



A study of food safety knowledge, practice and training among food handlers in Ireland



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ABSTRACT

Food safety knowledge, practice and training were examined among 689 food workers in Ireland. Parameters such as role, years worked, level of food safety training acquired, and establishment were all found to have a significant effect (p -values < 0.01) on knowledge score. It is notable that 28% of all respondents claimed 'never' to have received food safety training, suggesting insufficient compliance with this legislative requirement. Notably, absence of training only accounted for 1% of all canteen workers surveyed. In addition, individuals working in canteens were found to have the highest knowledge score (81%) and the highest percentage of level 3 training (60%). Respondents were asked a series of questions relating to operational prerequisite hygiene requirements such as working while unwell, critical limits, food allergens and hand hygiene. This study highlights the value of food safety training and elucidates potential areas for improvement.

1. Introduction

Globalisation, coupled with the demand for increased product shelf-life, has led to longer and intrinsically more complex supply chains than ever before (Copenhagen, 2015; Walsh & Leva, 2018). This creates many challenges for the food sector in delivering safe food produce to customers; particularly in light of the current consumer demand for minimally processed food (De Corato, 2019).

The global burden of foodborne disease has been reported to be comparable to major infectious diseases, HIV/AIDS, malaria and tuberculosis; with 1 in 10 individuals falling ill and 420,000 associated fatalities annually (Havelaar et al., 2015; WHO, 2015). In regional terms, European figures suggest that 23 million individuals became ill from foodborne disease, with an estimated 5000 fatalities, reported in the EU every year (WHO, 2015).

Interestingly, 61% of all foodborne outbreaks (including waterborne cases), reported in Europe (EFSA, 2018) and 78% in the USA (CDC, 2018), have been attributed to food from the food service sector. Similarly, approximately 50% of foodborne illness (Bolton, Meally, Blair, McDowell, & Cowan, 2008), has been previously reported to be associated with catering establishments and restaurants in Ireland, respectively. These figures combined with several recent studies documenting insufficient levels of knowledge, negative attitudes and optimistic bias among food handlers (Bou-Mitri, Mahmoud, El Gerges, & Jaoude, 2018;

Parry, Kunadu, Oforu, Aboagye, & Tano-Debrah, 2016; Rossi, Stedefeldt, da Cunha, & de Rosso, 2017; Woh et al., 2016) suggest that more could be done by the food service sector in the prevention of foodborne illness in Europe, and elsewhere. Since all food production is underpinned by food safety, a review of current practices in the catering sector in Ireland is warranted. The aim of this study was to investigate and assess the current levels of food safety knowledge, practice and training among food handlers working in the Irish food service sector. This will assist stakeholders in improving food safety protocols and their application, where necessary, and potentially inform policy in this growing area.

2. Methods

2.1. Questionnaire design

A 39-question survey (available in the supplemental section) was designed to examine food handler's knowledge on cross-contamination, cleaning, cooking, cooling, reheating, food allergens and food pathogens. The survey had approximately an 11-min completion time. It was developed to align with current Irish Standards (FSAI 2012; NSAI, 2015), and with regard to similar peer-reviewed studies in Ireland and the EU (Bolton et al., 2008; Panchal, Bonhote, & Dworkin, 2013; Pichler, Ziegler, Aldrian, & Allerberger, 2014; Smigic et al., 2016). The

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questionnaire was distributed among the food service sector in Ireland between October and November of 2017; of which 689 (99 electronic and 590 hardcopies) were completed.

2.2. Data analysis

The responses from 689 questionnaires were analysed using R statistical software (R Core Team, 2017). The knowledge score (KS) was calculated excluding the questions on allergens and pathogens, questions 27, 28, 29, 38 and 39; as these areas were not included in the calculation of KS in other studies. In summary, KS were calculated based on the percentage of correct answers out of an allocated 34 questions, while data regarding knowledge of allergens and pathogens among the sample group were also collated. Where a question was skipped or left unanswered, it was assumed the respondent did not know the answer, and it was therefore marked incorrect/wrong. However, surveys left unfinished or partially completed were removed from this study.

Pearson's Chi-squared tests were performed to examine if there was a significant relationship between establishments, roles and the level of food safety training that staff had received. Post hoc tests were carried out using pairwise comparisons and using false discovery rate (Benjamini & Hochberg, 1995) corrections for p-values. Cochran-Mantel-Haenszel tests (Agresti, 2002; Cochran, December 1954; Mantel and Haenszel, 1959) were also used to test the null hypothesis that role and level of training were conditionally independent in each type of establishment and that establishment and level of training were conditionally independent for each role in the survey. Multiple Factor (Independent Variable) ANOVA was used to assess the effect of gender, age, establishment, role, education, years worked and level of food safety training on the knowledge score. Post hoc tests (Tukey HSD) were performed to find the significant pairwise difference in means of the factor levels.

The code to reproduce the analysis can be accessed at <https://github.com/domijan/FoodControl>.

The role of food workers has been broken down into the following categories for the purposes of this study:

- Head Chefs, Managers and Supervisors (HC, M & S) e.g. food safety decision makers, typically with responsibility for other staff members
- Chefs and Food Preparation Assistants (C & FPA) e.g. food handlers working openly with food and performing duties such as cooking, sandwich making or preparing cold dishes such as salads, desserts etc.
- Front of House staff (FOH) e.g. staff working in a customer facing role, such as wait staff, bar staff and runners
- Back of House Staff (BOH), e.g. staff working in a non-customer facing position, often responsible for washing, cleaning and sanitation, such as kitchen porters
- 'Other', in this instance, included: Baker, Trainee/Duty Manager, Delivery Driver, Storekeeper, Conference & Banqueting Staff, Butcher, Cleaner, Host, Room Service, Care Assistant, Health & safety Manager, Operations Manager

3. Results

3.1. Demographics of head chefs, managers and supervisors (HC, M & S) and all others food handlers

On examination of the 689 questionnaires, the overall gender split of respondents was found to be 45% male (n = 313) and 55% female (n = 375); with a higher proportion of males noting roles in HC, M & S (55%), than females (44%). Ninety six percent of all respondents reported having completed second level education (NFQ Level 4/5 as per QQI, 2017) and 32% having completed a university degree (NFQ level 7

Table 1

Years Worked in the Food Sector and Place of Work/Establishment recorded for all Respondents Surveyed (n = 689) in this study.

