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Food safety expertise among professional food handlers and consumers related to foodborne viruses: Case Slovenia

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ABSTRACT

The objective of this quantitative survey was to determine the knowledge of Slovenian consumers and food handlers about viral food safety. For this reason, interviews were conducted using structured questionnaires and included 417 consumers and 61 food handlers. Foodborne viruses were not recognisable as distinctive foodborne hazards by food handlers, which demonstrates the lack of viral food safety knowledge using the chi-square test. The analysis pointed out that higher educated food handlers showed a lack of food safety expertise. However, at the same time, higher educated food handlers possessed more knowledge compared to less educated handlers. Multiple logistic regression analysis was performed on data restricted to consumer study group. The results pointed out that the lack of awareness and knowledge strongly prevails over the viral food safety knowledge and awareness. The analysis showed that consumers' knowledge and awareness varied by consumers' education level, age and gender. On the basis of these results, we can conclude that the profile of comprehension and consequences is not the same for food handlers and for consumers. The obtained results revealed that food safety educational initiatives should be developed to better inform consumers about safe food handling practices and habits to protect their health form foodborne disease, including viral infections.

Key words: foodborne viruses, consumer, logistic regression analysis, food handler, food safety

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INTRODUCTION

During the past century, most foodborne diseases were attributed to bacterial pathogens. However, food and waterborne viral infections are becoming an increased challenge to public health [1, 2, 3, 4, 5]. Of the approximately 600 million cases of illness caused by foodborne hazards in 2010 worldwide, infectious agents that cause diarrheal diseases accounted for the vast majority (550 million). Among them, noroviruses (NoV) were responsible for 120 million cases and hepatitis A virus (HAV) for 14 million cases [6].

In the EU [2], foodborne viruses were identified as the most commonly detected causative agent in the reported foodborne outbreaks (20.4 % of all outbreaks) in 2014. 1,070 foodborne outbreaks were caused by viruses, implicated 11,740 cases, 2,486 hospitalizations and 2 deaths. National statistics on foodborne viral disease are not easily available and, where present, likely to reflect significant under-reporting. The burden of foodborne diseases to public health, welfare, and economy has often been underestimated due to under-reporting, because they cause short-term diseases or asymptomatic infection. Outbreaks of foodborne diseases occurring in private homes are less likely to be reported than those in commercial and public premises, and it is believed that infections attributed to private homes are three times more frequent than those attributed to canteens [7]. Studies in the last few years have highlighted gaps in food safety knowledge and critical safety violations regarding food handling at home [8, 9, 10] and by food handlers [11, 12, 13, 14, 15].

Consumption of ready-to-eat foods contaminated by infected food handlers remains an important risk factor for viral outbreaks [11, 16]. Particularly oysters are commonly considered as the most frequently associated food vehicles in NoV outbreaks [17, 18]. Other foods, especially raw materials like soft fruits and vegetables, are also recognized as relevant food vehicles of enteric viruses [19, 20, 21]. The hands of food handlers may become contaminated with human enteric viruses if the handlers are shedding viruses in their faeces, changing diapers or cleaning toilet areas, and are not practising appropriate personal hygiene. These same viruses can be transmitted from human skin (hands) to foods and inanimate surfaces [12, 22, 23, 24], which serve as a secondary source of contamination if they come in contact with food. Virus contamination as a consequence of human handling can occur at any stage of the farm-to-fork continuum.

Most foodborne viruses are more resistant [25] than bacteria to commonly used control measures, (e.g. refrigeration, freezing, pH, drying, UV radiation, heat, pressure, disinfection, etc.). There are currently no effective, realistic, and validated risk management options to eliminate viral contamination prior to consumption without changing the normally desired characteristics of the food. Because the burden of viral foodborne disease, particularly NoV and HAV, is high, effective control strategies need to focus on the prevention of contamination.

Food and waterborne viral infections are becoming an increased challenge to public health.

Consumption of ready-to-eat foods contaminated by infected food handlers remains an important risk factor for viral outbreaks.

Virus contamination as a consequence of human handling can occur at any stage of the farm-to-fork continuum.

