Food safety knowledge and climate in the university canteens of three European countries

Sanja Vidaček Filipec,[1] Petra Ratković,[1] András Bittsánszky,[2,3] András József Tóth,[2,3] João PM Lima,[4] Ada Rocha[5]

[1]Faculty of Food Technology and Biotechnology, University of Zagreb, Croatia; [2]Indere Institute for Food System Research and Innovation Ltd, Budapest, Hungary; [3]Digital Food Chain Education Research Development and Innovation Institute, University of Veterinary Medicine, Budapest, Hungary; [4]GreenUPorto - Sustainable Agrifood Production Research Center, ciTechCare - Center for Innovative Care and Health Technology, Pedagogical and Scientific Unit of Dietetics and Nutrition, Coimbra Health School - Polytechnic Institute of Coimbra, Portugal; [5]GreenUPorto - Sustainable Agrifood Production Research Center, Faculty of Nutrition and Food Sciences, University of Porto, Portugal

Abstract

The association of food safety knowledge and climate with gender, education level, length of employment, food safety training, and professional role was measured using a 15-item food safety climate survey and a 20-item food safety questionnaire on a sample of 263 employees from 19 small and medium-sized university canteens in Croatia, Hungary, and Portugal. The relationship between knowledge and climate and the demographic determinants of both variables were examined. Food safety knowledge was inadequate (45.5% of correct responses), while perceptions of food safety, as measured by the food safety climate survey, were positive (2.69 out of a maximum of 3.00). The perception of resources in canteens was the least favorable across all countries. Leaders did not exhibit better food safety knowledge or perceptions. Food safety climate and knowledge were significantly positively correlated and influenced by training. Perceptions of food safety compared to employee knowledge levels indicated that some employees were overly optimistic about food safety risks. Therefore, food safety knowledge and food safety climate should be assessed in parallel, and both could be improved through ongoing training of employees, especially leaders.

Correspondence: Sanja Vidaček FIlipec, Faculty of Food Technology and Biotechnology, Pierottijeva 6, 10000 Zagreb, Croatia.
Tel.: +385 1 4605 099 - Fax: +385 1 4605 072.
E-mail: svidacek@pbf.hr

Key words: food safety knowledge, food safety climate, demographic characteristics, university canteens.

Contributions: SVF, AR, idea; PR analyzing data from Croatia; AB, AJT, analyzing data from Hungary; JPML, AR, analyzing data from Portugal; SVF, PT, interpretation of data of all countries; SVF, AB, AR, manuscript draft; SVF, manuscript final form.

Conflict of interest: the authors declare no potential conflict of interest.

Ethics approval and consent to participate: the research was approved by the Ethical Committee in Portugal (CE19114, approved on 30.5.2019).

Funding: this research was supported by national funds through FCT - Foundation for Science and Technology within the scope of UIDB/05748/2020 and UIDP/05748/2020.

Availability of data and materials: data and materials are available from the corresponding author upon request.

Received: 28 June 2022.
Accepted: 24 May 2023.
Early: 11 July 2023

Italian Journal of Food Safety 2023; 12:10580
doi:10.4081/ijfs.2023.10580

Introduction

For decades, food safety training has been the primary tool to improve the food safety knowledge of food handlers, as improved knowledge leads to increased awareness and safe food handling practices. However, training and knowledge are not the only determinants of safe practices (McIntyre *et al*., 2013; Al-Akash *et al*., 2022). The importance of a food safety culture in ensuring food safety was recently recognized by European legislation, which states that all food business operators should establish, maintain and provide evidence of an appropriate food safety culture (European Commission, 2021). Food safety culture is defined as a long-term construct that exists at the organizational level and impacts the food safety performance of the organization. On the other hand, food safety climate is a temporary construct existing at the individual level, relating to the perception and attitudes of individuals (Sharman *et al*., 2020). It is assessed through surveys in which employees tick how much they agree with various statements (indicators) on different categories such as leadership, communication, commitment, resources, and risk awareness or hazard awareness (De Boeck *et al*., 2015). Food safety climate may be influenced by subjective parameters, such as motivation or burnout at work (De Boeck *et al*., 2017), demographic (Ellis *et al*., 2010), or national cultural values (Tomasevic *et al*., 2020).

In the Croatian and Hungarian food industries, food safety climate has recently been assessed and discussed in terms of national cultural values (Tomasevic *et al*., 2020), but the study did not focus on food service units, which are more frequently involved in food safety incidents than the larger establishments (EFSA, 2021).

