaire and asked to complete it while the researcher collected swabs from the various sites in the kitchen as well as food and hands.

2.1 Data analysis

Total scale scores for contamination were calculated based on the presence or absence of three bacteria *S. aureus*, E. *coli* and *C. jejuni* before and after cooking in 17 tests (four surfaces (before and after), two utensils (before and after), four food samples (meat, poultry, salad vegetables from each meal) and hands after food preparation. Scores could range from 0-51 (51 would be achieved if the three potential pathogens were found in all tests). Separate total scores for contamination of kitchen sites and cooking utensils before and after food preparation and cooking were also calculated based on the presence/absence of bacteria. Potential scores could range from 0-18; 0-6 indicating low levels of contamination, 7-12 indicating mid-levels of contamination and 13-18 indicating high levels of contamination.

Total scale scores for hand cleanliness were calculated based on the observations checklist, incidence of washing hands before, during and after food preparation as well as incidences of hand usage with raw meat/poultry and subsequent cross-contamination. A total of 14 items were included in the construction of this scale and scores ranged from 0-14; 0 indicating a poor level of hand cleanliness and 14 indicating a high level of hand cleanliness.

Total scores for observed safe food practices were calculated based on observations before, during and after food preparation. The observation checklist included cleaning of hands, utensils, raw salad ingredients, as well as cross-contamination, and the employment of the correct methods to ensure that meat was cooked thoroughly. Potential scores could range from 0-21; 0 indicating a poor level of observed food safety and 21 indicating a high level of observed food safety.

Participants were asked about the level of importance that they attribute to range food safety practices. This was measured by their responses to nine safe food practices (Table I). For the purpose of analysis a 36-point scale "importance of correct food safety practices" was developed using these nine items (Cronbach's $\alpha = 0.80$). Low scores indicated a high level of perceived importance of correct food safety practices in the prevention of food poisoning.

Participants' perceived risk of contracting food poisoning was measured by their response to nine situational vignettes (see Table II). For the purpose of analysis a 36-point "Risk" scale (ranging from 9 to 45) was constructed (Cronbach's $\alpha = 0.85$) using these nine items.

Recent unsafe food behaviour last month was measured by the frequency with which participants reportedly engaged in nine unsafe food practices in the previous month (Table III). For the purpose of analysis a 36-point scale (ranging from 9 to 45) (Cronbach$\alpha = 0.84$) was constructed using these nine items, 9 indicating that participants reported engaging in all unsafe food practices "All the time" and 45 indicating that participants reported engaging in all unsafe food practices "None of the time".

Perceived importance of correct food-handling behaviours in the prevention of food-borne illness	Mean score	SD	*n*
Correctly checking that beef burgers and poultry are sufficiently cooked	1.02	0.13	57
Washing your hands before preparing food	1.03	0.18	60
Storing leftover meat/poultry correctly	1.16	0.37	57
Making sure that bacteria are not spread from uncooked/raw food to kitchen surfaces and utensils	1.16	0.45	57
Making sure your refrigerator is operating at the correct temperature	1.21	0.58	58
Making sure that the restaurant in which you are going to eat looks clean	1.22	0.45	60
Storing raw meat on the correct shelf in the refrigerator	1.23	0.72	60
Transporting chilled/frozen food home from the supermarket	1.24	0.57	59
Using food by its use-by date	1.26	0.58	58
Overall	10.4	2.8	

Note: 1 = Very useful; 4 = Not useful at all

Table I. Participants' ranking of the perceived importance of various food safety behaviours in the prevention of food-borne illness

Table II. Participants' ranking of the perceived risk of contracting food poisoning from various scenarios

Perceived risk of contracting food poisoning	Mean score	SD	*n*
Susan does not have a thermometer, so she is never sure at what temperature the refrigerator is operating	3.1	1.3	59
When Mark goes shopping it usually takes him more than 90 minutes to get the food from the supermarket to home storage	3.31	1.2	59
Kate buys discounted food which is on its use-by date, stores it in the refrigerator and eats it within two days	3.41	1.4	56
Susan ate in a restaurant that she later heard had received an 'improvement notice' a week previously	3.54	1.2	59
Sam keeps raw meat anywhere where there is space in the refrigerator	3.71	1.3	59
Lucy checks that her beef burgers and poultry are sufficiently cooked by making sure they have a crisp, brown outer coating	3.88	1.1	57
When Julie is barbequing she uses tongs to lift the raw meat and vegetables on to the grill. When the food is fully cooked, she uses the same plate and tongs to bring them to the patio table, where they are eaten within three hours	3.93	1.4	59
Jim prepares food, which is not going to be cooked, on a chopping board and prepares raw meat on the same chopping board	3.97	1.4	58
Mike is a farmer. When he comes home from work and prepares sandwiches, he often forgets to wash his hands first	4.2	1.3	59
Overall	37.6	6.2	