	Food Handlers ^a (n = 565, 82%)	HC, M & S ^b (n = 124, 18%)	All Respondents (n = 689)
Years working in industry			
≤ 2 years	287 (52%)	7 (5%)	294 (43%)
2–8 years	196 (35%)	21 (17%)	217 (32%)
8–16 Years	38 (7%)	41 (33%)	79 (12%)
16–25 years	20 (4%)	28 (23%)	48 (7%)
≥ 25 years	13 (2%)	27 (22%)	40 (6%)
No response	11	0	11
Establishment			
Restaurant	158 (28%)	41 (33%)	199 (29%)
Hotel	128 (23%)	18 (15%)	146 (21%)
Café/Deli	111 (20%)	18 (15%)	129 (19%)
Other Establishments ^c	77 (14%)	24 (19%)	101 (15%)
Canteen	36 (6%)	21 (17%)	57 (8%)
Bar	54 (9%)	2 (1%)	56 (8%)
No response	1	0	1

^a Food Handlers consisted of: 304 individuals (44% of all respondents) working Front of House (FOH); 184 (27%) working as Chefs and Food Preparation Assistants (C & FPA); 49 (7%) working in other roles (Baker, Delivery Driver, Storekeeper, Conference and Banqueting Staff); 22 (3%) working Back of House (BOH); and 6 (1%) no response.

^b Head Chefs, Managers and Supervisors (HC, M & S).

^c Examples of 'Other' includes: Bakeries, Butchers, Caterers, Take-away's, Cookery Schools, Nursing Homes, Hostels, Food Stores, Gelaterias, Cinema/Théâtres etc.

or above) – in fact, 44% of all HC, M & S surveyed reported qualifications at level 7 or higher (QQI, 2017).

Over half of all respondents (n = 374) were aged between 19 and 24 years of age (54%) and another 18% between 25 and 34 years; highlighting the large number of young adults working in this sector. In fact, the highest percentage (64%) of food handlers (excluding HC, M & S) surveyed, were found to be in the 19–24 years category; compared to the highest percentage (36%) of HC, M & S who were in the 35–44 years category.

The majority of individuals surveyed were employed in restaurants (29%), followed by hotels and café/delis, at 21% and 19%, respectively (Table 1). In relation to role, 44% of all respondents reported that they worked Front of House (FOH), 27% as chefs and food preparation assistants (C & FPA) and 18% as HC, M & S. In all establishments, the majority of respondents (43%) reported to have worked in the food sector for ≤ 2 years, compared to 7% reporting to have worked 16–25 years, or 6% more than 25 years, respectively (Table 2). In more specific terms, a distinct difference with regard to staff retention was noted when canteen workers (30% of their staff working for ≤ 2 years and 25% of their staff ≥ 25 years), were compared to restaurants (37% working ≤ 2 years and 4% ≥ 25 years), hotels (42% working ≤ 2 years and 1% ≥ 25 years), and café/delis employees (54% working ≤ 2 years and 4% ≥ 25 years).

3.2. Knowledge scores

The overall knowledge score (KS) obtained in this study of 689 individuals working in the food service sector in Ireland was calculated at 73% (questions and answers are available in the supplemental section). In more specific terms, HC, M & S had an average KS of 80% and all other food handlers (excluding HC, M & S) a KS of 72%. Multiple Factor (Independent Variable) ANOVA was used to assess the effect of gender, age, establishment, role, education, years worked and level of food safety training on the score. A significant main effect was noted for role, years worked, level of food safety training, and place of work ('establishment') (all p-values < 0.01). However, gender, education and age

Table 2
The Relationship between Place of work/Establishment and Years Worked in the food sector among 678^a surveyed in this study.

ESTABLISHMENT	≤ 2 years	2–8 years	8–16 Years	16–25 years	≥ 25 years	Total
Restaurant	73 (37%)	69 (35%)	29 (15%)	17 (9%)	8 (4%)	196 (29%)
Hotel	61 (42%)	60 (42%)	13 (9%)	8 (6%)	2 (1%)	144 (21%)
Café/Deli	69 (54%)	35 (28%)	10 (8%)	8 (6%)	5 (4%)	127 (19%)
Other ^b	44 (45%)	22 (22%)	16 (16%)	7 (7%)	10 (10%)	99(15%)
Canteen	17 (30%)	6 (11%)	11 (20%)	8 (14%)	14 (25%)	56 (8%)
Bar	30 (53%)	25 (45%)	0 (0%)	0 (0%)	1 (2%)	56 (8%)
TOTAL	294 (43%)	217 (32%)	79 (12%)	48 (7%)	40 (6%)	678 (100%)

^a Total number of respondents for this survey was 689, but 11 individuals did not complete this question.

^b Examples of ‘Other’ includes: Bakeries, Butchers, Caterers, Take-away’s, Cookery Schools, Nursing Homes, Hostels, Food Stores, Gelaterias, Cinema/Théâtres etc.

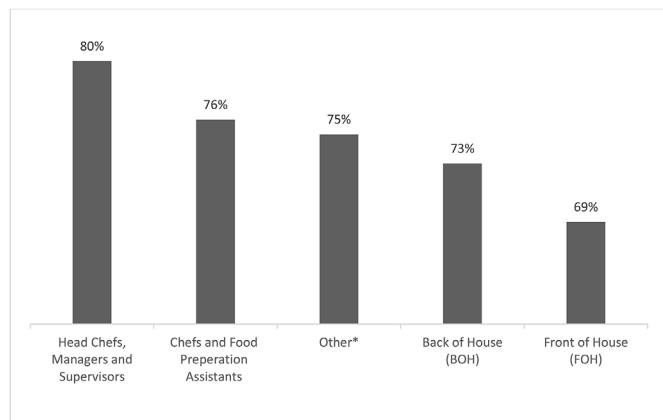


Fig. 1. The Percentage of Average Knowledge Scores (KS), by Role in the Food Sector, for all respondents who completed this survey (n = 689)

*Baker (n = 5), Trainee/Duty Manager (n = 5), Delivery Driver (n = 2), Storekeeper (n = 2), Conference & Banqueting Staff (n = 2), Butcher (n = 2), Cleaner (n = 2), Host (n = 1), Room Service (n = 1), Care Assistant (n = 1), Health & safety Manager (n = 1), Operations Manager (n = 1), Not specified (n = 2) - The following relationships were found to be statistically significant (adjusted p value < 0.05) when compared: 'Head Chefs, Managers & Supervisors' and 'Chefs & Food Preparation Assistants'; 'Head Chefs, Managers & Supervisors' and 'Others'; 'Head Chefs, Managers & Supervisors' and 'BOH'; 'Head Chefs, Managers & Supervisors' and 'FOH'; 'Chefs & Food Preparation Assistants' and 'FOH'.

were not found to be significant (p-value > 0.05); once the significant main effects were taken into account in the model. Post hoc tests (Tukey HSD) were performed to find the significant pairwise difference in means of the factor levels.

