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Highlights

- Food safety knowledge amongst Irish residents was explored.
- 1069 participants from across Ireland contributed to the study.
- Knowledge of food handling and food poisoning observed was critically low.
- Gender, age, place of residence and education level impacted the knowledge level.
- Per capita income had no influence on the knowledge level.

1 **Knowledge of Food Safety and Food Handling Practices amongst Food Handlers in the**
2 **Republic of Ireland**

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21 **Abstract**

22 Food safety concerns have existed for a long time, as millions of people across the globe
23 suffer from food borne disease every year. Contamination of food owing to limited
24 knowledge of food safety practices primarily increases the risk of food borne illnesses. In the
25 present study, quantitative research was carried out to gauge the level of food safety
26 knowledge amongst people living in Ireland. A total of 1069 participants from all over the
27 Republic of Ireland contributed to the survey (of which 821 were included in this research).
28 Results showed that the residents of Ireland overall had an average level on knowledge of
29 food safety practices (67.0% passing rate). They had an average level of knowledge in food
30 storage (52.8% passing rate), usage and maintenance of the kitchen facilities (59.0% passing
31 rate), and personal hygiene (61.0% passing rate). Conversely, they had a critically low level
32 of knowledge in food handling (10.8% passing rate) and food poisoning (20.1% passing rate).
33 The results of the present study also showed that, the level of knowledge of food safety
34 practices varies amongst the residents based upon their gender, age, place of residence,
35 education level, and marital status, while no significant difference in the knowledge level was
36 observed based upon their per capita income. The study thus, highlights that there is scope for
37 improvement for the residents to advance their knowledge of food safety practices. Therefore,
38 it can be recommended that researchers, educators, food safety communicators, and the
39 media can engage in educating the population, to help the residents advance their food safety
40 knowledge to safer food practices.

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43 **Keywords:** Food safety; Food handling; Food hygiene; ; Knowledge; Practice

44

45 1 Introduction

46 Foodborne illnesses are a burden globally to public health and to a nation's economy
47 (Copenhagen, 2015; Young, & Waddell, 2016). In the Republic of Ireland, the numbers of
48 foodborne cases have been rising for the fifth consecutive year in 2015 according to data
49 collected nationally as part of the EU Zoonoses regulation (Health Protection Surveillance
50 Center [HPSC], 2016). Vulnerable groups are the most exposed to the risks of foodborne
51 illnesses (World Health Organization [WHO], 2015a & WHO, 2014), because their immune
52 systems are not fully capable of fighting off infections (Food and Drug Administration
53 [FDA], 2016a & FoodSafety.org). A large percentage of the population in Ireland can be
54 categorised as vulnerable, with older adults "65 years old and older" and younger children of
55 "14 years old and younger" (13.38% and 22.24%, respectively), compared to the general
56 population (Central Statistics Office [CSO], 2016) increasing the risk of foodborne incidents.

57 Research has shown that the increase in foodborne illnesses could be linked to improper food
58 safety practices in homes, as home environments can harbour an array of foodborne
59 pathogens (Langiano et al., 2012; Mountjoy, 2014; Young & Waddell, 2016), such as
60 bacteria, viruses and fungi (Byrd-Bredbenner et al., 2013; National Health Services [NHS],
61 2014). Furthermore, due to home kitchen being used as a "multipurpose area" for more than
62 just food preparation; this increases the risk of food contamination, proliferation, and possible
63 foodborne illnesses (Byrd-Bredbenner et al., 2013 & NHS, 2014). According to WHO,
64 *Campylobacter*, *Salmonella* and *E. Coli* are the most common foodborne pathogens that
65 affect millions in the world (WHO, 2015b), including in the Republic of Ireland (HPSC,
66 2016). While prior research shows that improper handling, preparation, and storage of food
67 can cause foodborne illness (USDA, 2016a), evidences support that in most cases, proper
68 cooking or processing can eliminate the risk of foodborne illnesses (USDA, 2013). The most
69 common source of food in Ireland are home cooked meals made from scratch using fresh

70 ingredients increasing the importance of being vigilant about knowledge of food safety
71 practices (Healthy Ireland Survey, 2015).

72 Recent studies have investigated people's knowledge of food safety in many countries around
73 the world, while in Ireland in 2001, a study was conducted testing the pathogenic foodborne
74 bacteria in domestic kitchens within 25 homes. A total of 325 sampling sites, which included
75 sampling before and after preparing chicken and six sites around the house, results showed
76 that contamination was still found after the preparation of meals, increasing the need for
77 consumer awareness and knowledge in food handling and hygiene (Gorman et al., 2002).
78 Another study that was conducted in Ireland was in 2005, the study was to test the knowledge
79 of 1025 participants from the Irish residents using a questionnaire, the findings of the
80 research is that the majority of the Irish residents have a good base of food safety knowledge,
81 however, that did not translate to the adherence to food safety practices, and knowledge on
82 food poisoning was at a low level (McCarthy et al, 2007). Lastly, in Ireland in 2006 a study
83 that tested the knowledge of food safety amongst 200 of chefs and catering manager was
84 conducted through face to face interviews, the results showed that although they were aware
85 of basic knowledge in order to deliver safe food that followed the law, they still needed extra
86 training to further their knowledge to implement food safety effectively (Bolton et al., 2008).
87 While the number of foodborne incidents are still increasing (HPSC, 2016), current studies to
88 assess the public's knowledge in the Republic of Ireland does not exist.