Cross-national studies on food safety knowledge have rarely been conducted (Smigić *et al*., 2016). Thus, this paper aims to assess whether and to what extent food safety knowledge and climate negatively affect food safety in university canteens in Croatia, Hungary, and Portugal. The results are discussed in terms of the relationship of knowledge and climate with demographic values, and countries.

Materials and Methods

The relationship of food safety knowledge and climate with gender, education level, length of employment, food safety training, and role (demographic parameters) was examined using a 15-item food safety climate survey and a 20-item food safety questionnaire. The sample included food handlers in 19 public university canteens with less than 30 employees from Croatia, Hungary, and Portugal. The canteens varied in size (7-29 employees). All kitchens were cooking facilities, which means meals were prepared from raw materials, and several thermally processed dishes were prepared daily. Employees cleaned the equipment after their work shift according to cleaning protocols. Food handlers participated in this study by anonymously completing questionnaires on food safety knowledge and self-assessment surveys about food safety climate. A total of 290 workers in 9 university canteens in Croatia (Zagreb), 3 in Hungary (2 in Budapest, 1 in Gödöllő), and 7 in Portugal (5 in Porto, 1 in Coimbra, and 1 in Aveiro) participated in this study. Canteen managers in each country approved the questionnaires/surveys and confirmed that food handlers would understand the questions.

Questionnaire development

The tools from previously conducted research on food safety climate and knowledge were used in the initial phase. The tools were then modified to reduce the time for completion to 15 minutes. In addition, some new categories and questions were added as they were deemed important for the food handlers in the canteens. The final structure was approved by the Ethical Committee in Portugal (CE19114, approved on 30.5.2019).

Survey content

The survey was divided into 3 parts. The first part examined the demographic characteristics of food handlers (gender, education degree, total and current work experience, training, and role within the establishment). The second part of the survey was the food safety knowledge questionnaire, which assessed employees' knowledge of cross-contamination, refrigeration, cooking, and cleaning. The questionnaire contained a total of 20 questions; it used 2 types of questions: some could be answered with "correct", "incorrect" or "I don't know", and others with multiple-choice answers. Out of the 20 questions, 14 were used in previous studies (Pichler *et al*., 2014; Smigić *et al*., 2016; Moreb *et al*., 2017); 6 questions were added to assess specific knowledge about temperature control, cleaning, and *Listeria monocytogenes*. The third part, the survey on food safety climate, included 15 statements (indicators) to assess food safety climate, *i.e.*, employees' opinions on food safety in the facility where they are employed. The survey was divided into 5 categories: communication, commitment, risks, resources, and documentation. The indicators in the first 4 categories were taken from the previously developed food safety climate tool (De Boeck *et al*., 2015). Additionally, employees' opinions on the use of written procedures and mandatory checklist completion requirements were assessed and designated as the documentation category. Since the instrument originally developed by De Boeck *et al*. (2015) was drastically modified, internal consistency was calculated using Cronbach's a (CA), which is a measure of scale reliability. The resulting scores were all above the threshold for reliability (CA>0.60). Respondents indicated on the Likert scale (1-3) how much they agreed with certain statements (I do not agree-1, I partially agree-2, I agree-3).

Data analysis

The results of the questionnaires and surveys were analyzed in SPSS 17.0 (IBM, Armonk, USA). Two new variables were calculated: the mean values of answers from the food safety climate survey [mean climate (MC)] and the percentage of correct answers from the food safety knowledge questionnaire [knowledge score (KS)]. KS was calculated by dividing the number of correct answers by 20, *i.e*., the total number of questions. The final version of the food safety climate survey had 6 indicators that could be viewed as objective indicators, *e.g*., indicators 3, 7-9, 13 and 15 (Table 1), while the others could be considered more subjective observations on communication, commitment, and risks; the mean values of the results of objective and subjective indicators were calculated and coded as MCobj and MCsubj.

The distribution of respondents' answers in all question categories was determined and the normality of variable distribution was tested. The statistical tests employed afterward were performed to examine the relationship between MC and KS and demographic characteristics. The non-parametric Mann-Whitney and Kruskal Wallis tests were used to test MC. Since KS was a normally distributed continuous variable, a t-test and one-factor analysis of variance with a post-hoc Tukey test were used. To determine the correlation between the variables, Spearman's rho was calculated.