A significant difference (p-value < 0.001) in KS was noted between staff in the role of HC, M & S (80%, n = 124) and C & FPA by (76%, n = 184) (Fig. 1). The two categories with the lowest scores were from staff working back of house (BOH) with 73%, and front of house (FOH) with 69%. In more general terms, a statistically significant difference in KS was observed between staff FOH and the following: HC, M & S (p-value < 0.001), C & FPA (p-value < 0.001), and ‘Other’ roles (p-value < 0.001) - such as baker, delivery driver, storekeeper, conference and banqueting staff (Fig. 1). Similarly, a significant difference was recorded in KS between staff BOH, and individuals in HC, M & S roles (p-value < 0.01). Furthermore, a statistically significant relationship (p-value < 0.01) was also recorded between years worked and average KS. In particular, those working for 25 years (or more) scored the highest KS (84%, n = 40), compared to those working for ≤ 2 years who scored the lowest (70%, n = 294) (Fig. 2). In fact, a significant difference (p-value < 0.01) was noted between KS in individuals with 16–25 years experience and with ≥ 25 years experience, when compared to ≤ 2 years working in this sector. From a practical perspective, these findings suggest that good staff retention (allowing employees to

gain continual experience within a food business), will assist employers in having a knowledgeable workforce; thereby reducing the possibility of inadvertent contamination of food.

3.3. Level of training

Fifty nine percent of HC, M & S in this study reported to have received level 3 ‘food safety management training’ (levels as deemed by the FSAI 2016), compared an average of 21% of all other food handlers. It is notable that 28% of all individuals surveyed claimed not to have received any food safety training, suggesting insufficient compliance with this legislative requirement. Respondents who had ‘never’ received training scored, on average, 67% (n = 191), compared to an average of 80% (n = 179), for those who had completed level 3. Moreover, a significant difference in KS (p-values < 0.01) was found between respondents who reported to have ‘never’ received food safety training, versus those who completed any of the three levels of training (1, 2 or 3) outlined by the FSAI. Three percent of HC, M & S questioned reported to have ‘never’ received food safety training’, 18% of C & FPA, and on average, 41% of other food handlers (consisting of ‘BOH’, ‘FOH’ & ‘Other’, Table 3) questioned in this study. In summary, a more proactive approach should be taken by food business operators (FBO) to ensure that all food workers are trained in food safety, even if temporary, part-time or covering holiday leave.

3.4. Establishment

When place of work (or ‘establishment’) was examined (Fig. 3), individuals working in canteens were found to have the highest KS (81%), the highest percentage of level 3 training (60%) and the lowest percentage of individuals reporting to have ‘never’ received any food safety training (1%). A statistically significant relationship (p-value < 0.001) was noted between establishment worked in and KS; in particular the KS for canteens was found to be significantly higher than for hotels (p-value < 0.01), café/delis (p-value < 0.02) and bars (p-value < 0.001), but not for restaurants or ‘other’ establishments (e.g. bakeries, butchers, caterers, take-away’s, cookery schools, nursing homes, hostels, food stores, gelaterias, cinema/théâtres etc.) examined. Similarly, a significant relationship was observed between the type of establishment and the level of training acquired (p-value < 0.001). Notably, a lower percentage of level 3 training was reported in ‘Other’ establishments (31%), restaurants (26%), hotels (23%), and café/delis (22%), respectively, than for canteens (60%) (Table 3). In addition, a higher level of individuals who reported not to have received any food safety training, was noted in respondents working in hotels (30%), ‘Other’ establishments (27%), café/delis (29%), and restaurants (25%) respectively, compared to canteens (1%) (Table 3). In fact, the low percentage of canteen workers (1%) who reported to have never received food safety training, was significantly lower (p-value < 0.01) than for all other establishments examined in this study.

In contrast, individuals working in bars were found to have the

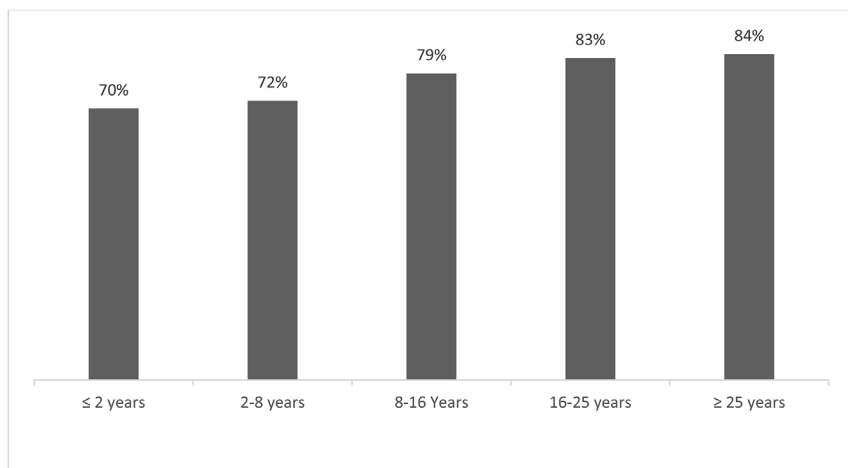


Fig. 2. The Percentage of Average Knowledge Scores (KS), by Years Worked in the Food Sector, for all respondents who completed this survey (n = 689)

- The following relationships were found to be statistically significant (p value < 0.01) when compared: ≤ 2 years and 16–25 years; ≤ 2 years and ≥ 25 years; 2–8 years and 16–25 years.

lowest KS (65%), the lowest percentage of level 3 training (5%) and reported the highest level of individuals who had ‘never’ received food safety training (61%). Notably, the KS for bars was found to be statistically lower than for canteens (p-value < 0.001), restaurants (p-value < 0.01) and many ‘other’ establishments (p-value < 0.03, Fig. 3) examined. However, no significant difference was found between the KS for bars and hotels, or café/delis. Lastly, the high percentage of bar workers (61%) who reported to have ‘never’ received food safety training, was significantly higher (p-value < 0.01) than for all other establishments examined in this study. The relationship between role and level of training in each type of establishment can be visualised in Fig. 4, e.g. HC, M & S can be seen to have the highest level of training in all establishments etc.

3.5. Examination of specific areas of operational food safety

If food handlers knowledge of critical limits is examined (without HC, M & S data), a large cohort of individuals were uncertain of critical limits with regard to cooking (66%), hot holding (47%), cold display

(57%), refrigeration (51%) and reheating (89%). In contrast the level of knowledge regarding correct critical limits was higher for HC, M & S with regard to cooking (63%), hot holding (81%), cold display (81%) and refrigeration (81%), but notably still remained low with regard to the knowledge of the minimum recommended temperature of food on reheating (≥70 °C) (19%) (Fig. 5). When the relationship between knowledge of critical limits was considered in line with various reported places of work or ‘establishments’, those working in canteens had the highest awareness (Fig. 6), with bars having the lowest. Moreover, a statistically significant relationship was noted between knowledge of critical limits and the establishments examined in this study (p-value < 0.01) - suggesting that training could be improved among certain targeted cohorts in this regard, in the future.

Seventy two percent of respondents (n = 498, 53% of HC, M & S and 76% of food handlers) were unfamiliar with Regulation (EC) No. 852/2004 Hygiene of Foodstuffs, and 19% (n = 134, 11% of HC, M & S and 21% food handlers) did not know what the acronym HACCP stood for. HC, M & S knowledge of foodborne pathogens was found to be as follows: 98% reported to be familiar with *Salmonella*, 90% with *E. coli*,

Table 3

The relationship between the Role, Establishment and level of training reported for all respondents who completed this survey (n = 689).