The vast majority of publications dealing with soft elements like culture, trust and teamwork [58] of food safety expertise are by principle focused on bacteria and hygienic issues [26, 27, 28, 29]. We also contributed to those studies in the past [10, 15, 30, 31]. However, there is really a shortage on soft element within food safety dealing with foodborne viruses [18], especially for consumers' studies. As the preventive measures developed for the reduction of bacterial infections and general hygienic measures are not always efficient to reduce viral infections and contamination, we need to implement additional measures. However, with researching the root cause of infections detectable in clinical samples over time, food supply chains are identified as the major viral transmission route, where actions directed at prevention of viral foodborne infections are being evolved and established now. Nowadays, it became essential to promote improvements in food safety with strong consideration of socio-cultural factors since the main actor in food safety circle is a person, who plays a crucial role in personal food safety management.

Due to the lack of satisfactory data in Slovenia as well as worldwide, a pilot study among local professional food handlers and consumers was carried out to investigate food safety handling practice and knowledge of foodborne viruses as food safety hazards. The aim of this study was to find whether professional food handlers and consumers have viral food safety knowledge.

MATERIALS AND METHODS

Data collection

Two self-administrable questionnaires (one for consumers and one for food handlers) were developed for this study. They both contained multiple-choice questions with already offered answers, including "do not know" and "other" for minimizing the possibility of selecting the correct answer by chance. To guarantee anonymity of respondents and enable easier identification of questionnaires, identity numbers were assigned to each questionnaire when collected. The questionnaires were pilot tested by 30 participants for questionnaires designed for consumers and 15 for food handlers during February to March of 2015 to confirm question clarity, identify response options, which resulted in minor modifications of questions' wording. Each questionnaire took approximately 5 to 10 minutes to complete. A full study was conducted from April to July of 2015.

Food handlers

Questionnaire for food handlers had eight questions, which were designed to assess food handlers' knowledge and practical habits focused on viral food safety and three demographic questions (gender, year of birth; 7-level education scale). The questionnaires were delivered in two companies, which volunteered to participate in the pilot survey. In each food company, questionnaires were delivered to the responsible

person for the food safety, i.e. food technologist. The number of respondents was determined regarding the number of food handlers present on the day of investigation. Ninety-three questionnaires were distributed among food handlers and their content was explained to them by the responsible person during lunch time. Completed questionnaires from two companies were mailed by the same day by responsible food technologists.

Consumers

A cross-sectional study of consumers' food safety knowledge interlinked to foodborne viruses was conducted in different parts of Slovenia. Gender and age distribution were controlled to assure a balanced structure of the sample by 20 interviewers, each of whom were distributed 25 questionnaires (a total of 500 questionnaires). Interviewers were trained, final year students, who visited selected households or interviewed consumers in larger shopping centres. Interviewers briefly explained the purpose and nature of the study to the potential adult respondent over 18 years of age and sought permission for inclusion of their views in the survey. As interviewers conducted interviews in their home cities, a considerable geographical distribution of data was obtained.

The questions in the questionnaire dedicated to consumers were designed and structured in three groups. The first group of questions including "*Have you ever heard of foodborne viruses?", "Is vomit infectious material?", "When could you say that the food is contaminated with viruses?"* and "*Applied handwashing practices"* was designed to assess the knowledge and practice habits focused on foodborne viruses and its integration into food safety practices in consumers' home.

The second group of questions that embraced the questions "*In your opinion, what are the sources of viral contamination?"* and "*In your opinion, where food can get contaminated by viruses?"* was designed to assess consumers' awareness of foodborne viruses and its role in food safety.

The third group of questions consisted of the questions about the demographic data (gender, year of birth, 9-level education scale).

Data preparation

Food handlers

For statistical analysis, we prepared demographic data groups. The question of gender had "female" and "male" option. Year of birth was recoded into three categories: ≤30 years, 31-50 years, and ≥51 years. Education level was recoded from the initial 7 levels into three categories: low (vocational level or less), middle (secondary school), and high (university degree or more). Recoding was used due to different level of food safety knowledge possession with intention to evaluate differences between them.

Based on the correct/incorrect answers to the question, "*What is food safety?"* and "*Recognition of most common foodborne microbial hazards in food supply chain"*, respectively, we created variables "*have knowledge*"/"*lack of knowledge*". When all the questions were answered correctly, criteria for "*have knowledge*" were fulfilled.

Consumers

For the statistical analysis, we prepared demographic data groups in the same way as described for food handlers.