Results and Discussion

Food safety knowledge/climate scores and demographic determinants

Of the 290 surveys collected, 263 were valid, *i.e*., fully completed (113 from Croatia, 121 from Portugal, and 29 from Hungary), as reported in Table 2. The mean KS was 45.5%. Similar studies were previously conducted in school canteens in Portugal and Hungary and had higher KS values than in this study, *e.g*., 66.1% in Portugal and 69.6% in Hungary (Santos *et al*., 2008; Toth *et al*., 2014). The lower score found in this study could be partially explained by the higher difficulty of the questions (most were multiple-choice and only a few questions were obvious or general knowledge); however, the knowledge level was still low. The inadequate knowledge could not be explained by the nature of the activities in the kitchens, or the size of the canteens (data not shown). A significant association ($p<0.05$) was found between KS with total work experience and KS with training. It was found that both types of mandatory training had a significant impact on KS. A direct relationship between training and employees' food handling knowledge was expected and confirmed in other studies (Santos *et al*., 2008; Gruenfeldova *et al*., 2019).

In contrast with KS, MC was quite high (2.69 out of a maximum of 3.0), indicating that food handlers perceive the food in their facilities to be safe. High climate scores appear to be common in food establishments (Tomasevic *et al*., 2020). In addition to the

objective determinants of food safety climate, some other factors that could also result in the masked or over-positive results are fear of being honest and possibly losing one's job or the trust of managers, superficial approach in completing the surveys due to lack of time or interest, *etc*.

In terms of demographic determinants, this study found that in-house training conducted by leaders was a statistically significant factor in the improvement of food safety perceptions. Therefore, the importance of training was demonstrated not only in the improvement of knowledge but also in perceptions of food safety, *e.g.*, organizational climate. The impact of other demographic parameters on the organizational culture was previously, but not often, studied in the food safety context.

In this study, the respondents with high school diplomas evaluated the climate better than the others, but a more general conclusion about the relationship between educational level and climate cannot be drawn from the results. Gender was expected to have an impact on the MC scores as female workers are more internally motivated to follow proper food handling procedures (Ellis *et al*., 2010). However, in this study, gender did not have an impact on the climate scores.

Differences in knowledge and climate scores between the countries

The best overall KS was obtained by the Croatian food handlers (54.2%), followed by the Hungarian and Portuguese ones (44% and 43.3%, respectively) as reported in Table 3 (Pichler *et al*., 2014; Smigić *et al*., 2016; Moreb *et al*., 2017). The low KS score in Hungary may be partially attributed to the relatively short duration of respondents' employment in these canteens, while in

Table 1. Food safety climate survey with mean scores by country. Indicators marked in italics are objective indicators of the food safety climate survey.