ROLE/ESTABLISHMENT	NEVER	LEVEL 1	LEVEL 2	LEVEL 3	TOTAL
Front of House	135 (44%)	78 (26%)	56 (18%)	35 (12%)	304 (45%)
C & FPA ^a	33 (18%)	41 (22%)	52 (29%)	56 (31%)	182 (27%)
HC, M & S ^a	4 (3%)	24 (19%)	23 (19%)	73 (59%)	124 (18%)
Other ^b	14 (30%)	15 (32%)	6 (13%)	12 (25%)	47 (7%)
Back of House	5 (23%)	10 (45%)	4 (18%)	3 (14%)	22 (3%)
No response					10
TOTAL	191 (28%)	168 (25%)	141 (21%)	179 (26%)	689 (100%)
Restaurant	50 (25%)	52 (26%)	43 (23%)	52 (26%)	197 (29%)
Hotel	45 (30%)	35 (24%)	33 (23%)	33 (23%)	146 (21%)
Café/Deli	37 (29%)	38 (29%)	26 (20%)	28 (22%)	129 (19%)
Other ^c	27 (27%)	21 (21%)	21 (21%)	30 (31%)	99 (14%)
Canteen	1 (1%)	8 (14%)	14 (25%)	34 (60%)	57 (8%)
Bar	34 (61%)	14 (25%)	5 (9%)	3 (5%)	56 (8%)
No response					5
TOTAL	194 (28%)	168 (25%)	142 (21%)	180 (26%)	689 (100%)

- A significant difference in KS (p-values < 0.01) was found between: (i) respondents who reported to have ‘never’ received food safety training, compared to those who completed any of the three levels of training (1, 2 or 3) (FSAI 2015b, 2016) (ii) Canteens workers who reported to have ‘never’ having received food safety training (1%), was significantly lower than for all other establishments examined in this study and (iii) Bar workers who reported to have ‘never’ received food safety training, was significantly higher (p-value < 0.01) than for all other establishments examined in this study.

^a C & FPA: Chefs and Food Preparation Assistants, HC, M & S: Head Chefs, Managers and Supervisors.

^b Baker, Trainee/Duty Manager, Delivery Driver, Storekeeper, Conference & Banqueting Staff, Butcher, Cleaner, Host, Room Service, Care Assistant, Health & safety Manager, Operations Manager.

^c Examples of ‘Other’ includes: Bakeries, Butchers, Caterers, Take-away’s, Cookery Schools, Nursing Homes, Hostels, Food Stores, Gelaterias, Cinema/Théâtres etc.

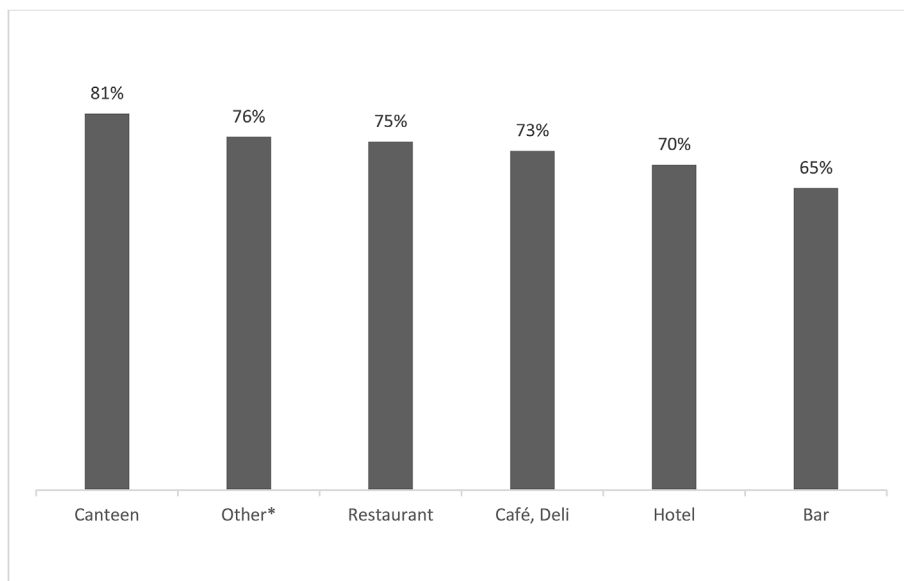


Figure 3. The Percentage of Average Knowledge Scores (KS), by Place or Work/Establishment, for all respondents who completed this survey (n = 689)

*Examples of ‘Other’ includes: Bakeries, Butchers, Caterers, Take-away’s, Cookery Schools, Nursing Homes, Hostels, Food Stores, Gelaterias, Cinema/Théâtres etc.-The following relationships were found to be statistically significant (adjusted p value < 0.05) when compared: Canteens and Café, Delis; Canteens and Hotels; Canteens and Bars; Others and Bars; Restaurants and Bars.

and 79% with *Staphylococcus aureus* - but only 72%, 71% and 58% had heard of *Bacillus cereus*, *Listeria monocytogenes* and *Campylobacter*, respectively. In addition, respondents were more familiar with foods associated with *Salmonella* (82%), and were the least familiar with foods associated with *Campylobacter* (17%). From a practical perspective, 89% of respondents understood that cooked rice stored incorrectly could cause illness, and 83% noted that salad splashed with raw chicken liquid must be discarded (as opposed to rinsed). However, on average, 13% of all respondents, (n = 93, 15% of HC, M & S, 17% of C & FPA and 13% food handlers) were unaware that eating undercooked minced meat could result in diarrhoeal illness.

Ninety three percent (n = 638, 94% of HC, M & S, 93% of C & FPA, and 92% of all other food handlers) recorded that it was unacceptable for a food handler who was suffering from diarrhoeal illness to handle ‘raw food’ prior to cooking, with 91% (n = 629, 95% of HC, M & S, 91% of C & FPA, and 90% of all other food handlers) noting that it was unacceptable to prepare ‘ready-to-eat food’ while suffering with diarrhoea/vomiting. Moreover, these responses suggest that 7% and 9%, respectively, of individuals surveyed considered these practices acceptable. In addition, 87% of food handlers agreed that handwashing was required after using the bathroom, even without a bowel movement, with 13% considering it an acceptable practice - highlighting important knowledge gaps among certain food workers. Furthermore, 39% of participants were unaware that disposable gloves could be a potential cause of contamination, although 86% reported to know that hands should be washed prior to putting on gloves; suggesting some level of knowledge with regard to their correct use.

3.6. Knowledge of allergens

Only 16% (n = 112) of respondents (30% of HC, M & S and 13% of food handlers) could list each of the 14 named allergens (as identified in Regulation (EU) No. 1169/2011) and only 51% of food workers (71% of HC, M & S and 46% food handlers) could list more than 7. The most commonly reported allergens included gluten (82%), nuts (80%), milk (79%) and eggs (66%) (Table 4). In contrast, molluscs (30%), lupin (34%), sesame seeds (35%) and SO₂/Sulphites (37%) were the least commonly listed.