89 Therefore, the aim of this study is to contribute to the existing knowledge to tackle the
90 reasoning behind the increasing foodborne incidents by giving an updated insight on the
91 assessment of knowledge of people living in the Republic of Ireland on food safety and their
92 practices on preparing food at home. The study will compare demographics based on their
93 level of knowledge of food safety practices and also to determine common areas of weakness.

94 This research can help practitioners and researchers in identifying the areas of weakness of
95 the residents for furthering research in the areas needed. It can also aid the educators, food
96 safety policy makers and food safety communicators on where the knowledge is lacking in
97 the Irish residents. The study will achieve the objective by surveying the residents in multiple
98 regions and analysing and comparing the results.

99 **2 Materials and Methods**

100 **2.1 Questionnaire Design**

101 A questionnaire was designed with multiple-choice questions to survey the public in the
102 Republic of Ireland for their knowledge of food safety practices. It follows a validated
103 questionnaire (Gong et al., 2016) developed and used for conducting similar studies.
104 Appropriate modifications were made to the questionnaire to fit the popular habits and
105 traditions of consumers in Ireland. It was also simplified to make it easier for the participant
106 to answer, as according to McLeod (2014), questionnaires should be simple and easy for the
107 surveyor to understand and aimed to address the concerns of the research.

108 The questionnaire comprised of 32 multiple-choice questions. It was divided into two
109 sections. The first section consisted of six questions that covered the demographics of the
110 individuals being surveyed, such as gender, age, place of residence, per capita annual income
111 (in Euros), educational level and marital status. The second section tested their knowledge of
112 food safety handling in domestic kitchens, which consisted of 26 questions with a total of five
113 subsections that tested knowledge of food storage with six questions, knowledge of food
114 handling via four questions, knowledge of the usage and maintenance of kitchen facilities
115 through six questions, knowledge of personal hygiene with five questions and knowledge of
116 food poisoning via five questions. Once the design of the questionnaire was established, it
117 was pilot-tested amongst food safety and business management professionals to ensure

118 accuracy, and adjustments were made to enhance the survey based on the feedback received.

119 **2.2 Target Participants**

120 The target participants of the study were the people that reside in the Republic of Ireland,
121 with the restrictions that they were over the age of 18, speak English in order to understand
122 the survey, and handle food in their domestic kitchen to test their knowledge of food safety
123 practices.

124 **2.3 Data Collection**

125 McLeod (2014) highlights that surveys are a useful tool to obtain a high volume of
126 information from a large number of people in an efficient way and in a short period of time.
127 In order to assure coverage in multiple areas on the Republic of Ireland, a survey was
128 conducted across the Republic of Ireland. The participants were selected at random and were
129 approached both in person with a print version of the survey or an electronic link to the
130 survey was sent out for participation and completion of the survey. The print version was to
131 be returned after it was completed on the spot, while participants who used the electronic link
132 filled either on the spot or later at their own convenience. The participants were explained the
133 objective of the study before completion of the survey, and assurance of their complete
134 confidentiality as per the institution ethical guidelines. Furthermore, to ensure a non-bias
135 sampling in coverage, the sample had a frame that covered the demographic aspects of the
136 survey including: gender, age, place of residents, per capita annual income (in Euro's),
137 educational level, and marital status.

138 The survey was distributed and responses were collected from September to December of
139 2016. On average, the participants spend around 20-30 minutes to complete the survey.
140 Participants were approached in high traffic areas, such as popular streets, buildings, events,
141 gatherings etc. Some of the participants were approached in their own households to get the

142 older age range and countryside array involved. The participants were contacted in a non-
143 systematic way, a total of 1,069 participants contributed, of which, 248 surveys were
144 dismissed due to incomplete survey or participants selected more than one option per
145 question. Thus, 821 surveys were included in this research.

146 **2.4 Data Analysis**

147 For the data analysis, the software package of SPSS version 20.0 by IBM Corporation was
148 used to statistically analyze all the data collected. There were twenty-six questions; each
149 question answered correctly would award the participant one point and zero for incorrect
150 answers, percentages of correct and incorrect answers for each question was calculated.
151 Additionally, each subsection of the knowledge portion of the survey the participant could
152 receive between four to six points depending on the subsection. The entire knowledge section
153 of the survey as well as each subsection had their mean score and standard deviation
154 analyzed. After calculating correct and incorrect answers for each participant, the participants
155 that answered more than half of the questions on the survey correctly would have attained a
156 pass; furthermore, for each subsection and demographics group the passing rates were also
157 analyzed. If the participants achieved a passing rate of 70.0% or more, they were considered
158 to have a good level of knowledge, however, if the results showed a passing rate of less than
159 50.0% that would point towards a poor level of knowledge, with 51.0% to 69.0% considered
160 as an average level of knowledge.