Note: 1 = Not at all likely; 5 = Very likely

Table III. Participants' ranking of frequency with which they engaged in unsafe food behaviour in the last month

Engagement in unsafe food behaviours in the last month	Mean score	SD	*n*
Eaten fruit and/or salad vegetables without washing them first	3.5	1.2	60
Stored meat on any refrigerator shelf other than the bottom shelf	3.7	1.3	57
Taken more than an hour to get perishable goods from the supermarket to the refrigerator/freezer	4.0	0.9	60
Prepared food without washing your hands first	4.09	1.1	58
Eaten food after its use-by date	4.11	1.2	56
Chopped raw meat and ready-to-eat foods using the same knife or chopping board (without washing them between uses)	4.23	1.1	60
Tasted food to see whether or not it had gone off	4.25	1.2	57
Defrosted raw meat in a basin or sink of hot/warm water	4.6	0.9	60
Eaten a take-away that has been left out of the refrigerator overnight	4.8	0.7	60
Overall	37.7	6.2	

Participants' knowledge relating to nine food safety issues was measured, the results of which were used to calculate total scores for food safety knowledge on a scale of 1 to 10; 1 indicating a poor level food safety knowledge and 10 indicating a good level of food safety knowledge (see Table IV).

Each survey item was subjected to descriptive analysis. Pearson product-moment correlation coefficient was utilised to identify any correlations. Independent samples *t*-tests were utilised to identify differences between safe food behaviour last month and gender, experience of food poisoning and experience of illness from contaminated

Knowledge question:	Responses (%)
Most common cause of food poisoning:	
Listeria	1.8
Salmonella	69.1
E. coli	25.5
Campylobacter	3.6
Cryptosporidium	0
Food most commonly linked with Salmonella:	
Chicken	54.2
Eggs	41.7
Pork	0
Beef	2.1
Salads	0
Dairy products	2.1
Most likely site for the contraction of food poisoning:	
At home	24.1
"Fast food" outlet	25.9
At work/college canteen	0
At a restaurant	11.1
All equally likely	38.9
Food most commonly linked with E. coli:	
Chicken	30.8
Eggs	9.6
Pork	7.7
Beef	19.2
Salads	7.7
Dairy products	25
The temperature "danger zone" within which food bacteria multiply:	
5-63°C	37.3
25-40°C	17.6
0-100°C	11.8
0-5°C	19.6
63-100°C	13.7
The food preparation/storage practice most likely to result in food poisoning:	
Keeping raw meats beside one another in the refrigerator	10.7
Keeping cooked meat beside raw vegetables in the refrigerator	7.1
Using the same chopping board for raw meat and salad	50
Keeping cooked meat beside cooked vegetables on the counter	3.6
Using the same chopping board for different types of raw meat	28.6
Food which caused the most food poisoning on the IoI in the last year:	
Poultry	73.2
Bean sprouts	0
Chocolate	0
Spinach	0
Milk	1.8
Beef burgers	25

Table IV. Food safety knowledge – questions and responses water. A paired samples t-test was utilised to identify the magnitude of the difference in contamination levels before and after cooking. A standard multiple regression using the enter method was performed in order to determine whether safe food behaviour (as measured by the dependent variable "Observations Score") was predicted by food safety knowledge and reported safe food behaviour. A standard multiple regression using the enter method was also performed in order to determine whether higher counts of coliforms in samples of cooked beef were predicted by the use of hands contaminated with raw beef on taps.

3. Results

3.1 Profile (sex, age and formal education) of the respondents

Of the 60 participants included in the study, 50 were female and ten were male. The location of participants was divided equally between Northern Ireland and the Republic of Ireland. Participants' ages varied between 18 to 67 with 11.1 per cent aged between 18 and 24, 22.2 per cent aged between 25 and 34 years, 33.3 per cent aged between 45 and 64 years, and 11.1 per cent aged between 65 and 67 years. The level of education completed by participants varied considerably within the sample. Those who had fully completed secondary level education (equivalent to 13 years of formal education) contributed most to the sample (30.5 per cent). The second largest contributing group was those who had completed some secondary level education (27.1 per cent), followed by those who had only completed primary level education (equivalent to eight years of formal education) (11.9 per cent). Only a small proportion of participants (8.5 per cent) completed a diploma, professional qualification (6.8 per cent) or a degree (6.8 per cent).