Seventy four percent of respondents (85% HC, M & S, 71% food handlers and 73% bar staff, respectively) were aware that the answer “No written declaration, but staff are very knowledgeable and can tell customers what allergens are in the product/dish” is not acceptable, or a legal means of allergen declaration in Ireland. In addition, on average, 80%

of all respondents (82% of HC, M & S, 80% of food handlers and 79% of bar staff, respectively) also knew that beverage lists, including alcoholic beverages must contain allergen information.

4. Discussion

When the demographics of this study are compared in the context of recent Irish studies of the food hospitality sector (Bobek & Wickham, 2015; Failte Ireland, 2011), similar figures and trends are observed with regard to: gender (marginally more females), average age (nearly 90% of employees are under the age of 44 years in this study, under 50 years in Bobek & Wickham, 2015 survey), average level of education (42% having completed second level education/NFQ level 4/5 in this study; 44% in Bobek & Wickham, 2015 survey), and the establishments with the highest rate of employment (mainly restaurants, followed by hotels etc.). The alignment of the findings of this study, with previous Irish surveys, not only indicates that there has been little change in this sector (with regard to the cited parameters) over the last few years, but additionally suggests that the survey sample (n = 689) is generally representative of the Irish catering sector.

The overall knowledge score (KS) obtained in this study of 689 participants working in the food service sector in Ireland was 73%. While this figure is not directly comparable to other studies assessing knowledge among food workers (due to variations in questions, sampling, marking rubrics, methods of analysis etc.), it is, however, in-line with other reported surveys. For instance, previous studies examining KS in this sector report values of 71% for Switzerland (Panchal et al., 2013); 71% in Chicago (Panchal, Liu, & Dworkin, 2012); 71% for Serbia, Greece and Portugal (Smigic et al., 2016) and 76% for Austria (Pichler et al., 2014). A lower average score of knowledge and practice (62%) was also reported for food handlers employed in small businesses in Portugal (Gomes-Neves, Araújo, Ramos, & Cardoso, 2007).

It is notable that role, years worked, level of training, and associated establishment of employment were all found to have a significant effect (p-value < 0.01) on KS in this study; unlike gender, education and age, which were not found to be significant (p-value > 0.05) - once the significant main effects were taken into account in the model. HC, M & S were found to score the highest KS (80%) (Fig. 1), followed by C & FPA, ‘others’, BOH staff and FOH staff (scoring 76%, 75%, 73% and 69%, respectively). This is consistent with the fact that 59% of HC, M & S in this study reported to have received level 3 management training; as recommended for all food safety decision makers e.g. chefs, managers etc., in Ireland (FSAI, 2016). This finding is in agreement with

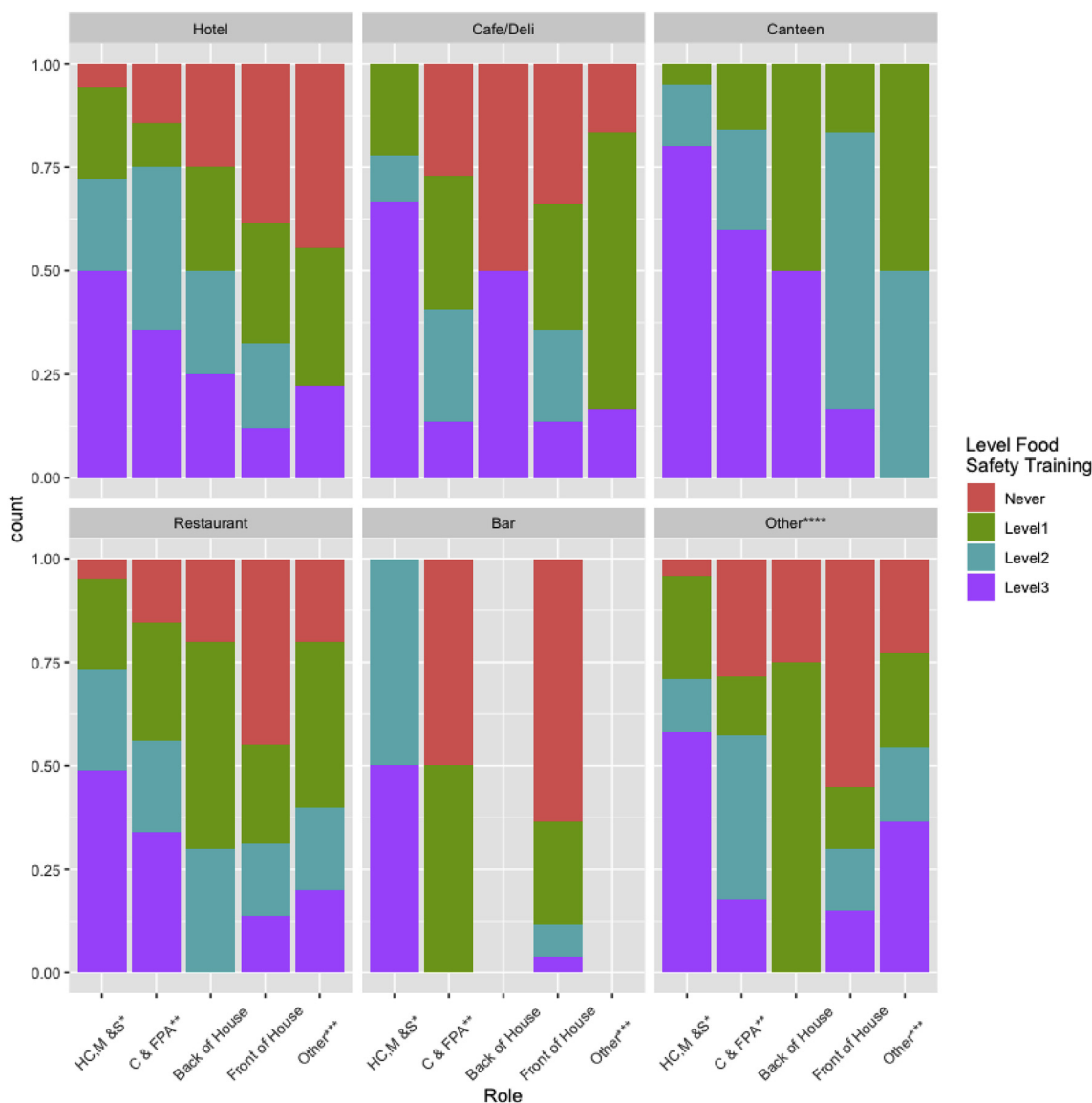


Fig. 4. The Relationship between Establishment, Role and Food Safety Training

*HC, M & S: Head Chefs, Managers and Supervisors

**C & FPA: Chefs and Food Prep. Assistant

*** Examples of 'Other' includes Baker, Trainee/Duty Manager, Delivery Driver, Storekeeper, Conference & Banqueting Staff, Butcher, Cleaner, Host, Room Service, Care Assistant, Health & safety Manager, Operations Manager