161 As the data had a skewed distribution, this suggested that it did not follow normal distribution
162 and thus non-parametric analysis would be the most appropriate method for analyzing the
163 data (Sullivan, 2016). Non-parametric tests (Chi-square (χ^2), Manne-Whitney U and
164 Kruskale-Wallis) were used to analyze the entire data. The Chi-square (χ^2) test was adopted
165 to compare the different demographics with the passing rates of the respondents to determine

166 whether there was a difference. The Mann-Whitney U test was used to compare the
167 demographics with two independent samples (Sullivan, 2016). Therefore, it was used to
168 compare the difference between city residents and countryside residence with the mean score,
169 and the Kruskal-Wallis test was used to compare the specific demographics of three or more
170 independent samples (Sullivan, 2016). Thus, it was used for the rest of the demographics
171 (gender, age, per capita annual income (in Euros), educational level and marital status), and
172 compared them with the mean scores of the participants

173 **3 Results and Discussion**

174 **3.1 Samples Profile**

175 Table 1 presents 6 of the demographic characteristics of the sample. 51.3% of the respondents
176 were females, 35.2% were between the ages of 26 and 35, 73.3% were from the city, 59.0%
177 had an annual income of 30,000 euro's or below, which is equivalent to 31,354.5 US dollars
178 by the end of 2016; 72.5% of the respondents had a university education or above, and 55.7%
179 were unmarried.

180 **3.2 Knowledge of Food Safety Practices in Domestic Homes in the Republic of** 181 **Ireland**

182 **3.2.1 Knowledge on Food Storage**

183 Table 2 presents the knowledge of food safety in food storage; there were 6 questions in this
184 subsection to assess their knowledge, resulting in the mean score of 3.5 points (from a range
185 of 0-6). If the respondents got three or more out of this section of questions correctly, they
186 attained a pass. The passing rate for this section in Ireland was at 52.8%, indicating an
187 average degree of knowledge in food storage, which links a higher risk of poor food safety
188 practices with mistakes done with improper food storage practices (Langiano et al., 2012).

189 The highest pass rate in this subsection was that 78.1% of the respondents knew that meat
190 should be bought at the end of the shopping time. Moreover, the pass rate for the same
191 question in China was 36.7% (Gong et al., 2016), in Lebanon 59.7% (Hassan &Dimassi,
192 2014), in Greece 55.3% (Lazou et al., 2012), in Jordan 73.6% (Osailiet al., 2011), and in the
193 US it was observed 38.5% did not pick frozen foods or raw meat at the end of shopping time
194 (Yapet al., 2016), highlighting that Irish residents got the highest passing rate among the
195 countries discussed above.

196 However, the lowest knowledge in this subsection is whether or not freezing temperatures
197 would affect bacterial activity, in where Ireland's passing rate was only 28.6%; while in
198 Canada 77.0% (Courtney et al., 2016), and in China it was 12.4% (Gong et al., 2016), in
199 Lebanon 64.0% (Hassan & Damassi, 2014), in Greece 78.3% (Lazou et al., 2012), and in
200 Jordan 52.2% (Osaili et al., 2011), indicating that Ireland is one of the lower passing rate for
201 this question.

202 **3.2.2 Knowledge on Food Handling**

203 Table 3 presents the knowledge of food safety in food handling; there were 4 questions in this
204 subsection to assess their knowledge, resulting in a mean score of 2.1 points (from a range of
205 0-4). The respondents needed to get two questions or more correctly in order to attain a pass
206 in this subsection, which was 10.8% in Ireland, indicating critically low degree of knowledge.

207 Most respondents in present study (66.1%) knew that the correct answer on washing
208 vegetables and fruits must be washed with running cold water, while in China 51% knew the
209 correct answer to this same question (Gong et al., 2016), in Canada 92.5% knew that fresh
210 produce should be washed with cold running water (Burke et al., 2016), in South Africa 82%
211 claimed to have washed their fruits and vegetables correctly (Sibanyoni et al., 2016), in
212 Lebanon 51.4% wash them under running water (Hassan &Dimassi, 2014), In Greece 72.8%

213 knew the correct answer (Lazou et al., 2012), in Saudi Arabia 91.7% knew the correct answer
214 (Sharif & Al-Malki, 2010), and in Jordan 28.4% knew the correct answer (Osaili et al., 2011).
215 Ireland's knowledge is on the lower average of the passing rate although this is the highest
216 knowledge in this subsection.