Based on the correct/incorrect answers to the first group of questions, which assess consumers' knowledge, we created a new set of complex variables "*have knowledge*"/"*lack of knowledge*". When all the questions were answered correctly, criteria for "*have knowledge*" were fulfilled.

Based on the correct/incorrect answers to the second group of questions, which assess consumers' awareness, we created a new set of complex variables *"have awareness"*/*"lack of awareness"*. Formulation of complex variables from multiple questions provides more accurate information about the knowledge or lack of knowledge and awareness or lack of awareness in the field of viral food safety.

Data analysis

Food handlers

The relationship between food handler's demographic data (independent variable) and the food handlers' "*knowledge"*/*"lack of knowledge"* (dependent variables) of food safety meaning and recognition of the most common microbial hazards in food supply chain were analysed using the chi-square test. With the chi-square test, we analysed the relationship and significance between each observed demographic data and dependent variable. In the chi-square test p-value, 0.05 or less was considered significant.

Consumers

In the first step of the analysis, the relationship between dependent variables ("*knowledge"*/*"lack of knowledge*" and "*awareness"*/*"lack of awareness*" of viral food safety) and independent variables (demographic variables) were analysed using the chi-square test. With the chi-square test, we analysed the relationship and significance between each observed demographic data and dependent variables. In the chi-square test p-value, 0.05 or less was considered significant.

In the second step of our analysis, differences in complex variables "*lack of knowledge*" and "*lack of awareness*", respectively (the observed outcomes), were adjusted to the effects of the observed demographic data (independent variables) using binary multiple logistic regression. With binary multiple logistic regression, we analysed the relationship and significance between all the observed demographic data and dependent variables. Logistic regression provides a method

for modelling a binary response variable, which takes values 1 and 0. In our case, we tried to investigate how lack of knowledge and lack of awareness of participants can be predicted by observed demographic variable (e.g. gender). The dummy variables (reference group) were created for all independent variables considered in the model. The reference group in our analysis were (gender: female; age group: ≥ 51, and education: high). In the results, we report the odds ratio (OR) and 95 % confidence interval (CI) with p-value.

The OR is a measure representing the odds that an outcome would occur in the presence of a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure [32]. Therefore, OR was a measure of the association between an exposure and an outcome.

SPSS statistical package for Windows Version 21.0 (SPSS Inc., Chicago, IL, USA) was used for all analyses in our study.

RESULTS AND DISCUSSION

Food handlers

A total of 61 questionnaires (out of 93) were obtained from food business operators in Slovenia, which contacted us to participate in the survey. The overall response rate to the survey was 65.6 %. Of the 61 food handlers taking part in the research, half of them (50.0 %) were female and half of them were male. As seen from Table 1, 8.9 % respondents were under 30 years old, 66.1 % between 31-50, and 25.0 % were over 51 years old. As for the educational level, 40.7 % of respondents finished high school (25.4 % finished vocational level of education or less, and 33.9 % had higher education. The most significant responses for this area are presented in Figure 1. Only a quarter (21.3 %) of respondents correctly defined food safety as the assurance that food will not cause harm to the consumer, although 90.2 % agreed to the question that an important part of food handlers' job responsibilities was to follow all the requirements for ensuring food safety for a consumer. With this set of questions, we tested education and training efficiency, which are according to food safety management systems obligatory and necessary [33]. There is no doubt that effectiveness of education and training is an important factor contributing to the overall food safety. Training employees on food safety practices has been shown to be one of the most important programs that food establishments can implement [34, 35]. However, knowledge assessment not necessarily shows actual knowledge and competences of food handlers', but it is intended only for satisfying the legal requirements.

Training employees on food safety practices has been shown to be one of the most important programs that food establishments can implement.

Due to limited scientific research that assessed reported knowledge and behaviour related to foodborne viral transmission and prevention, we created questions, where we studied food handlers' identification and recognition of the most common foodborne microbial hazards, including foodborne viruses in food supply chain. Knowledge (Figure 1) was found to be age-dependent, food handlers aged between 31-50