Food safety climate indicators	Mean N=263	Croatia (N=113)	Hungary (N=29)	Portugal (N=121)
Communication	2.64±0.46	2.7±0.45^{a}	2.62±0.56^{ab}	2.57±0.43^{b}
1. In my organization, the leaders are clear about the expectations concerning hygiene and food safety towards employees.	2.65±0.58	2.69±0.53^{a}	2.62±0.78^{a}	2.62±0.57^{a}
2. In my organization, my colleagues give their comments and remarks regarding hygiene and food safety to the leaders.	2.54±0.65	2.64±0.59^{a}	2.66±0.49^{a}	2.42±0.71^{b}
3. *In my organization, the importance of hygiene and food safety is permanently present by means of, for example, posters, signs and/or icons related to hygiene and food safety.*	2.73±0.57	2.80±0.53^{a}	2.59±0.63^{b}	2.70±0.60^{ab}
Commitment	2.80±0.38	2.89±0.28^{a}	2.55±0.60^{b}	2.78±0.36^{b}
4. In my organization, the leaders clearly consider hygiene and food safety to be of great importance.	2.91±0.36	2.97±0.22^{a}	2.62±0.68^{b}	2.92±0.33^{a}
5. My colleagues are convinced of the importance of hygiene and food safety for the organization.	2.74±0.50	2.86±0.40^{a}	2.45±0.63^{c}	2.70±0.53^{b}
6. In my organization, the leaders act quickly to correct problems/issues that affect hygiene and food safety.	2.75±0.53	2.82±0.45^{a}	2.59±0.73^{a}	2.73±0.54^{a}
Resources	2.49±0.51	2.46±0.53^{a}	2.51±0.62^{a}	2.51±0.46^{a}
7. In my organization, employees get sufficient time to work in a hygienic and safe way.	2.42±0.63	2.38±0.66^{a}	2.52±0.63^{a}	2.43±0.60^{a}
8. In my organization, the necessary infrastructure (e.g., good workspace, good equipment...) is available to be able to work in a hygienic and food-safe way.	2.30±0.71a	2.18±0.76^{a}	2.38±0.78^{a}	2.39±0.63^{a}
9. In my organization, good procedures and instructions concerning hygiene and food safety are in place.	2.74±0.52a	2.81±0.44^{a}	2.62±0.68^{a}	2.70±0.57^{a}
Risks	2.76±0.40	2.80±0.32^{a}	2.59±0.57^{a}	2.75±0.42^{a}
10. In my organization, the risks related to hygiene and food safety are known.	2.78±0.50	2.77±0.50^{a}	2.69±0.60^{a}	2.81±0.47^{a}
11. In my organization, the risks related to hygiene and food safety are under control.	2.74±0.53	2.83±0.38^{a}	2.48±0.74^{b}	2.71±0.57^{ab}
12. My colleagues are alert and attentive to potential problems and risks related to hygiene and food safety.	2.75±0.47	2.82±0.41^{a}	2.59±0.57^{b}	2.72±0.50^{ab}
Documentation	2.77±0.36	2.87±0.25^{a}	2.52±0.53^{c}	2.74±0.37^{b}
13. In my organization, a checklist regarding temperature control is completed daily.	2.85±0.44	2.97±0.22^{a}	2.45±0.74^{c}	2.82±0.46^{b}
14. In my organization, my colleagues believe that it is important to complete the checklists regularly.	2.75±0.53	2.86±0.44^{a}	2.48±0.69^{b}	2.70±0.54^{b}
15. In my organization, my colleagues clean the equipment and apparatus according to the written cleaning schedule.	2.72±0.51	2.77±0.48^{a}	2.62±0.45^{a}	2.69±0.55^{a}
Overall	2.69±0.33	2.74±0.27^{a}	2.56±0.52^{b}	2.67±0.32^{ab}

N, number; ^{a,b,c}statistically significant differences between countries.

Portugal about 30% of employees did not receive food safety training (Table 2). The lack of training in Portuguese restaurants, bars, and school canteens has been previously reported (Santos *et al*., 2008; Smigić *et al*., 2016). Some knowledge gaps are similar across countries (*e.g*., the difference between the control measure and the corrective action). Overall, the largest knowledge gap is found in cooking, *e.g*., time-temperature control (KS=39.4%), which is a common knowledge gap also in other studies conducted in canteens (Tóth *et al*., 2017; Gruenfeldova *et al*., 2019).

Regarding the differences in food safety climate scores, Croatian respondents perceive food safety climate better than respondents from Portugal or Hungary, with a significantly higher overall score than Hungary (Table 1). In all 3 countries, the indicator "In my organization, the necessary infrastructure (*e.g*., good workspace, good equipment...) is available to be able to work in a hygienic and food-safe way" was the least positively rated. This is often the least positively rated indicator in food safety climate studies (Tomasevic *et al*., 2020).

Relationship between knowledge and perception

Looking at the results as a whole, Croatian participants had the highest KS and climate scores, while knowledge and climate should be better in Hungarian canteens. However, when comparing the KS and climate scores in each country, the interpretation of the results may differ. Hungarian respondents seem to be more realistic about the risks in their establishments (as shown in the Risks category of Table 1), especially compared to Croatians. Croatian respondents did not know that *L. monocytogenes* is an important pathogen for their establishments: only 14.3% gave the correct answer, as reported in Table 3 (Pichler *et al*., 2014; Smigić *et al*., 2016; Moreb *et al*., 2017), although Croatian canteens are classified as high-risk establishments and scientific evidence suggests that *L. monocytogenes* poses a significant risk in retail and food service, including canteens (Dufour, 2011). However, Croatian food handlers mainly believed that the risks in their canteens were known and under control, suggesting that they were overly optimistic in their response. This phenomenon, in which people believe they are less likely to be affected by adverse events than others (*i.e*., optimistic bias) has been previously observed among food handlers (Rossi *et al*., 2017). Optimistic bias can have a negative impact on food safety because an overly optimistic food handler may overlook some procedures and consequently contaminate food.