217 The lowest knowledge in this subsection was regarding thawing of raw meat, 43.5% of the
218 Irish residents knew that the least safe way to thaw raw meat is on the chopping board, while
219 in China 38.2% knew the correct answer (Gong et al., 2016), 58.3% in Brazil knew the best
220 way to defrost food (Uggioni & Salay, 2012), in the US among the elderly 50.0% did not
221 thaw their meat in the refrigerator (Yap et al., 2016), while in the US 79.2% knew that the
222 best way to thaw meat is in the refrigerator and only 1.4% thought that thawing on the
223 countertop is the best way (Meysenburg et al., 2014), in Lebanon 28.0% knew to defrost raw
224 meat in the refrigerator while 38.5% thought that on the countertop is the best way (Hassan &
225 Dimassi, 2014), in Greece 24.1% knew the correct answer (Lazou et al., 2012), and in Jordan
226 27.1% knew the correct answer (Osaili et al., 2011). Irish residents in the present study are
227 within the lower knowledge rate of this question.

228 Control measures that are currently in place by producers are not sufficient in eliminating the
229 risk of food borne illness, so precautions taken by the consumer in handling food is critically
230 important as it could avoid cross-contamination, eliminate or slow the growth of existent
231 bacteria, which eventually would avoid foodborne illnesses, making it very important for the
232 consumer to be well informed about proper food handling practices (Langiano et al., 2012;
233 Mountjoy, 2014). Plus, Ireland is alarmingly low in knowledge in this subsection making it
234 essential for the public to be better informed.

235 3.2.3 *Knowledge on Usage and Maintenance of Kitchen Facilities*

236 Table 4 presents the knowledge of food safety on usage and maintenance of kitchen facilities
237 at domestic homes in Ireland; there are 6 questions in this subsection to assess their
238 knowledge, resulting in a mean score of 3.7 points (from a range of 0-6). The respondents
239 needed to get three questions or more correctly in order to attain a pass in this subsection,
240 which was 59.0% in Ireland, confirming residents had average degree of knowledge.

241 The highest passing rate in this subsection was that 71.6% of the respondents knew the
242 correct temperature to store food in the refrigerator, while in China it was 32.4% (Gong et al.,
243 2016), in Portugal 69.5% of respondents chose the answer of below or at 2-8°C (Carbas et al.,
244 2013), in Wales 84.0% of the elderly were unaware of the proper temperature of the
245 refrigerator (Evans & Redmond, 2016), in Lebanon 53.1% knew the correct answer (Hassan
246 & Damassi, 2014), in Greece 44.4% knew the correct answer (Lazou et al., 2012), and in
247 Jordan 34.1% knew the correct answer (Osaili et al., 2011). Results showed that Ireland is at
248 the higher end of knowledge with regard to this question, and that Irish participants scored
249 highest in this subsection.

250 On the other hand, the lowest knowledge in this subsection is on the use of the chopping
251 board for raw meat and fresh fruit. 51.2% of the Irish respondents got the correct answer,
252 while in Canada it was 97.7% (Burke et al., 2016), in China 12.4% (Gong et al., 2016), in
253 Brazil 54.0% (Uggioni & Salay 2012), 21.0% among elderly in the US did not use a separate
254 cutting board (Yap et al., 2016), in Lebanon 38.6% knew the correct answer (Hassan &
255 Dimassi, 2014), and in Jordan 61.6% knew the correct answer (Osaili et al., 2011). Survey
256 reveals that Ireland ranks average in where it could be improved.

257 This subsection is of importance to have knowledge in usage and maintenance of kitchen
258 facilities to avoid pathogenic growth or cross-contamination in order to gain food safety

259 practice (Evans & Redmond, 2016; Langiano et al., 2012), including the need to concentrate
260 on hotspots that gather the highest bacterial count based on studies (NHS, 2014), since the
261 Irish consumer has average knowledge, it is clear that the knowledge can and should be
262 improved in order to see decreased incidence of foodborne illnesses.

263 **3.2.4 Knowledge on Personal Hygiene**

264 Table 5 presents the knowledge of personal hygiene in the Republic of Ireland; there were 5
265 questions in this subsection to assess their knowledge, resulting in a mean score of 3.5 points
266 (from a range of 0-5). The respondents needed to get three questions or more correct in order
267 to attain a pass in this subsection, which was 61.0% in Ireland, which is an average degree of
268 knowledge.

269 85.0% participants in Ireland that knew to wash their hands with soap and warm water then
270 wipe dry after handling raw meat. While in Canada 66.4% between the ages of 19-29 knew
271 the correct answer (Burke, et al., 2016), while 71.5% of the Canadian undergraduate
272 university students knew how to wash their hands correctly (Courtney et al., 2016), in china
273 27.2% (Gong et al., 2016), and in the US 30.8% in 1998 and 21.5% in 2010 reported that they
274 did not wash their hands before preparing food showing a decreased curve which indicates
275 improved knowledge over the years and that could be due to several federal media coverage
276 on food safety (Fein et al, 2011), 50.0% in another study showed that young adults in the US
277 washed their hands properly after handling raw chicken (Byrd-Bredbenner et al., 2009), in
278 another study 91.4% among the elderly in the US washed their hands properly before
279 preparing food (Yap et al., 2016), while another showed that 45.8% of the elderly did not
280 know or did not wash their hands properly after handling raw meat (Cates et al., 2009), and in
281 the US 95.8% of the parents with young children knew to wash their hands before preparing
282 food (Meysenburg, et al., 2014), in South Africa 97.0% claimed to wash their hands after