****Examples of 'Other' includes: Bakeries, Butchers, Caterers, Take-away's, Cookery Schools, Nursing Homes, Hostels, Food Stores, Gelaterias, Cinema/Théâtres etc.

similar studies conducted in other countries including, the US, India, Austria and Nigeria who report significantly higher KS for certified managers, than food handlers (non-management); including higher overall inspection scores following formal training of managers (Adesokan, Akinseye, & Adesokan, 2015; Dudeja, Singh, Sahni, Kaur, & Goel, 2017; Panchal et al., 2012; Pichler et al., 2014). Panchal et al. (2012) also report a direct relationship between KS and the frequency of time spent cooking food (assisting these individuals in retaining pertinent information such as critical limits), in contrast to individuals in other roles. Respondents working FOH were found to have the lowest KS, and to be less aware of critical limits than other food workers (Fig. 5); specifically knowledge regarding reheating (8%) and cooking temperatures (17%), followed by cold display (32%), refrigeration (38%) and hot holding (39%). Panchal et al. (2012, 2013) also observed that food handlers not working directly with food, were often unaware of specific time and temperature criteria. While FOH staff may not be involved in food preparation, they are often responsible for the

supervision of hot & cold buffets. It is therefore important that they are knowledgeable of the associated critical limits, with regard to their allocated activities, in order to prevent the proliferation of pathogenic bacteria.

In more general terms, a lack of knowledge (17–63% depending on the cohort examined) regarding the exact recommended minimum cooking temperature and, even more so, a lack of certainty (8–20%) in relation to the recommended minimum reheating temperature was noted among all respondents (Fig. 5). This observation included HC, M & S, with 63% answering the correct minimum cooking temperature ($\geq 75^\circ\text{C}$, or 70°C for 2 min etc.), and 19% recording the correct minimum reheating temperature ($\geq 70^\circ\text{C}$) in this study. However, this is only an observation on knowledge regarding two specific parameters among HC, M & S, and possible variations in the information disseminated by food safety trainers, and not necessarily a reflection of existing cooking practices. In reality, these food workers cook and re-heat dishes to much higher temperature e.g. until piping hot, boiling,

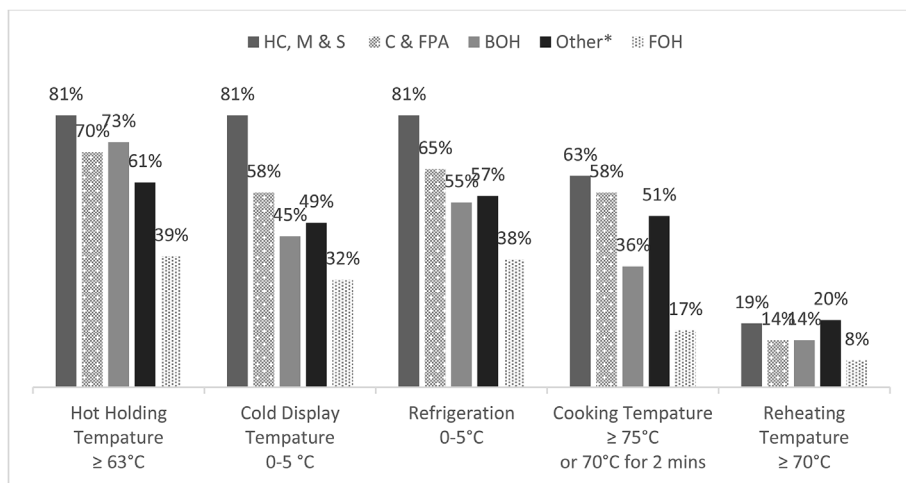


Fig. 5. Examination of Knowledge of Critical Limits (Temperature) by Role for all respondents who completed this survey (n = 689)

*'Other' consists of: Baker (n = 5), Trainee/Duty Manager (n = 5), Delivery Driver (n = 2), Storekeeper (n = 2), Conference & Banqueting Staff (n = 2), Butcher (n = 2), Cleaner (n = 2), Host (n = 1), Room Service (n = 1), Care Assistant (n = 1), Health & safety Manager (n = 1), Operations Manager (n = 1), Not specified (n = 22)

- HC, M & S: Head Chefs, Managers and Supervisors; C, & FPA: Chefs, Food Prep. Assistant; BOH: Back of House and FOH: Front of House

- While minimum thresholds temperature were requested and corrected against defined critical limits in this study, they were marked against agreed Irish guidelines (FSAI, 2012; NSAI, 2015) with a 2 °C allowance (on the side of food safety) to allow for in-build margins of errors within a food business e.g 70–72 °C were acceptable for a recommended > 70 °C reheating temperature, similarly 75–77 °C were acceptable ≥ 75 °C etc.

steaming, when colour change occurs when cooking etc. - depending on the food product and the associated processing step. That said, a greater awareness of the absolute minimum temperature parameters would be preferable among all individuals with a role in food preparation. It is worth noting that when minimum threshold temperatures were requested and corrected against defined critical limits in this study (as per Irish guidelines: (FSAI, 2012; NSAI, 2015), a 2 °C allowance (on the side of food safety) was accepted in order to accommodate pre-existing in-built margins of errors within the associated food businesses. For example, answers with values of ≥70, ≥71, or ≥72 °C were acceptable for a recommended ≥70 °C reheating temperature, similarly ≥63, ≥64, or ≥65 °C were acceptable for ≥63 °C hot-holding temperature. Given that the FSAI recommend that “time-temperature controls, to prevent and control bacterial growth” (FSAI, 2015a) should be demonstrated by a food handler within 3–12 months (level 2) of employment, a knowledge of critical limits should be a priority for all individuals working in this sector. When place of work (or ‘establishment’) was examined, individuals working in canteens were found to have the highest KS (81%, compared to the average of 73% for all other establishments examined), the highest percentage of level 3 training (60%, compared to an average of 21% for all other establishments), and the lowest percentage of individuals reporting ‘never’ having received

Table 4

The Percentage of Food Workers (n = 689) who were able to list each of the 14 Food Allergens as Per Regulation (EU) No. 1169/2011 surveyed in this study.

Allergen	Food Handlers (except HC, M & S ^a)	HC, M & S ^a	All Respondents
Gluten	81%	84%	82%
Nuts	80%	78%	80%
Milk	79%	81%	79%
Eggs	64%	73%	66%
Crustaceans	55%	69%	57%
Fish	50%	73%	54%
Soybeans	52%	65%	54%
Celery	42%	69%	47%
Peanuts	36%	58%	40%
Mustard	34%	57%	38%
SO ₂ /Sulphites	31%	60%	37%
Sesame seeds	31%	54%	35%
Lupin	28%	61%	34%
Molluscs	26%	50%	30%

^a HC, M & S: Head Chefs, Managers and Supervisors.