The food safety climate survey revealed the level of commitment and communication regarding food safety, taking into particular consideration the role of leaders. It seems that Hungarian leaders do not consider hygiene and food safety to be as important as in the other 2 countries. This could influence the perceptions of

Table 2. Knowledge of food handlers and mean climate scores by demographic characteristics.

Demographic characteristics		Croatia	Hungary	Portugal	Total		
		N (%)	N (%)	N (%)	N (%)	KS	MC
	Total	113 (100)	29 (100)	121 (100)	263 (100)	45.5	2.69
Gender	Female	99 (87.6)	20 (69.9)	110 (90.9)	229 (87.1)	47.9	2.70
	Male	14 (12.4)	9 (31.0)	11 (9.1)	34 (12.9)	47.8	2.66
Education	Elementary school	20 (17.7)	7 (24.1)	52 (43.0)	79 (30.0)	47.6	2.63[a]
	High school	88 (77.9)	17 (58.6)	55 (45.5)	160 (60.8)	56.2	2.72[b]
	College	2 (1.8)	4 (13.8)	11 (9.1)	17 (6.5)	41.7	2.63[ab]
	University	3 (2.7)	1 (3.4)	3 (2.5)	7 (2.7)	50.1	2.54[ab]
Total work experience in the food sector	<2 years	8 (7.1)	6 (20.7)	17 (14.0)	31 (11.8)	40.0[a]	2.61
	2-8 years	11 (9.7)	9 (31.0)	16 (13.2)	36 (13.7)	50.1[b]	2.68
	9-16 years	12 (10.6)	7 (24.1)	22 (18.2)	41 (15.6)	47.7[ab]	2.69
	17-25 years	82 (72.6)	7 (24.1)	66 (54.5)	155 (58.9)	49.4[b]	2.72
Work experience at the current place	<2 years	26 (23.0)	10 (34.5)	30 (24.8)	66 (25.1)	46.9	2.74
	2-8 years	14 (12.4)	10 (34.5)	19 (15.7)	43 (16.3)	43.0	2.64
	9-16 years	15 (13.3)	4 (13.8)	21 (17.4)	40 (15.2)	49.1	2.69
	17-25 years	58 (51.3)	5 (17.2)	49 (40.5)	112 (42.6)	51.2	2.68
Official food safety training	Yes, organized by authorities	95 (84.1)	27 (93.1)	78 (64.5)	200 (76.0)	50.1[a]	2.69
	Yes, organized by others	14 (12.4)	2 (6.9)	12 (9.9)	28 (10.6)	48.3[a]	2.66
	No	4 (3.5)	0	31 (25.6)	35 (13.3)	38.0[b]	2.71
In-house food safety training	Yes, delivered by an external consultant	35 (31.0)	4 (13.8)	23 (19.0)	62 (23.6)	47.3[ab]	2.62[ab]
	Yes, delivered by my leader(s)	65 (57.5)	16 (55.2)	70 (57.9)	151 (57.4)	50.0[b]	2.73[a]
	No	13 (11.5)	9 (31.0)	28 (23.1)	50 (19.0)	42.3[a]	2.60[b]
Role	Leader	13 (11.5)	4 (13.8)	10 (8.3)	27 (10.3)	51.8	2.67
	Preparing food	68 (60.2)	24 (82.8)	105 (86.3)	197 (74.9)	46.3	2.68
	Serving food	32 (28.3)	1 (3.4)	6 (5.0)	39 (14.8)	51.2	2.77

N, number; KS, knowledge scores; MC, mean climate scores; [a,b]statistically significant differences in KS and MC between categories demographic characteristics, $p<0.05$.

Table 3. Food safety knowledge questionnaire with knowledge scores by country. Statements in bold are the correct ones.