283 handling raw food (Sibanyoni et al., 2016), in Ghana 75.6% agree that hands should be
284 washed before prepping food (Akonor&Akonor, 2013), in Greece 57.5% knew the correct
285 answer (Lazou et al., 2012), and in Saudi Arabia 96.1% of university students wash their
286 hands before preparing foods (Sharif & Al-Malki, 2010), 92% of chefs in Ireland from a
287 previous study knew the correct answer (Bolton et al., 2008). Present study showed that
288 knowledge on when and how to wash hands properly is important and Ireland was on the
289 higher end of the passing rate with knowing both aspects in washing hands after handling raw
290 meats and how to wash it correctly, showing a decent degree of knowledge in personal
291 hygiene.

292 The lowest knowledge in this subsection was related to whether it is safe to handle food as
293 long as gloves are worn. Only 46.3% Irish participants answered this question correctly. In
294 China, 25.5% knew the correct answer (Gong et al. 2016); in Brazil, 29.1% were correct
295 (Ugioni & Salay 2012); in Greece, 19.6% chose the correct answer (Lazou et al. 2012);
296 64.0% of Hispanic families with younger children knew the correct answer (Stenger et al.
297 2014); and, in Jordan, 23.0% were aware of the correct answer (Osaili et al. 2011). It is
298 evident that, although Irish participants had the poorest level of knowledge in this subsection,
299 they scored at the higher end in terms of knowledge when compared to other countries.
300 However, it is noteworthy that they scored below 50.0%, which is considered a poor degree
301 of knowledge, and there is scope for improvement.

302 According to research, knowledge of the importance of personal hygiene immediately
303 coincides with the adherence to personal hygiene practices (Ismail et al., 2016; Jianu &
304 Golet, 2014), however, research has shown that knowledge on hand hygiene and adherence to
305 the knowledge does not necessarily coincide, which correspondingly needs more attention
306 and stress on its importance (Jianu & Golet, 2014).

307 **3.2.5 Knowledge on Food Poisoning**

308 Table 6 presents the knowledge of personal hygiene in the Republic of Ireland; there are 5
309 questions in this subsection to assess this knowledge, resulting in a mean score of 2.4 points
310 (from a range of 0-5). The respondents needed to get three questions or more correctly in
311 order to attain a pass in this subsection, which was 20.1% in Ireland, which is critically poor
312 degree of knowledge.

313 The highest knowledge in this section was regarding raw or undercooked beef or eggs
314 causing food poisoning and 74.5% of participants knew the correct answer, this can be easily
315 explained with how recommendations of the Food Safety Authority in Ireland (FSAI) on
316 labelling or serving safely based on the study that showed present pathogens in raw meat and
317 the fact that the European Union (EU) made it mandatory to present safety instructions on
318 cooking raw meat or eggs to avoid food borne illnesses (FSAI, 2013; EC NO 1169/2011);
319 while in China 25.3% knew undercooked beef, 8.9% knew raw eggs or 12.2% knew that both
320 could cause food poisoning (Gong et al., 2016), in Portugal 12.5% respondents knew that
321 undercooked beef, 19.0% knew raw eggs, or 43.8% knew that both including unpasteurized
322 milk could cause food poisoning (Carbas et al., 2013), in South Africa 64.3% knew that raw
323 eggs could cause food poisoning (Sibanyoni et al., 2016), 44.1% in Ghana agree that it is
324 safer to eat fully cooked eggs rather than raw (Akonor & Akonor, 2013), in Saudi Arabia
325 43.9% knew that eating raw eggs was not safe while 86.1% knew that eating under cooked
326 meats is not safe (Sharif & Al-Malki, 2010), of Hispanic families with young children 35.0%
327 knew that under cooked eggs can be unsafe and 82.0% knew that undercooked meat is unsafe
328 (Stenger et al., 2014), and in Jordan 52.9% knew that undercooked eggs can be unsafe and
329 79% knew that undercooked meat is unsafe (Osaili et al., 2011). Ireland though shows decent
330 knowledge in comparison to other countries, yet it is evident from our results that this needs
331 improvements.

332 The lowest knowledge in this subsection was that 10.1% of the respondents knew that meat
333 sauce from the deli is most likely to become contaminated with *Listeria* in comparison to raw
334 or undercooked meat, eggs or vegetables; while in China 24.3% knew the correct answer
335 (Gong et al., 2016), in Greece it was 15.1% (Lazou et al., 2012), and only 40% in the US ever
336 heard of *Listeria* (Cates et al., 2009). Overall results showed that Ireland has critically poor
337 knowledge in food poisoning.