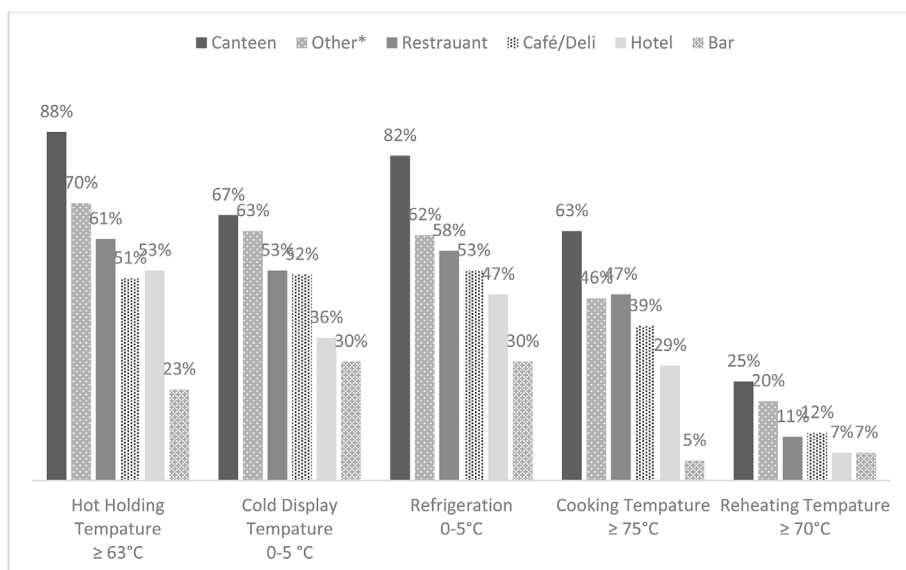


Fig. 6. Examination of Knowledge of Critical Limits (Temperature) by Establishment for all respondents who completed this survey (n = 689)

*Examples of ‘Other’ includes: Bakeries, Butchers, Caterers, Take-aways, Cookery Schools, Nursing Homes, Hostels, Food Stores, Gelaterias, Cinema/ Théâtres etc.

- While minimum thresholds temperature were requested and corrected against defined critical limits in this study, they were marked against agreed Irish guidelines (FSAI, 2012; NSAI, 2015) with a 2 °C allowance (on the side of food safety) to allow for in-build margins of errors within a food business e.g 70–72 °C were acceptable for a recommended ≥70 °C reheating temperature, similarly 75–77 °C were acceptable ≥ 75 °C etc.

- A statistically significant relationship was noted between knowledge of critical limit sand the establishments examined in this study (p-value < 0.01).

food safety training' (1%, compared to an average of 34% for all other establishments). Similarly, canteens reported the highest percentage of individuals working 16–25 years and ≥ 25 years; which is in line with the fact that a direct and significant relationship (p -value < 0.01) was observed between KS and 'Years Worked' in this sector (Fig. 2). While many studies in other countries (Akabanda, Hlortsi, & Owusu-Kwarteng, 2017; Sharif, Obaidat, & Al-Dalalah, 2013; Vo, Le, Le, Tran Minh, & Nuorti, 2015) have examined institutional food safety practices, only one study (Da Cunha, Rosso, & Stedefeldt, 2018) directly comparing food safety performance in institutional food premises with other food businesses was found. Da Cunha et al. (2018) reported a higher score (by using a food safety checklist) for hospitals (84%) and schools (86%) in Brazil, compared to commercial food premises (50–68%) examined. Da Cunha et al. (2018) findings are aligned with this study, and similarly suggest a strong food safety culture in the institutional food premises examined. Furthermore, this study and Da Cunha et al. (2018) paper suggest a possible link between food safety training, job satisfaction/staff morale, and staff retention. While this relationship has been previously proposed (Poulston, 2008), further investigation is required to understand exactly why canteens were observed to have comparatively more individuals working in this sector for longer.

A significant (p -value < 0.01) relationship was observed between training and food safety knowledge in this study. It is widely agreed that food safety training is an effective tool for improving knowledge which is fundamental to proper hygiene practices (Gormley, Rawal, & Little, 2012; Hislop & Shaw, 2009). A direct relationship between training and knowledge, attitudes and practice has also been reported in other studies conducted in Malaysia, Nigeria, India, Portugal and Vietnam (Abdul-Mutalib et al., 2012; Adesokan et al., 2015; Dudeja et al., 2017; Gomes, Lemos, Silva, Hora, & Cruz, 2014; Oi Nee & Abdullah Sani, 2011; Vo et al., 2015). In addition, guidance and supervision by managers and supervisors during work improves attitudes and practices (Egan et al., 2007). It is notable, however, that 28% ($n = 191$) of respondents in this study claimed to 'never' have received any food safety training.

Food safety training is an intricate part of food safety management and food handlers must be "supervised, instructed and/or trained commensurate with their work activity", under EU food law (Regulation (EC) No. 852/2004). While flexibility exists regarding the type of 'training' undertaken by food businesses (e.g. in-house training, external training, online training, blended learning etc.), training must be provided. In Ireland, the competent authority (FSAI) has published national guides for food safety training, to assist industry with meeting training requirements (FSAI, 2015a; FSAI, 2016). These guides provide the skills that should be demonstrated by food handlers depending on the length of time they have spent in the food sector, and their roles and responsibilities; and should be used by employers to assist them in meeting their legal requirements in this regard.

It is important for food workers to be aware of microbiological hazards so that they can be effectively controlled. When specific questions regarding foodborne pathogens were asked in this study, HC, M & S, reported being familiar with *Salmonella* (98%), *E. coli* (90%) and *L. monocytogenes* (71%). Similarly, Bolton et al. (2008) reported that head chefs and catering managers were more familiar with pathogens like *Salmonella* (100%) and *E. coli* (98%), than *L. monocytogenes* (84%), in a previous Irish survey. Interestingly, only 43% of food handlers (excluding HC, M & S) in this study were familiar with *L. monocytogenes*, as oppose to *Salmonella* (94%) and *E. coli* (87%). Notably, 13% of all respondents were unaware that eating undercooked minced meat can result in diarrhoeal disease. This is comparable to a study conducted by Pichler et al. (2014) in Austria, where 17% of those asked (managers and food handlers) were unaware of this fact when the same question was posed to them. Moreover, higher figures have been reported when this question was presented in other studies, e.g. 31% of head chefs & food handlers in Switzerland and 41% of food handlers in Chicago

(Panchal et al. (2012, 2013). Raw and inadequately cooked meat may harbour pathogens such as *E. coli* O157, O26, O111 (and other VTEC serotypes), and a lack of knowledge regarding this pathogen may lead to improper handling or cooking practices that could place customers at risk of foodborne disease (FSAI 2013). The overriding principle that eating raw or undercooked minced beef/beef burgers can cause illness is well-established, and many VTEC related outbreaks and fatalities have been documented in Europe (Doorduyn et al., 2006; Gormley et al., 2012; Soborg et al., 2013) and elsewhere (King et al., 2014; Torso et al., 2015; Yahata et al., 2015). Previous Irish studies have reported a prevalence of 2.8% for *E. coli* O157 in raw minced meat/beef burgers (Cagney et al., 2004); and 0.25% for *E. coli* O111 and O26 (FSAI, 2004). These figures reinforce the importance of applying stringent cooking criteria for these products (Duffy, Walsh, Blair, & McDowell, 2006; Walsh and Leva., 2018), and highlight a knowledge gap which should be more adequately explained, and addressed, in food safety training in Ireland and elsewhere.