3.2 Microbiological status of key contamination sites in the kitchen

The incidence and prevalence of each of the potential pathogens as well as TVCs and TCCs before and after food preparation on kitchen surfaces (Table V) and utensils (Table VI) show that *C. jejuni* was not detected at all and *S. aureus* was more likely to be found and more prevalent than *E. coli*. Similarly, the potential pathogens as well as TVCs and TCCs after food preparation on hands and in food samples, displayed in Table VII show that *S. aureus* was more likely to be found and more prevalent than *E. coli,* particularly on hands.

Higher counts of *S. aureus* present in chicken samples were found to be moderately correlated with failure to achieve the optimum internal cook temperature of 74°C (when tested by the researcher), $r = 0.373$, $n = 30$, $p = 0.043$. Separate scores for contamination before and after food preparation and cooking indicated (on a scale of 0-18) a mean score of 6.13 $\pm$ 2.52 and 7.20 $\pm$ 2.21 respectively. A statistically significant increase in scores for contamination before food preparation (M = 6.13, SD = 2.52) and after food preparation ($\mathrm{M} = 7.20, \mathrm{SD} = 2.21$, $t(37) = -3.340$, $p = 0.002$) was observed with a large effect size (eta squared = 0.23).

3.3 Observations checklist

3.3.1 Hand cleanliness and cross-contamination. A total of 70 per cent of participants did not thoroughly wash their hands after handling the raw chicken when preparing the warm chicken salad. A total of 60 per cent of participants used their hands to transfer the raw chicken to the frying pan; 91.7 per cent of whom failed to thoroughly

Table V.
The incidence (%) (and prevalence cfu/ml) of each of the potential pathogens as well as TVCs and TCCs before and after food preparation on kitchen surfaces

	Sink drainer				Taps				Worktop				Refrigerator handle			
	Before		After		Before		After		Before		After		Before		After	
	%	cfu/ml	%	cfu/ml	%	cfu/ml	%	cfu/ml	%	cfu/ml	%	cfu/ml	%	cfu/ml	%	cfu/ml
S. aureus	46.7	1.7	63.3	2.2	36.7	1.2	53.3	1.7	45.0	1.2	56.7	2.0	30.0	0.9	30.0	0.8
E. coli	10.0	0.3	10.0	0.3	3.3	0.1	6.7	0.2	3.3	0.1	5	0.1	n/d		n/d	
C. jejuni	n/d		n/d		n/d		n/d		n/d		n/d		n/d		n/d	
TCC	81.0	72.4	83.3	2.9	66.7	1.8	66.7	2.6	69.4	1.2	75	1.8	38.3	0.2	0.31	0.5
TVC	3.14		3.68		2.26		3.09		1.96		2.13		0.96		1.49	

wash their hands (as per recommendations by safefood (n.d. a)) after handling the raw chicken. Hands which were contaminated from raw chicken were seen to make contact with various sites in the kitchen as well as with kitchen utensils. Hand contaminated with raw chicken were used on taps (75.6 per cent of cases), made contact with other food packaging such as olive oil (23.3 per cent of cases), and made contact with other equipment such as the frying pan handle (70 per cent of cases).

A total of 70 per cent of participants handled the raw beef when removing it from the packaging; only approximately one-fifth (21.7 per cent) of participants washed their hands thoroughly after handling the raw beef. All participants (100 per cent) handled the raw beef when forming the beef burger patties; 80 per cent of who did not thoroughly washed their hands after handling the raw mince. A total of 89.7 per cent of participants handled the raw beef when transferring the beef burger patties to the frying pan; 80 per cent of whom did not wash their hands after handling the raw beef. Hands that were contaminated from raw beef were seen to make contact with various sites in the kitchen as well as with kitchen utensils. Hands contaminated with raw beef were used on taps (96.3 per cent of cases), placed in flour (37 per cent of cases), made contact with other food packaging such as olive oil (48 per cent of cases) and made contact with other equipment such as the frying pan handle (53.8 per cent of cases).

3.3.1.1 Hand cleanliness – correlations with food safety knowledge and cross-contamination to food. On a scale of 0-14 the mean score for hand cleanliness among participants was 3.6 ± 2.16 indicating a relatively low level of hand cleanliness before, during and after food preparation. Hand cleanliness scores were seen to be significantly correlated with scores for food safety knowledge, $r = 0.360$, $n = 60$, $p = 0.005$, whereby high levels of hand cleanliness were correlated with high scores for food safety knowledge among participants.