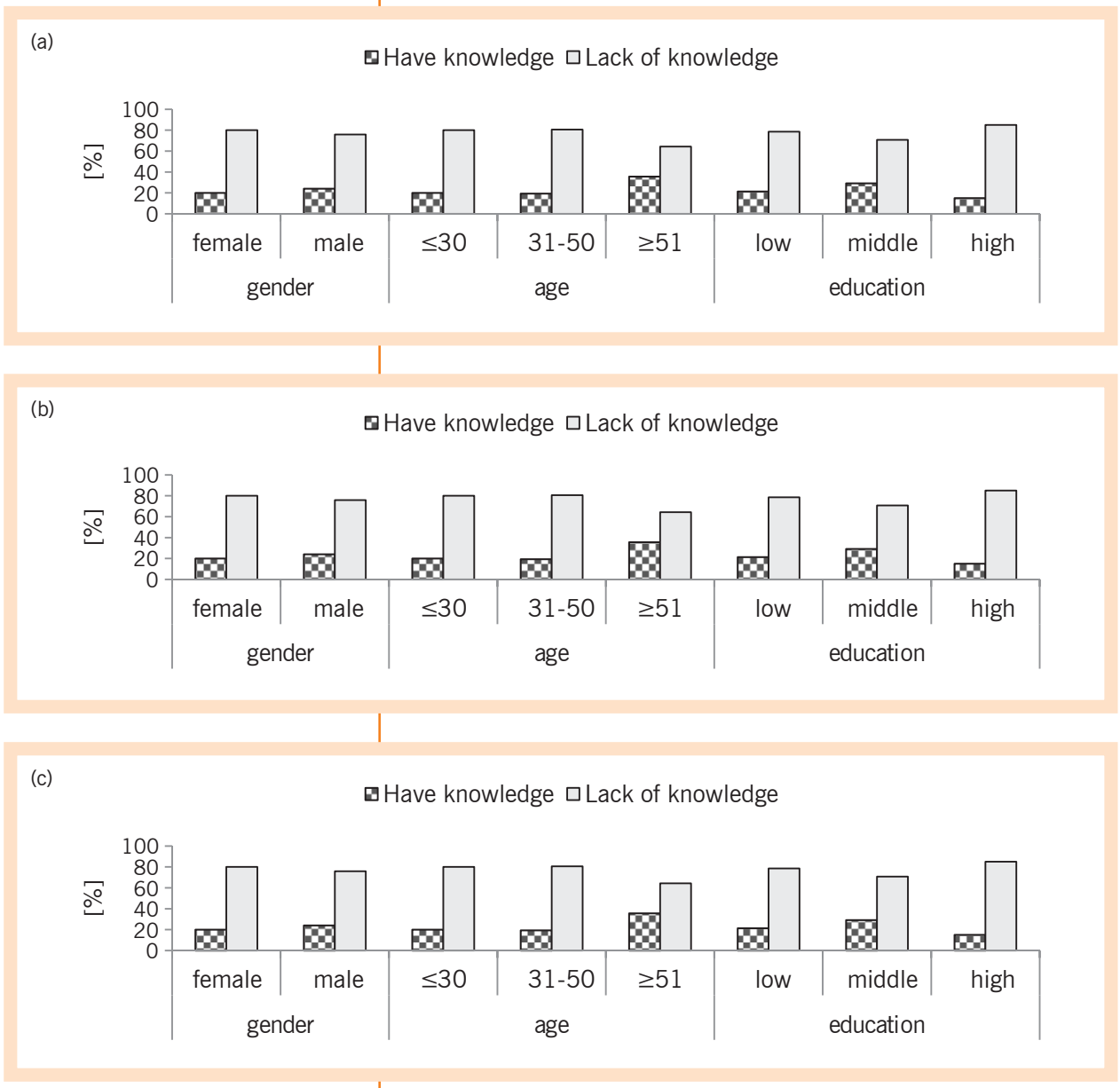

Figure 1:
Understanding food safety meaning among 61 food handlers (a); identification and recognition of the most common foodborne microbial hazards, including foodborne viruses in food supply chain (b); norovirus (c) hepatitis A virus

years possessed more knowledge compared to younger or older food handlers. As expected, we found that higher educated food handlers had better knowledge, which can be illustrated by correctly identified most common foodborne microbial hazards. It was already pointed out [36, 37] that knowledge is education-related. At the same time, we observed that higher educated food handlers showed a lack of food safety expertise (Figure 1), that can be illustrated by correctly identified definition of food safety meaning. This observation can be explained by the fact that higher educated food handlers are in leading positions and their job responsibilities are not strictly connected to food safety expertise.