Food safety knowledge questionnaire	Frequencies (%) - all countries			% of correct answers per country		
	Correct	Incorrect	I do not know	Croatia (N=113)	Hungary (N=29)	Portugal (N=121)
General knowledge and cross contamination	49.7	30.1	19.2	54.3±18.3[a]	54.0±23.0[a]	40,9±18,9[b]
Raw eggs may be stored above a prepared salad or cakes in the refrigerator. (Pichler *et al*. 2014) a) True; **b) False**; c) I do not know	82.4	9.2	4.8	89.9±30.2[a]	79.9±41.3[b]	76±42.9[b]
How to prevent Salmonella poisoning? (Moreb *et al*., 2017) **a) Fully heat food**; b) Wash food with hot water; c) Freeze food for more than 3 days; d) I do not know	67	12.8	14.7	84.9±35.8	68.1±41.3	47.2±50.1
Which of the following is most likely to become contaminated with *Escherichia coli*? (Moreb *et al*., 2017) a) Tap water; **b) Raw beef**; c) Raw vegetables; d) Raw eggs; e) I do not know	22.3	52.4	20.9	14.3±35.1	31.±47.1	28±45.1
Listeria monocytogenes is an important pathogen for the establishment where I work. (Pichler *et al*. 2014) **a) True**; b) False; c) I do not know	22.5	28.5	49	28.6±45.3[a]	20.7±41.2[c]	13.6±34.4[b]
At what temperature do pathogens best thrive? (Smigić *et al*., 2016) a) 10°C; b) 25°C; **c) 37°C**; d) 50°C; e) I do not know	16.8	53.8	22.3	23.5±42.9[a]	31±47.1[a]	7.2±26[b]
How should vegetables and fruits be washed? (Moreb *et al*., 2017) a) Soak in cold water, then wash; b) Soak in temperate water, then wash; **c) Wash with running cold water**; d) I do not know	68.5	23.8	3.3	68.1±46.8	82.8±38.4	65.6±47.7
Cooling	53.3	34.4	7.4	63.1±28.6[a]	43.1±26.7[b]	51±29.5[b]
How would you react if the temperature of chilled food, such as meat, cakes, *etc*. at delivery is too high (*e.g*., 12°C)? (Smigić *et al*., 2016) **a) Reject the delivery**; b) Immediately put the food in the refrigerator and chill it; c) I would consult with my supervisor; d) I would consult with my co-workers; e) I do not know	56.4	32.2	6.6	54.6±49.9	58.6±50.1	57.6±49.6
The temperature inside a refrigerator should be at or below which temperature? (Smigićć *et al*., 2016) a) 10°C; **b) 8°C**; c) -18°C; d) -25°C; e) I do not know	70	15.4	9.2	81.5±39[a]	75.9±53.5[ab]	57.6±49.6[b]
Cooked rice, if not chilled properly, is a high-risk food? (modified from Smigić *et al*., 2016) **a) True**; b) False; c) I do not know	47.6	39.2	8.8	58±49.5[a]	6.9±25.8[b]	47.2±50.2[a]
The least safe method of thawing raw meat is? (Moreb et al., 2017) a) In water; b) In a refrigerator; **c) On a counter**; d) In a microwave oven; e) I do not know	39.2	50.9	4.8	45.4±49.9	31±47.1	35.2±47.6
Cooking	39.3	40.2	14.7	40.3±23.3	36.2±23	42.3±24.9
Hot food must be kept above which temperature? (Smigić *et al*., 2016) a) 73°C; **b) 63°C**; c) 47°C; d) 22°C; e) I do not know	31.1	49.1	15.8	42.9±49.7[a]	31±47.1[a]	20±40.1[b]
When thermally processing food, measuring internal food temperature is (Smigić *et al*., 2016): a) Not important; b) Not important, as the procedure is standardized and time is measured; c) Important, so that time of cooking can be adjusted and thus energy can be saved; d) Important, so that foodstuffs do not lose nutritional value (*e.g*., are not overcooked); **e) Important, so that we know when harmful microorganisms are destroyed**; f) I do not know	42.1	37.4	15	39.5±49.1	51.7±50.8	42.4±49.6
Good practice for heating fats or oils is that it should not be heated above (Smigić *et al*., 2016): **a) 180°C**; b) 220°C; c) 250°C; d) 200°C; e) 150°C; f) I do not know	49.5	33.7	12.1	41.2±49.4[ab]	27.6±45.5[b]	62.4±48.6[a]
Which of the following would not be an example of corrective action? a) Continuing to cook a hamburger that has not reached a required internal temperature of 73°C; b) Throwing out potato salad that has remained at room temperature for more hours than is allowed; **c) Measure the temperature of cooking the food**; d) Rejecting a delivery of cakes received at an internal temperature of 12°C; e) I do not know	8.8	58.2	21.6	5.9±23.6	13.8±35.1	10.4±30.6
How many hours can a warm meal be kept before it is discarded? **a) Less than 4 hours**; b) Less than 6 hours; c) Less than 8 hours; d) I do not know	60.1	24.5	10.6	47.9±50.2[a]	58.6±50.1[ab]	72±45.1[b]
The correct minimum internal temperature for cooking chicken is 70°C? a) True; **b) False**; c) I do not know	44.0	38.1	13.2	52.1±50.1[a]	34.5±48.4[b]	38.4±48.8[b]
Cleaning	49.9	37.6	7.6	66.2±25.4[a]	41.4±30.1[b]	40.9±27.2[b]
Which of the following would be the best procedure to ensure that there are no dangerous bacteria on the equipment? a) Washing with warm water; b) Washing with detergent and warm water; **c) Washing with detergent and warm water, applying the sanitizing agent**; d) Washing with warm water and applying the sanitizing agent; e) I do not know	67.8	23.4	4.4	83.2±37.6[a]	55.2±50.6[b]	56±49.9[b]
How is cleaning checked on a daily basis? **a) Visually or by instrumental readings**; b) By microbiological analysis; c) Daily control is not required; d) I do not know	51.6	28.9	13.2	64.7±48[a]	44.8±50.6[b]	40.8±49.3[b]
Properly labeled detergents may be kept in the same area where food is prepared if they are stored in a designated separate area? (Pichler *et al*. 2014) **a) True**; b) False; c) I do not know	27.1	63.0	5.9	40.3±49.3[a]	13.8±35.1[b]	17.6±38.2[b]
A combination of factors is critical to achieving clean equipment. One of them is the method used (*e.g*., heavy brushing). The others are: a) Temperature of water used for cleaning; b) Concentration of cleaning solution; c) Time of cleaning; **d) a, b and c**; e) a and b; f) I do not know	53.1	35.2	7	63±48.5[a]	51.7±50.9[ab]	44.6±49.8[b]
Overall	45.5	35.7	12.7	54.2±16.0[a]	44.0±19.2[b]	43.3±16.9[b]