Table VI.
The incidence (%) (and prevalence cfu/ml) of each of the potential pathogens as well as TVCs and TCCs before and after food preparation on kitchen utensils

	Chopping board				Knife blade			
	Before		After		Before		After	
	%	cfu/ml	%	cfu/ml	%	cfu/ml	%	cfu/ml
S. aureus	43.3	1.1	65	2.0	36.7	2.0	26.7	0.8
E. coli	n/d		6.7	0.3	1.7	0.1	1.7	0.1
C. jejuni	n/d		n/d		n/d		n/d	
TCC	51.7	1.1	68.3	1.8	46.2	0.5	50	0.8
TVC	1.22		2.03		0.88		1.03	

Table VII.
The incidence (%) (and prevalence cfu/g) of potential pathogens, TVCs and TCCs on hands and food samples after food preparation

	Hands		Beef burger		Burger vegetable		Chicken		Chicken salad	
	After		After		After		After		After	
	%	cfu/g	%	cfu/g	%	cfu/g	%	cfu/g	%	cfu/g
S. aureus	78.3	2.97	26.7	0.88	40	1.8	66.7	0.85	36.7	1.84
E. coli	3.3	0.1	0.00		0.00		0.00		0.00	
C. jejuni	n/d		n/d		n/d		n/d		n/d	
TCC	53.3	0.85	66.7	0.8	46.7	1.3	60	1.0	70	1.73
TVC	2.23		0.70		2.82		1.61		2.03	

Higher counts for coliforms present in samples of cooked beef were highly correlated with the using hands contaminated with raw beef on taps during food preparation ($r = 0.711$, $n = 24$, $p < 0.000$). After controlling for; the prevalence of coliforms on all kitchen surfaces before food preparation, and for the prevalence of coliforms on taps before food preparation, this correlation was seen to increase (0.721** and 0.984** respectively). Higher counts for coliforms were also not associated with counts for hands and beef salad samples after food preparation. A standard multiple regression using the enter method was performed in order to determine whether higher counts of coliforms in samples of cooked beef were predicted by the use of hands contaminated with raw beef on taps. The model was significant (($F1, 22 = 22.51$, $p = 0.000$) and showed a good fit, with an Adjusted R-squared value of 0.483 (with 48.3 per cent of the variance explained).

3.3.2 Observations during warm chicken salad preparation. During chicken preparation, a total of 71.7 per cent of participants failed to thoroughly wash the knife that they used in preparing raw chicken before its reuse on raw salad vegetables. A total of two-thirds (66.7 per cent) of participants did not wash the chopping board after use with raw chicken and 26.7 per cent of participants prepared vegetables for the chicken salad on the board that was contaminated from raw chicken. In 4.3 per cent of the cases where chicken was prepared, cooking utensils became re-contaminated through contact with contaminated items or materials such as the mixing bowl, the chopping board or the raw meat packaging. It was observed that all participants (100 per cent) touched their hair during the food preparation and cooking process.

The temperature 68.9 per cent of the cooked chicken samples had not achieved the optimum cook temperature (74 °C) (Home Economics Support Services, 2003) and the average temperature when inspected was 63.25 ± 11.21 °C. However, the time taken to get the food from the cooking stage to the temperature recording stage was not recorded.

In order to determine that the chicken was cooked thoroughly, 38.9 per cent of participants were observed cutting the chicken and examining the internal colour of the chicken. A further 5.5 per cent of participants were observed touching the chicken to check that it was cooked thoroughly.

3.3.3 Observations during beef burger preparation. During beef burger preparation, 66.7 per cent failed to thoroughly wash the knife that they had used to prepare raw beef prior to its reuse in preparing the burger salad of raw vegetables. Similarly, two-thirds of the participants (66.7 per cent) did not thoroughly clean the chopping board after use with raw beef before preparing the burger salad and in 20 per cent of the cases; the raw vegetables for the salad were prepared on the chopping board that was contaminated by raw beef. In 9.5 per cent of the cases where beef was prepared, cooking utensils were re-contaminated through contact with contaminated items or materials such as the mixing bowl, the chopping board or the raw meat packaging.

The temperature for the beef burgers was also taken to determine if the minimum cook temperature (74 °C) for the meat had been achieved. The required temperature (Home Economics Support Services, 2003) was not reached in just 7.8 per cent of the cases and the average temperature was 81.36 ± 8.42 °C. However, the time taken to get the food from the cooking stage to the temperature recording stage was not recorded.