Despite the beneficial health effects of healthy foods, there is a growing awareness concerning its microbial and chemical safety [38]. Increased consumption of food traditionally eaten raw and globalization of international trade have also increased the risks of viral contamination of foods, especially soft berry fruits, salad greens, shellfish and

ready to eat foods. In recent years, numerous foodborne outbreaks due to consumption of berry fruit [20] and shellfish [17] contaminated by human enteric viruses have been reported. Food handlers recognized steak tartar (75.4 %), shellfish, which are eaten raw (70.4 %), and cheeses from unpasteurized milk (45.9 %) as hazardous food items, while raspberries (42.6 %) and lettuce (34.5 %) as safe, and heat-treated shellfish (24.6 %) and salad meal at restaurants (24.6 %) as potentially safe item, although the virus-commodity combinations of greatest public health concern recognised NoV and HAV in prepared (ready-to-eat) foods, bivalve molluscs, fresh produced and HEV in traditional pork dishes [18, 25, 39, 40, 41].

Food handlers play an important role in the transmission of enteric viruses due to poor hygiene practices or being in contact with faecal material or vomit [15, 25]. Vomit was recognised (78.7 %) as infectious material, less than half (40.0 %) of respondents know period being infectious after recovery of gastroenteritis symptoms, and nearly half of them (45.9 %) correctly identified contamination routs with viruses.

Our study revealed that although trained, food handlers do not recognize foodborne viruses as distinctive food safety hazards (Figure 1), which was already observed [14]. It was also revealed that food handlers are not recognising ready-to-eat foods and fresh products as vehicles for virus transmission, which indicates that the study population overall has poor knowledge of viral food safety practices. As a result, food safety trainings should be developed according to the recently developed Codex Alimentarius guidelines to control viruses in food to better inform food handlers on all-important aspects of viral food safety, although food handlers possess knowledge about microbial food safety and consequences of poor hygiene practices. It was demonstrated [42, 43] that the importance of continuous and specific goal-oriented training to food handlers can lead to easily improved sanitation practices, such as health checking, adequate handwashing, observation of proper personal hygiene, prevention of cross-contamination and correct sanitation procedures. Guidance documents on food hygiene and food transmittable diseases are essential for the training of food handlers. Foodborne viral infection remains very common in many parts of the world despite the measures already in place, mainly targeted at reducing bacterial contamination. For this reason, the Codex Alimentarius Commission decided to develop specific guidelines for the control of viruses in food, which have been available since 2012 [25]. The primary purpose of the codex guidelines for the control of viruses in food is to give guidance on how to prevent or minimize the presence of human enteric viruses in food, especially NoVs and HAV, and to emphasize that management strategies regarding foodborne viruses and associated illnesses should be different from those for bacterial pathogens. Guidelines are not disseminated as legally enforceable in national guidelines or regulations and consequently remain unknown to professionals. There is a need to disseminate current guidelines as good viral food safety practice via food safety authorities and professional associations, chambers and societies to enhance the awareness about foodborne viruses.

The importance of continuous and specific goal-oriented training to food handlers can lead to easily improved sanitation practices, such as health checking, adequate handwashing, observation of proper personal hygiene, prevention of cross-contamination and correct sanitation procedures.

Consumers

A total of 417 questionnaires were obtained. The overall response rate to the survey was 83.4 %. As seen from Table 1, 60.3 % of the respondents were female and 39.7 % male. 43.9 % of respondents were under 30 years old, 24.9 % between 31-50, and 31.2 % was over 51 years old. Educational level of more than half of the respondents (53.0 %) was finished high school, 32.6 % finished vocational level of education or less, and 14.4 % have higher education. Outcomes revealed (Figure 3) that lack of knowledge strongly predominates over knowledge. This can also be illustrated by the fact that majority (94.2 %) of consumers were familiar with foodborne viruses and 68.8 % of consumers recognised vomit as infectious material. However, only 24.7 % of respondents correctly identified that viruses do not cause organoleptic properties of the contaminated food, which deserves a special attention in education of consumers at all levels.

Variable *"awareness"* was formulated to perceive the awareness of consumers related to viral food safety in domestic food preparation. The most significant responses for this group of questions are described in Figure 2, where outcomes revealed that also lack of awareness strongly prevails over having awareness. Female showed more viral awareness compared to men, due to evolutionary expressed patterns for caring for the home and her family. It was also observed that higher educated consumers have more awareness about viral food safety in home kitchen compared to less educated. Nearly half (48.0 %) of the consumers were aware that food can become infected anywhere from farm to plate, and 47.7 % that human sewage and faeces; infected food handlers and animals harbouring zoonotic viruses are major sources of viral contamination.