N, number; [a, b, c]statistically significant differences in knowledge scores between countries.

other workers, who were not convinced of the importance of food safety (as reported in the Commitment category of Table 1). In all countries, leaders, who are often responsible for in-house training and should be role models, did not show a higher knowledge of food safety (Table 2). Documentation was the category with the largest differences between countries. One of the most important requirements of food safety management systems is regular temperature control. However, many food handlers in our study did not check the temperature daily, especially in Hungary (Table 1). Differences in compliance with daily checks between countries were not reflected in cooking knowledge, *e.g.*, Hungarian food handlers did not have significantly lower knowledge scores on time/temperature checks. In general, food handlers are not enthusiastic about filling out mandatory checklists. It appears that completing the checklists does not contribute to knowledge, yet it is critical to the safety of the food prepared.

Factors influencing food safety climate

As already shown, training is related to an increase in knowledge and also to climate. Therefore, a correlation analysis was performed between KS and MCsubj of the food safety climate survey

The results showed a weak significant positive correlation between the KS and the MCsubj of the food safety climate survey (rs=0.126; p=0.041). This implies that higher knowledge can increase food safety perceptions, as measured by food safety climate tools. Although low knowledge does not necessarily indicate incorrect food safety practices, high knowledge could increase food safety perceptions and indirectly contribute to food safety practices.

Positive weak correlations were also found between KS and MCsubj when only female responses were considered (rs=0.136; p=0.042); this was not the case for males, meaning that the increased knowledge led to higher climate scores only for female respondents.

Limitations of the study

One of the limitations of this study is the unbalanced sample (*e.g.*, the small number of respondents from Hungary) which limits the interpretation of the results. However, the balanced representation of food handlers employed in university canteens in Portugal and Croatia provides reasonable confidence in the results. The sample was not as balanced as far as other factors were concerned (*e.g.*, gender and work experience), which may also limit the interpretation of the results. However, it should be noted that the distribution of gender and years of experience is representative of university cafeterias.

Conclusions

Employees working in university canteens in three European countries showed inadequate food safety knowledge. Food safety training is a reliable means of improving knowledge, but it also positively affects the perception/awareness of food safety. This is especially important for leaders, whose knowledge and perceptions can impact other food handlers. To improve food safety knowledge and climate, the following opportunities were identified: provide ongoing training to employees and, especially, to leaders; conduct knowledge and climate assessments, as this information can help identify knowledge gaps and assess the reliability of responses to specific food safety climate survey categories; and ensure adequate equipment, devices, and spaces for employees to work hygienically.