A relatively high proportion of respondents (93%), (similar to 88% reported by Panchal et al., 2013), considered it to be unacceptable for a food handler who is suffering from diarrhoeal illness to handle raw food prior to cooking; suggesting 7% (6% of all HC, M & S surveyed) consider this practice acceptable. Similarly, 91% reported it was unacceptable to prepare ready-to-eat food while suffering with diarrhoea/vomiting, suggesting 9% (5% of all HC, M & S all surveyed) consider this practice acceptable. These findings are notable, as based on these data, almost 1 in 10 respondents surveyed and approximately 1 in 20 individuals in the role of HC, M & S believe that it is an acceptable practice to handle food while unwell. Several studies have observed an association between ill food workers and outbreaks of foodborne illness (Gormley et al., 2012). In addition, 87% of food handlers agreed that handwashing was required after using the bathroom, even without a bowel movement, suggesting that 13% of all respondents (again, approximately 1 in 10 food handlers) do not feel compelled to wash their hands every time they use the facilities. This suggests a lack of understanding of the role of clean hands in hygienic and safe food production in this particular cohort, and the potential for unclean hands to cause foodborne infection. The importance of good hand hygiene and the correct use of single-use gloves should be emphasised by trainers, managers and supervisors alike, to reinforce good practice among food workers and to prevent foodborne disease.

The prevalence of food allergies is reported to be increasing in both developed and developing countries (Loh & Tang, 2018). When food handlers were asked to list the 14 foods designated as allergens in EU food law (as per Regulation (EU) No. 1169/2011), only 16% of respondents could list them; with 51% of respondents naming 7 or more. It was noted, however, that asking participants to identify allergenic foods from a list (rather than recalling them from memory - as per this survey question), would most likely have resulted in a higher level of recognition among respondents. Interestingly, only 40% of participants in this study recorded peanut as an allergen, while 80% noted 'nut', highlighting not only a knowledge gap in this area but possible confusion regarding the terms peanut (grown in the ground) and tree nuts (e.g. almonds, hazelnuts, walnuts, cashews, pecans, brazil nuts, pistachios, macadamia nuts etc.). The importance of appropriate identification and handling is underpinned by a Safefood report (Safefood, 2013) which indicates that peanut and tree nut are among the five most reported food allergies in the Republic of Ireland; along with egg, crustaceans and milk. This is consistent with global trends, which suggest that the most common allergens in children under 5 years of age include cow's milk, egg, peanuts and seafood (Prescott et al., 2013).

While 79% of respondents identified milk as an allergen, only 57% included crustacean and 66% egg, suggesting more focus is required to ensure that food handlers can recognise and correctly identify the food allergens named in EU food law. A lack of understanding regarding these 14 allergens, will not only result in consumers receiving misinformation, but also a lack of appropriate implementation of food

safety management practices to prevent inadvertent cross-contamination - potentially putting allergen sufferers at risk.

In Ireland, FBO are also required to make written allergen information available (as per Statutory Instrument (S.I.) 489 of 2014), at the point of presentation, sale or supply. Seventy four percent of respondents were aware that allergen declaration must be in a written format, which is in line with findings from a recent FSAI audit of 50 premises (FSAI, 2017); in which 68% were found to comply with written allergen information. However, the majority (88%) of food businesses examined in this FSAI audit required some form of corrective action due to incomplete and inaccurate allergen information. The prevalence of food allergies on the Island of Ireland is considered to be similar to that in the UK; with 1–2% of adults and 5–8% of children reported to be affected (IFAN, 2018; SafeFood, 2017). Severe allergic reactions can be life threatening, with available data for the UK, confirming at least six fatal incidents of food related anaphylaxis each year (SafeFood, 2017). When the figures regarding the lack of compliance are considered in the context of food allergy prevalence and the potential health risks to this population, it is clear that a greater awareness and compliance is required by the food service sector in this regard. This, in turn, highlights the importance of allergen training and its appropriate implementation, in order to produce safe food for all.

5. Conclusion

Many data sources (in the EU and globally) have indicated that poor food handling practices are a leading cause of foodborne illness (Adesokan et al., 2015; Bolton et al., 2008; NCEH 2012). In fact, inadequate cooking, reheating and inappropriate storage (temperature abuse) have been linked with many foodborne outbreaks worldwide (Brown, Hoover, Selman, Coleman, & Schurz Rogers, 2017; Gould, Roosenblum, Nicholas, Phan, & Jones, 2013; NSW Food Authority, 2011). From this perspective appropriate food safety knowledge regarding operational prerequisite hygiene practices such as those examined in this study (e.g. critical limits, allergen awareness, and not working while unwell etc.) are important to safeguard food production both locally and globally.

It is noteworthy that a high level of training was reported among individuals working in canteens (60% had completed level 3 training, with only 1% reporting to having ‘never’ received any training); which was underpinned by this cohort achieving the highest KS score (81%) in this study. This is consistent with previous findings (Da Cunha, Stedefeldt, & De Rosso, 2012; Da Cunha et al., 2018; Rossi et al., 2017) and highlights (and models) a strong food safety culture that should be investigated more thoroughly; to understand the intrinsic factors involved.

It was notable that 28% of all respondents claimed to have not received any food safety training. Whether informal training was completed (and possibly forgotten) by this cohort or not, these employees did not believe that they had received adequate food safety training. FBO have a legal responsibility to ensure this requirement is being met. In addition, they should check that training is implemented correctly and encourage high standards of hygiene (and their associated practices) where possible. Moreover, while appropriate training is important from a public health perspective, it is also essential for the underlying commercial viability of a food business. Further benefits include assisting companies in becoming more efficient, competitive and profitable, raising performance standards, promoting the company image, increasing staff morale, and reducing waste (FSAI, 2015b). Fact sheets on food safety published recently by the World Health Organization (WHO, 2018b) continue to promote the “Five Keys to Safer Food” (WHO, 2006) as the basis for educational programmes. In an increasingly globalised world, training food workers in safe food handling practices is one of the most critical interventions in the prevention of foodborne illnesses (WHO, 2018a). Consequently, trainers should consider focusing more closely on the identified knowledge gaps

highlighted in this study.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.foodcont.2019.05.023>.

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