338 This section is of extreme importance for the Irish residents to understand on how to handle
339 the food to avoid cross contamination and how to cook it properly according to the safety
340 guidelines that are provided by the FDA and USDA in order to avoid food poisoning,
341 moreover, to understand the possible risks of foodborne illnesses if they are to occur (FDA,
342 2016-b& USDA, 2016-b). An example for this is, in 2015 in Ireland reports showed that one
343 of the most common bacteria is *Campylobacter* in where 2,451 cases were reported this is the
344 fifth consecutive year to where numbers of cases are elevated; Ireland also had the highest
345 number of cases of verotoxigenic *Escherichia coli* "*E. coli*" (VTEC) comparison to Europe
346 where 730 of reported cases and rising every year; 269 cases of *Salmonella* cases, and 19
347 cases of *Listeriosis* and rising (HPSC, 2016), if the consumer is eating at home, pathogenic
348 foodborne could be avoided with proper handling using four simple steps, making sure
349 personal and kitchen hygiene is present, separating to avoid cross contamination, cooking
350 each food item to the proper temperature using a thermometer, and chilling promptly (USDA,
351 2016b), and if dining out to assure that the restaurant takes these precautions with hygiene
352 and that the food is fully cooked (Cunningham, 2015).

353 3.3 The Relation between the Demographic Characteristics and Knowledge of Food 354 Safety in Homes

355 There were 5 subsections in total that covered different aspects on food safety knowledge in
356 Ireland, which consisted of 26 questions in total, if the respondent were to get thirteen or
357 more of the overall questions correctly then they have attained a pass, the mean score for the
358 entire survey was 15.3 points (from a range of 0-26) and a standard deviation of 5.1, with an
359 overall passing rate of 67.0%. Table 7 presents the relation between specific demographic
360 characteristics and mean score and overall passing rate between respondents, using the non-
361 parametric tests (Chi-square (χ^2), Mann-Whitney U, and Kruskal-Wallis).

362 The results showed that, gender, age, place of residents, educational level, and marital status
363 with the ($P < 0.05$) for all five categories showed significant factors that impact the
364 knowledge of food safety practice in the Republic of Ireland, while on the other hand, per
365 capita annual income did not have any significance with the ($P > 0.05$), which suggests that
366 educators should direct their programs to those 5 factors in order to make an impact on their
367 knowledge level.

368 Females were better with food safety knowledge with the passing rate of 59.0%, respondents
369 at the age of 26-35 years old were more knowledgeable with a passing rate of 33.0%, people
370 that lived in cities were significantly more knowledgeable with the passing rate of 69.1%,
371 educated people with a university and above degree at 74.2% passing rate and unmarried
372 were with a passing rate of 53.3%, while married with children and married without children
373 showed significant results in passing rates as 31.1% and 7.8% respectively. It is however
374 noteworthy that as the participants were randomly selected, the pass rates of some
375 demographic groups can be very low due to the very small number of respondents in those
376 groups. The findings correlate with a report by WHO in 2015, that “demographic, cultural,

377 economic and environmental developments, an ageing population, changing consumer trends
378 and habits, new technologies” all factor increase foodborne health risks (Copenhagen, 2015).
379 Additionally, based on the research findings, it is argued that the aspects that affect food
380 safety practices and knowledge are broad, further education is universally needed in order to
381 help decrease foodborne illnesses and better understand the problem of why food safety is a
382 globally epidemic issue (Copenhagen, 2015).

383 **4 Conclusion**

384 With the overall passing score of participant being 67.0% and a mean score of 15.3 points (a
385 range of 0-26), residents of Ireland can be regarded as having an average level of knowledge
386 of food safety practices. Yet, when analysed for the different aspects of the 5 subsections in
387 the survey, their knowledge was found to be critically low in food handling (10.8% passing
388 rate) and alarmingly low with regard to the knowledge of food poisoning. Furthermore, the
389 different demographics did show some significant differences, overall women appeared to be
390 more knowledgeable and the eldest (51 years old and above) and youngest (18-25years)
391 groups had the least level of knowledge; people who lived in the city were more
392 knowledgeable than those who lived in the countryside; educated people who had at least a
393 university or above degree knew the most about food safety; and unmarried or married with
394 children had the highest level of knowledge versus those who did not have children and
395 others. Overall, the study indicates that there is scope for improvements about food safety
396 knowledge in people living in Ireland. It is recommended that researchers, educators, food
397 safety communicators, and the media should work towards educating the population to
398 advance their food safety knowledge to safer food practices.

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550 **Table Legends**

551 Table 1. Sample characteristics

552 Table 2. Respondents knowledge on food storage, pass rate, mean score and standard
553 devastation554 Table 3. Respondents knowledge on food handling, pass rate, mean score and standard
555 devastation556 Table 4. Respondents knowledge on usage and maintenance of kitchen facilities, pass rate,
557 mean score and standard devastation558 Table 5. Respondents knowledge on personal hygiene, pass rate, mean score and standard
559 devastation560 Table 6. Respondents knowledge on food poisoning, pass rate, mean score and standard
561 devastation562 Table 7. The relation between the demographic characteristics and knowledge of food safety
563 in homes

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Table 1. Sample characteristics