In order to determine that the beef burgers were cooked thoroughly, half of the participants (50 per cent) cut the beef burgers with a knife and examined the internal colour of the burgers. A further 5 per cent of participants touched the burgers to check that they were cooked thoroughly.

3.4 Questionnaire

3.4.1 General food-related lifestyle. Most participants (77.2 per cent) reported "always" doing their own shopping and nearly all participants (91.2 per cent) reported either "always" or "quite often" doing their own cooking. In relation to cooking skill level, the majority of participants reported their own cooking skill as either "good" or "very good" (71.2 per cent). This was followed by approximately a quarter of participants who reported their own cooking skill as "neither good nor bad" (26.5 per cent) and only 3.4 per cent of participants rated their own cooking skills as "poor". The majority (70.4 per cent) of participants reported spending between 31 and 60 minutes preparing their main meal each day.

The majority of participants (69.6 per cent) did not follow any specific diet. Of the remaining participants who did reported following a specific diet, the majority, (17.9 per cent) reported following a weight reducing diet, followed by those who reported following a low cholesterol diet (7.1 per cent).

3.4.2 Past experience of food- and water-borne illness. Over one quarter (27.1 per cent) of participants reported having experienced food poisoning and almost all participants (96.6 per cent) reported never having been ill from drinking contaminated water. Of those who had experienced food poisoning, the most commonly perceived source was restaurants (50.0 per cent). No participant reported their home as the source of their food poisoning. The largest proportion of participants (68.8 per cent) reported having experienced food poisoning within the last five years; 12.5 per cent reported having experienced food poisoning in the last six months, 6.3 per cent reported having experienced food poisoning in the last year and a further 12.5 per cent of participants had experienced food poisoning within the last two years. As a result of their last case of food poisoning experienced, 57.1 per cent of participants reported taking days off from work or college. Of those who reported taking time off work or college, 31.3 per cent reported visiting a doctor. Additionally, of those who took days off from work or college due to their last case of food poisoning experienced, 62.5 per cent reported taking between two and three days off, 12.5 per cent reported taking off four days, 12.5 per cent reported taking one week and 12.5 per cent of participants reported taking off two weeks or more. In relation, the medication taken to ease the symptoms associated with their last case of food poisoning, 44.4 per cent of participants reported taking over-the-counter medicine, 44.4 per cent of participants reported taking prescription medication and 11.1 per cent of participants reported treating their symptoms by drinking water only. The majority of participants (36 per cent) reported perceiving that it takes between one to six hours of eating contaminated food for symptoms to present. One-fifth (20 per cent) reported perceiving that it takes between seven and 12 hours and a further 26 per cent reported perceiving that it takes between 13 and 24 hours.

3.4.3 Making a conscious effort to ensure that food is safe. Participants were asked to report the frequency with which they make a conscious effort to ensure that the food they eat is safe on a five-point Likert scale, from "most of the time" to "none of the time". The mean response was 1.15 ± 0.44 indicating that overall, participants make a conscious effort to ensure that the food they eat is safe most of the time. A moderate correlation was observed between the frequency with which a conscious effort to ensure the food that is eaten is safe and food safety knowledge, $r = -0.340$, $n = 60$, $p = 0.008$, whereby a higher frequency of effort is associated with higher levels of food safety knowledge. Similarly, there was a moderate, significant relationship between the frequency with which a participant makes a conscious effort to ensure that the food they are eating is safe and experience of food poisoning, $r = -0.306$, $n = 60$, $p = 0.019$, whereby a higher frequency with which a conscious effort is made is associated with those who have suffered from food poisoning in the past. Finally, a small, significant relationship was observed between the frequency with which participants make a conscious effort to ensure that the food they eat is safe and scores for contamination after cooking, $r = 0.266$, $n = 60$, $p = 0.40$, whereby a higher frequency with which a conscious effort is made is associated with lower levels of kitchen utensil and food contamination post-cooking.

3.4.4 The perceived usefulness of correct food safety practices. In terms of the perceived importance of correct food safety practices, a high level of importance was attributed to each of the safe food behaviours in the prevention of food poisoning. The highest level of importance was attributed to "Checking that beef burgers and poultry are sufficiently cooked". Using food before its "use by" date was ranked the least useful. In relation to overall perceived importance of food safety in the prevention of food poisoning on a scale of 9 to 45 the mean score was 10.41 $\pm$ 2.85 indicating that overall, participants attributed a very high level of importance to safe food behaviour in the prevention of food poisoning (See Table I).