References

Al-Akash H, Abu Arrah A, Bhatti F, Maabreh R, Abu Arrah R, 2022. The effect of food safety training program on food safety knowledge and practices in hotels' and hospitals' food services. Ital J Food Saf 11:9914.

De Boeck E, Jacxsens L, Bollaerts M, Vlerick P, 2015. Food safety climate in food processing organizations: development and validation of a self-assessment tool. Trends Food Sci Technol 46:242-51.

De Boeck E, Mortier A, Jacxsens L, Dequidt L, Vlerick P, 2017. Towards an extended food safety culture model: studying the moderating role of burnout and jobstress, the mediating role of food safety knowledge and motivation in the relation between food safety climate and food safety behavior. Trends Food Sci Technol 62:202-14.

Dufour C, 2011. Application of EC regulation no. 2073/2005 regarding listeria monocytogenes in ready-to-eat foods in retail and catering sectors in Europe. Food Control 22:1491-4.

EFSA, 2021. The European Union one health 2020 zoonoses report. EFSA J 2021 19:e06971.

Ellis JD, Arendt SW, Strohbehn CH, Meyer J, Paez P, 2010. Varying influences of motivation factors on employees' likelihood to perform safe food handling practices because of demographic differences. J Food Prot 73:2065-71.

European Commission, 2021. Regulation (EC) no 2021/382 amending the annexes to regulation (EC) no 852/2004 of the European Parliament and of the Council on the hygiene of foodstuffs as regards food allergen management, redistribution of food and food safety culture. In: Official Journal, L 74/3, 03/03/2021.

Gruenfeldova J, Domijan K, Walsh C, 2019. A study of food safety knowledge, practice and training among food handlers in Ireland. Food Control 105:131-40.

McIntyre L, Vallaster L, Wilcott L, Henderson SB, Kosatsky T, 2013. Evaluation of food safety knowledge, attitudes and self-reported hand washing practices in foodsafe trained and untrained food handlers in British Columbia, Canada. Food Control 30:150-6.

Moreb NA, Priyadarshini A, Jaiswal AK, 2017. Knowledge of food safety and food handling practices amongst food handlers in the Republic of Ireland. Food Control 80:341-9.

Pichler J, Ziegler J, Aldrian U, Allerberger F, 2014. Evaluating levels of knowledge on food safety among food handlers from restaurants and various catering businesses in Vienna, Austria 2011/2012. Food Control 35:33-40.

Rossi MSC, Stedefeld E, Da Cunha DT, De Rosso DD, 2017. Food safety knowledge, optimistic bias and risk perception among food handlers in institutional food services. Food Control 73:681-8.

Santos MJ, Nogueira JR, Patarata L, Mayan O, 2008. Knowledge levels of food handlers in portuguese school canteens and their self-reported behaviour towards food safety. Int J Environ Health Res 18:387-401.

Sharman N, Wallace CA, Jespersen L, 2020. Terminology and the understanding of culture, climate, and behavioural change - impact of organisational and human factors on food safety management. Trends Food Sci Technol 96:13-20.

Smigić N, Djekic I, Martins ML, Rocha A, Sidiropoulou N, Kalogianni EP, 2016. The level of food safety knowledge in food establishments in three European countries. Food Control 63:187-94.

Tomasevic I, Kovačević DB, Jambrak AR, Zsolt S, Dalle Zotte A, Martinović A, Prodanov M, Sołowiej B, Sirbu A, Subić J, Roljević S, Semenova A, Kročko M, Duckova V, Getya A, Kravchenko O, Djekic I, 2020. Comprehensive insight into the food safety climate in central and eastern Europe. Food Control 114:107238.

Toth A, Bittsanszky A, Illes CB, Dunay A, 2014. Improving knowledge, technology and food safety in school catering system in hungary. In: Dermol V, Širca NT, Dakovic G (eds). Human capital without borders: knowledge and learning for quality of life - proceedings of the management, knowledge and learning international conference, 2014 Jun 25-27, Portoroz, Slovenia. Bangkok, Thailand: ToKnowPress. pp 1129-37.

Tóth AJ, Koller Z, Illés CB, Bittsánszky A, 2017. Development of conscious food handling in hungarian school cafeterias. Food Control 73:644-9.