Demographic Characteristics	N	Category	Respondents (n.)	Percentage (%)
Gender	802	Male	372	46.4
		Female	421	51.3
		Other	9	1.1
Age	805	18 - 25	254	31.6
		26 - 35	283	35.2
		36 - 50	175	21.7
		51 and above	93	11.6
Place of Residence	798	City	585	73.3
		Countryside	213	26.7
Per Capita Annual income (Euro's)	785	Below 30,000	463	59.0
		30,000 – 60,000	223	28.4
		60,001 – 100,000	74	9.4
		100,000 and above	25	3.2
Educational Level	801	University and Above	581	72.5
		Leaving Cert – Senior Secondary	147	18.4
		Junior Cert – Junior Secondary	47	5.9
		No qualification	26	3.2
Marital Status	803	Unmarried	447	55.7
		Married without children	84	10.5
		Married with children	218	27.1
		Other	54	6.7

Note: exchange rate was 1 euro equals 1.05 US dollars by the end of 2016.

Table 2. Respondents' knowledge on food storage, pass rate, mean score and standard deviation

Questions	N	Category	Respondents (n.)	Percentage (%)
1. How should chunks of raw meat be stored?	816	Store it directly in the refrigerator	315	38.6
		Slice it into smaller pieces, then store them in the refrigerator	56	6.9
		Slice into smaller pieces, seal and store them in the refrigerator	392	48.0
		Store it in a cool place	53	6.5
2. Can bacteria in food be killed by freezing at -18°C?	818	Yes, totally	115	14.1
		Yes, partly	306	37.4
		Not at all	234	28.6
		Do not know	163	19.9
3. When is the best time to purchase frozen food when shopping?	818	At the beginning of the shopping time	49	6.0
		At the end of the shopping time	639	78.1
		Whenever, does not matter	101	12.3
		Do not know	29	3.5
4. What is the optimal temperature for storing frozen food?	810	4 °C	63	7.8
		0 °C	117	14.4
		-18 °C or Below	516	63.7
		Do not know	114	14.1
5. What should be done with freshly prepared food that will be consumed 3 hours later?	808	Put in the refrigerator, then reheat when ready to eat	526	65.1
		Put it in the cupboard, then reheat when ready to eat	86	10.6
		Put it in the microwave oven	57	7.1
		Cover it and put it on the cabinet	139	17.2
6. Should thawed meat be frozen for later use?	805	Yes	96	11.9
		No	544	67.6
		Maybe	72	8.9
		Do not know	93	11.6
Total Score			430	52.8
Pass rate (%)				
Mean score ± standard deviation				3.5±1.4

The correct answer for each question is highlighted in bold

Table 3. Respondents' knowledge on food handling, pass rate, mean score and standard deviation

Questions	N	Category	Respondents (n.)	Percent (%)
7. How should vegetables and fruits be washed?	805	Soak in detergent	23	2.9
		Wash with hot water	100	12.4
		Wash with running cold water	532	66.1
		Soak in cold water, then wash	150	18.6
8. Of the following, which is the least safe way to thaw raw meat?	797	In refrigerator	113	14.2
		On chopping board	347	43.5
		In microwave oven	218	27.4
		In cold water in sealed package	119	14.9
9. Of the following, which is the correct way to heat leftovers?	805	Heat it to the temperature you prefer	235	29.2
		Reheat is not necessary if it is during the summer	42	5.2
		Heat until they are boiling	428	53.2
		Do not know	100	12.4
10. What should be done if the leftovers are still not eaten completely?	805	Discard them immediately	399	49.6
		Put in the refrigerator immediately and reheat before consuming	293	36.4
		Store in kitchen and reheat before consuming	54	6.7
		As long as they smell good, eat them	59	7.3
Total Score Pass rate (%) Mean score ± standard deviation			89	10.8
				2.1±1.1

The correct answer for each question is highlighted in bold

Table 4. Respondents knowledge on usage and maintenance of kitchen facilities, pass rate, mean score and standard deviation

Questions	N	Category	Respondents (n.)	Percentage (%)
11. A refrigerator has three shelves, on which shelf do you think raw meat should be placed?	805	Top shelf	157	19.5
		Middle shelf	56	7.0
		Bottom shelf	508	63.1
		Does not matter	84	10.4
12. What is the recommended temperature for fridges?	814	12 °C	51	6.3
		4 °C	583	71.6
		0 °C	86	10.6
		Do not know	94	11.5
13. How long should leftovers be kept in the fridge?	810	No more than 2 days	564	69.6
		No more than 5 days	113	14.0
		As long as the food has not gone bad	99	12.2
		Do not know	34	4.2
14. Of the following, which is the correct way to clean the kitchen countertop and stove?	811	Clean with dry rag	36	4.4
		Clean with wet rag	77	9.5
		Clean with detergent and warm water	534	65.8
		All of the above	164	20.2
15. Of the following, which do you think is the correct way to wash dishes?	806	Soak in water, after several hours, wash with the same water	20	2.5
		Wash immediately after meal	453	56.2
		Wash in water basin, dry with dishcloth	284	35.2
		Other	49	6.1
16. A person has cut meat on a chopping board and now he/she wants to cut fruit. Of the following, which are the correct ways?	808	Rinse the chopping board with hot water before cutting fruit	81	10.0
		Use the other side of the chopping board to cut fruit	63	7.8
		Clean the chopping board with detergent and hot water before cutting fruit	250	30.9
		Use another chopping board to cut fruit	414	51.2
Total Score Pass rate (%) Mean score ± standard deviation			484	59.0
				3.7±1.6