Using the overall mean score, a significant difference was observed between those who do not follow a specific diet ($M = 1, 1.35, SD = 3.256$) and those who do ($M = 9.41, SD = 0.8700$; $t(41.364) = 3.252$, $p = 0.002$). The magnitudes of the difference was large (eta squared = 0.117) with following a specific diet explaining 17.7 per cent of the difference in scores for the importance of correct food safety practices. The relationship between the perceived importance of food safety and gender was investigated using Pearson product-moment correlation coefficient. A strong, significant correlation was observed, $r = -0.505$, $n = 51, p = 0.000$, whereby a high perceived level of importance of food safety was seen to be associated with women. Similarly, a moderate, significant correlation was observed between the perceived level of importance of food safety in the prevention of food poisoning and following a specific diet. $r = -0.235$, $n = 51, p = 0.02$, whereby higher levels of perceived importance of food safety in the prevention of food poisoning were associated with following a specific diet.

3.4.5 Perceived risk of getting food-borne illness in the next 12 months. Participants were asked to indicate the risk that they will get food borne illness within the next 12 months on an eight-point Likert Scale (1 = "Definitely not", 8 = "Definitely will"). The mean response was 5.22 $\pm$ 1.61 and the model response was 5, indicating that overall, participants tended slightly towards perceiving that they would get food poisoning within the next 12 months. The extent of worry experienced by participants over the last month about the possibility of getting food poisoning was also measured. The majority of participants (65.5 per cent) indicated that they had "rarely" or "never" worried about getting food poisoning in the last month.

3.4.6 Perceived risk of contracting food poisoning from specific scenarios. The perceived risk of contracting food poisoning in nine situational vignettes was reported (see Table II). Based on these nine vignettes, the mean total score for perceived risk was 33.43 $\pm$ 7.78 indicating that overall, there is a high level of perceived risk of contracting food poisoning amongst participants in responses these everyday situations. The situation with the highest perceived risk of contracting food poisoning was "Mike is a farmer. When he comes home from work and prepares sandwiches he often forgets to wash his hands first". The relationship between perceived risk of contracting food poisoning in each of the nine situational vignettes and the level of importance of each of the nine safe food behaviours in the prevention of food poisoning using Pearson product-moment correlation coefficient. A moderate, significant correlation was observed between this vignette and the perceived level of importance of "transporting chilled/frozen food home from the supermarket", $r = -0.262$, $n = 59$, $p = 0.047$, whereby a high level of importance was associated with a perceived high risk. A moderate, significant correlation was observed between this vignette and the importance of "storing raw meat on the correct shelf in the refrigerator", $r = -0.285, n = 59$, $p = 0.029$, whereby a high level of importance was associated with a perceived high risk. A moderate, significant correlation was also observed between this vignette and the perceived level of importance of "correctly checking that beef burgers and poultry are sufficiently cooked", $r = -0.385, n = 56, p = 0.004$, whereby a high level of perceived risk was associated with a high perceived level of importance.

3.4.7 Unsafe food-handling behaviour. The overall mean score for participants reported engagement in unsafe food behaviour in the last month was 37.67 ± 6.21 indicating that participants reported that they engaged rarely engaging in unsafe food practices (see Table III). The most common unsafe food behaviour was "Eaten fruit and/or salad vegetables without washing them first" followed by "Stored meat on any refrigerator shelf".

There was a significant difference in scores between men ($M = 33.67 \pm 7.280$) and women ($M = 38.51 \pm 5.713$); $t(50) = -2.206$, $p = 0.032$). The magnitude of this difference was small (eta squared = 0.04). There was a significant difference in scores between those who have suffered from food poisoning ($M = 32.87, SD = 7.444$) and those who have not (39.62, $SD = 4.431$); $t(18.165) = -3.286$, $p = 0.004$). The magnitude of this difference was moderate (eta squared = 0.061). There was also a significant difference in scores for reported behaviour between those who have ever been ill from drinking contaminated water ($M = 35.0, SD = 0.000$) and those who have not ($M = 37.78, SD = 6.318$); $t(49) = -3.112, p = 0003$). The magnitude of this difference was moderate (eta squared = 0.058). There was a moderate, significant correlation observed between the importance of food safety and reported behaviour, $r = -0.351, n = 45$, $p = 0.018$, whereby a high level of importance of food safety was associated with low levels of engagement in unsafe food behaviour in the previous month.

3.4.8 Food safety knowledge. In relation to food safety knowledge, the most common cause of food poisoning, only 3.6 per cent of participants correctly identified *Campylobacter* as the most common cause of food poisoning. Over half of the participants (54.2 per cent) identified chicken as the food most commonly linked with *Salmonella*. Less than one-fifth (19.2 per cent) of participants identified beef as the food most commonly linked with *E. coli*. The majority (37.3 per cent) of participants identified the temperature zone of 5-63°C as the temperature "danger zone" within which pathogens can multiply. Half of the participants (50 per cent) correctly identified "Using the same chopping board for raw meat and salad" as the food preparation/storage practice most likely to result in food poisoning. Almost two-thirds of participants (73.2 per cent) reported that poultry causes the most food poisoning on the Island of Ireland (IoI) in the last year. This was followed by one quarter of participants (25 per cent) who reported beef burgers and 1.8 per cent of participants who reported milk (Table IV).

Participants were also asked to identify all the methods that they thought were necessary to check that a whole chicken and beef burgers are cooked thoroughly. The correct method involves three procedures: "If the juices run clear", "If it is piping hot all the way through" and if "there is no pink meat left" (safefood (n.d. b)). About three-quarters (76.3 per cent) of participants correctly identified all three methods for a whole chicken but only 6.6 per cent of participants identified all three procedures for beef burgers.

3.4.9. Linking observed food safety practices with food safety knowledge and reported behaviour. The mean score for food safety practices was 5.43 ± 2.53 and the maximum score recorded was 12 (out of a possible 21). Participants' food safety knowledge and observed safe food behaviour were positively correlated ($r = 0.430, n = 60, p = 0.001$). Similarly, there was a positive correlation between observed and reported food safety behaviour, $r = 0.357, n = 52, p = 0.009$.

A standard multiple regression using the enter method was performed to determine whether safe food practices (as measured by the dependent variable "Observations Score") was predicted by food safety knowledge and reported safe food behaviour. The models showed a good fit with an Adjusted R-squared value of 0.177 (with 17.7 per cent of the variance explained) and an overall significant model was observed (F2, 49 = $6.48, p = 0.003$). Both food safety knowledge and reported safe food behaviour were seen to make significant independent contributions to the model (Beta 0.299 and p.029 and Beta 0.271 and p.046 respectively) with food safety knowledge making the largest contribution.

4. Discussion

Results from this study show a key deficit in relation not only to food safety knowledge but in relation to safe food practices and importantly, that the two are statistically linked. This is contrary to some studies (Albrecht, 2007; Brennan *et al.*, 2007; Raab *et al.*, 1997; Worsfold and Griffith, 1997; Altekruse *et al.*, 1999) which have reported a disparity between food safety practices and knowledge but similar to others which have found a link (Kennedy, 2011; Kennedy, 2005; Dharod *et al.*, 2004).

Participants displayed low levels of food safety knowledge, particularly in relation to identifying the foods that are commonly associated with various bacteria, the most likely site to contract food poisoning, the temperature "danger zone" and the correct methods for checking that beef burgers and poultry are cooked thoroughly. Food safety knowledge was associated with food safety behaviours and hand cleanliness. Making a conscious effort to ensure that the food is safe was associated with food safety knowledge, lower levels of micro-organisms in the prepared food and no previous experience of food poisoning.

Scores for reported unsafe food behaviour and low scores for observed food safety were also correlated. In an application of the theory of planned behaviour to hygienic food handling behaviour, Mullen and Wong (2009) found that past behaviour/habit was a strong predictor of behaviour and, similarly to this study in relation to the importance of food safety, attitudes towards hygienic food preparation were seen to be positive, though not predictive of behaviour.

Those who reported making a conscious effort to ensure that the food they eat is safe, were more likely to have cooked and prepared microbiologically safer food and they were also more likely to have never suffered from food poisoning than those who reported not making a conscious effort. Reported "frequent" engagement in unsafe food practices was associated with men, those who have suffered from food poisoning in the past, those who have been ill from drinking contaminated water in the past and those who attributed lower levels of importance to safe food behaviour in the prevention of food poisoning.

Overall, a high level of importance was attributed to various food safety practices in the prevention of food poisoning by participants and the results show that higher levels of importance were associated with gender (female). Although a high level of perceived risk was reported in relation to situational vignettes, this perceived risk was often related to the importance of food safety practices but was not related to higher levels of observed food safety behaviour, nor was a high level of importance attributed to food safety in the prevention of food poisoning seen to be related to higher levels of observed safe food behaviour.