The correct answer for each question is highlighted in bold

Table 5. Respondents knowledge on personal hygiene, pass rate, mean score and standard deviation

Questions	N	Category	Respondents (n.)	Percentage (%)
17. Is it safe to handle food if a person has a wound on the back of his/her hand?	805	Yes, as long as the wound is not infected	70	8.7
		Yes, as long as the wound has a bandage on it	185	23.0
		Yes, as long as gloves are worn	373	46.3
		Not at all	177	22.0
18. Of the following, which is the correct way to wash hands?	810	Wash with running cold water, wipe dry	32	4.0
		Wash with running warm water, wipe dry	64	7.9
		Wet hands with cold water in a basin, use soap and then wash hands with cold water in the basin, wipe dry	98	12.1
		Wet hands with running warm water, use soap and then wash with running warm water, wipe dry	616	76.0
19. Of the following, which is the correct way to wash hands after handling raw meat?	806	Wipe with towel	21	2.6
		Wash with cold water, wipe dry	41	5.1
		Wash with warm water, wipe dry	59	7.3
		Wash with soap and warm water, wipe dry	685	85.0
20. After touching which of the following should a person wash his/her hands during the course of preparing food?	800	Face	30	3.8
		Pimple on the surface of skin	123	15.4
		Clothes	42	5.3
		All of the above	605	75.6
21. People with which of the following symptoms should not cook for others?	801	Diarrhea, Fever, Sore throat or Flu	607	75.8
		Skin allergies	96	12.0
		AIDS	78	9.7
		Headache	20	2.5
Total Score			501	61.0
Pass rate (%)				3.5±1.4
Mean score ± standard deviation				

The correct answer for each question is highlighted in bold

Table 6. Respondents knowledge on food poisoning, pass rate, mean score and standard deviation

Questions	N	Category	Respondents (n.)	Percentage (%)
22. Which is the most important for preventing food poisoning?	799	Spray the kitchen with insecticides weekly	41	5.1
		Avoid eating leftovers	138	17.3
		Keep food refrigerated until it is time to serve them	346	43.3
		Use detergent to disinfect kitchen countertop and stove weekly	274	34.3
23. How to prevent salmonella poisoning?	803	Fully heat food	554	69.0
		Wash food with very hot water	50	6.2
		Freeze food for more than 3 days	48	6.0
		Do not know	151	18.8
24. Which of the following is most likely to become contaminated with Escherichia Coli (E. coli)?	802	Tap water	139	17.3
		Raw pork or beef	423	52.7
		Raw vegetables	90	11.2
		Do not know	150	18.7
25. Which of the following is most likely to become contaminated with Listeria?	801	Raw or uncooked meat and eggs	361	45.1
		Meat sauce from the deli	81	10.1
		Raw vegetables	85	10.6
		Do not know	274	34.2
26. You can get food poisoning from eating which of the following?	801	Fruits taken out of the refrigerator immediately	17	2.1
		Unheated canned food	88	11.0
		Raw or undercooked beef and eggs	597	74.5
		Other	99	12.4
Total Score			165	20.1
Pass rate (%)				
Mean score ± standard deviation				2.4±1.2

The correct answer for each question is highlighted in bold

Table 7. The relation between the demographic characteristics and knowledge of food safety in homes

Variables	N	Pass rate (%)	P-value	Mean score	P-value
Gender	802		0.000		0.000
Male		39.7		14.4	
Female		59.8		16.4	
Other		0.6		11.3	
Age	805		0.000		0.000
18 – 25		29.2		14.8	
26 – 35		33.0		14.8	
36 – 50		23.6		16.4	
51 and above		14.2		17.0	
Place of Residence	798		0.000		0.000
City		69.1		15.0	
Countryside		30.9		16.7	
Per Capita Annual income (Euro's)	785		0.321		0.130
Below 30,000		58.9		15.2	
30,000 – 60,000		29.6		16.1	
60,001– 100,000		8.9		15.0	
100,000 and above		2.6		14.7	
Educational Level	801		0.000		0.000
University and Above		74.2		15.7	
Leaving Cert – Senior Secondary		20.8		16.2	
Junior Cert – Junior Secondary		3.3		11.9	
No qualification		1.7		11.0	
Marital Status	803		0.000		0.000
Unmarried		53.3		15.0	
Married without children		7.8		13.2	
Married with children		31.1		16.7	
Other		7.8		16.7	

Note: exchange rate was 1 euro equals 1.05 US dollars by the end of 2016.

Pass rates tested using Chi-square (χ^2) Test

Mean scores tested using Manne-Whitney U and Kruskal-Wallis Tests