Nearly all participants reported always doing their own cooking and food shopping, meaning they play a key role in the control of domestic food hazards and the prevention of food borne illness. No participants reported that their home was the source of a food borne illness that they had experienced but almost a quarter reported that the 'home' is the most likely source of food borne illness. Most participants also perceived that their cooking skills were good and many participants reported rarely engaging in unsafe food practices last month. Redmond and Griffith (2004) have commented on the advent of optimistic bias and the illusion of control in relation to the perceived risk of contracting food poisoning insofar as these judgements are likely to contribute to the ongoing implementation of unsafe food-handling behaviours, which are associated with microbial risk during domestic food preparation. It has also been suggested that it is this low level of perceived personal risk associated with food produced in the home that constitutes an important barrier to consumers taking appropriate steps to reducing their own exposure to food-related hazards (Redmond and Griffith, 2004; Frewer *et al.*, 1995).

It was possible using the results of this study to identify the CPs. A hierarchy of CPs for the domestic kitchen environment was created by taking into account the stage in the domestic food preparation chain that the hazard was present and also the frequency of the unsafe practice (as determined by the observations checklist) and severity of the hazard (as determined by the microbiological results).

4.1 CP1: cooking

When asked, participants attributed the higher level of importance to "checking that beef burgers and poultry are sufficiently cooked" than any other food safety practice. Most participants also identified the correct methods of checking that beef burgers and poultry are sufficiently cooked. However, the majority of participants did not employ these methods and a large number of samples of both beef and chicken were not cooked thoroughly when visually inspected by the researchers.

Of concern, was the presence of bacteria in the food samples after food preparation and cooking. The presence of *S. aureus* was significantly linked to a failure to reach the optimum cook temperature of 74°C.

4.2 CP2: cross-contamination

There was a significant difference (with a large effect size) between the microbiological scores before and after food preparation and cooking. All bacteria were most commonly present in sink drainers followed by worktops, taps, and chopping boards prior to food preparation and cooking. Observational analysis revealed that it was these areas, which were subjected to the highest frequencies of contamination via direct contact with raw food and cross-contamination via participants' hands after handling raw meat. More importantly, analysis of observational and microbiological data identified the sites that were sources of cross contamination were specifically chopping boards, hands, knives and taps.

Hand cleanliness was observed to be poor despite a high level of perceived risk of contracting food poisoning associated with failure to wash hands prior to food preparation. A large number of other studies have also identified failure to wash hands thoroughly before, during, and after, food preparation and handling of raw meat/poultry (Byrd-Bredbenner *et al.*, 2007; Anderson *et al.*, 2004; Gorman *et al.*, 2002; Jay and Rivers, 1984; Worsfold and Griffith, 1997). It was found that poor hand cleanliness, like poor food safety, was associated with poor food safety knowledge. The importance of cross-contamination is highlighted by the fact that bacteria were more prevalent in the samples of salads than the samples of beef burgers/chicken.

4.3 CP3: food storage temperature

There was a low level of importance attributed to the transport of chilled/frozen food from the supermarket to home storage. Furthermore, the perceived risk of contracting food poisoning where the refrigeration temperature is "unknown" was relatively low. Results from previous studies (Kennedy *et al.*, 2005; Worsfold and Griffith, 1997; Evans *et al.*, 1991) have shown that where a high level of temperatures abuse of chilled foods was reported during transportation from supermarket to home as well as during subsequent periods of refrigerator storage where temperatures in the majority of cases were logged above 5 °C.

5. Conclusion

The identified CPs offer a clear framework for the development of a food safety awareness campaigns which should ultimately aim to reduce the frequency and severity of the unsafe practices. As poor food safety behaviour has been statistically linked with poor food safety knowledge, enhancement of consumer food safety knowledge of these critical elements should underpin such campaigns. These campaigns should include information on how to reduce the likelihood of pathogens entering the domestic kitchen and controlling the spread of pathogens when they are introduced. It is important that all domestic food handlers are appropriately informed of both the risk associated with unsafe food safety practices and are competent in the employment of simple measures to effectively control domestic food hazards.

Note

1. According to the Household Budget Survey in 2005, the profile of the main food shopper was gender; male (22 per cent) and female (78 per cent) and age; 18 – 24 yrs (6.3 per cent), 25 – 34 yrs (18.8 per cent), 35 – 44 yrs (21.9 per cent), 45 – 64 yrs (40.6 per cent) and 65 + yrs (12.5 per cent) (Amarach, Marketing Research, Ireland, 2008).

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