To our knowledge, this was the first study that assessed consumers knowledge and behaviour specifically focussed on the viral food safety knowledge and awareness. There is a serious lack of food safety viral studies dealing with consumers' knowledge to compare our results with. We developed suitable methodology for addressing this challenge. The approach was found relevant since it can be used specifically for focussed groups like food handler study group but also for

Table 1: Demographic characteristics of food handlers and consumers

Characteristics of survey respondents		Food handlers (%)	Consumers (%)
Gender	Female	50.0	60.3
	Male	50.0	39.7
Age	≥ 51	25.0	31.2
	31-50	66.1	24.9
	≤ 30	8.9	43.9
Education	High	33.9	14.4
	Middle	40.7	53.0
	Low	25.4	32.6

$N_{food\ handlers}=61$; $N_{consumers}=417$

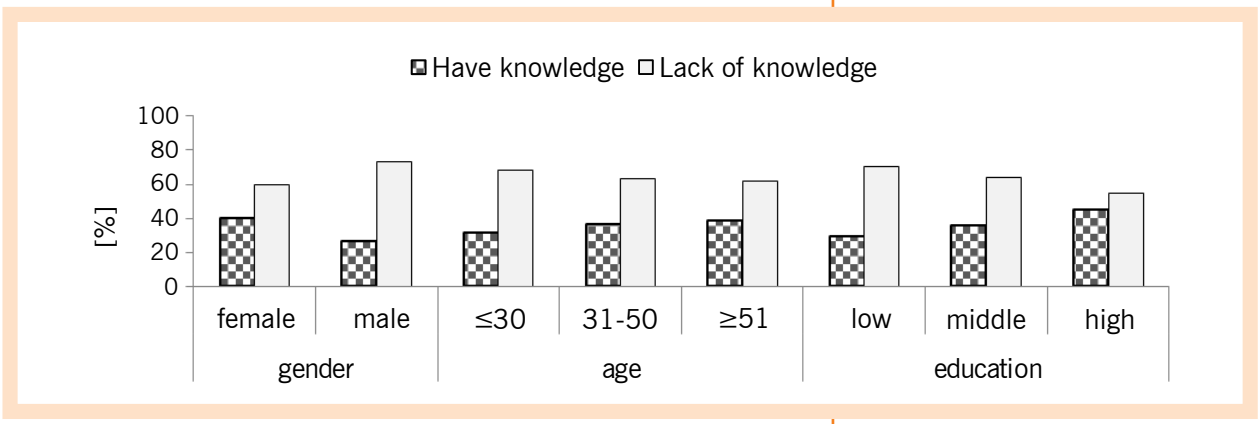

Figure 2:
Perceived awareness among 417 consumers related to viral food safety in domestic food preparation

more diverse populations and is able to estimate the relationship between the observed outcomes and demographic variables.

The results of multiple logistic regression analysis of the consumers' lack of knowledge impact (Table 2) in the model pointed out that the male consumers have 1.2 times higher odds ($p = 0.458$) than female consumers for lack of viral food safety knowledge. Compared with the above 51-years-old consumers, the consumers in the age group 31-50 years have 1.1 times higher odds ($p = 0.420$) than younger or older consumers. Consumers with low level of education (vocational level or less) have 1.3 times odds for lack of viral food safety knowledge than high-level educated consumers ($p = 0.076$). The model confirmed our assumptions that education, gender, and age influence the viral food safety knowledge. Education as a solution for the above-identified lack of knowledge strongly argues for specific training on foodborne viruses also for consumers. Verhoef et al. [14] in their study proposed that for food handlers and their managers, education is crucially important for ensuring viral food safety and improving public health importance.

This step can only be achieved by well available and easy to understand education given material, which is respected and followed by consumers. These results emphasize the need for tailored educational programs to improve consumers and food handlers' knowledge and awareness, as has been stressed many times in the last decade [10, 15, 29, 44, 45, 46, 47].

Figure 3:
Perceived knowledge among 417 consumers related to viral food safety in domestic food preparation

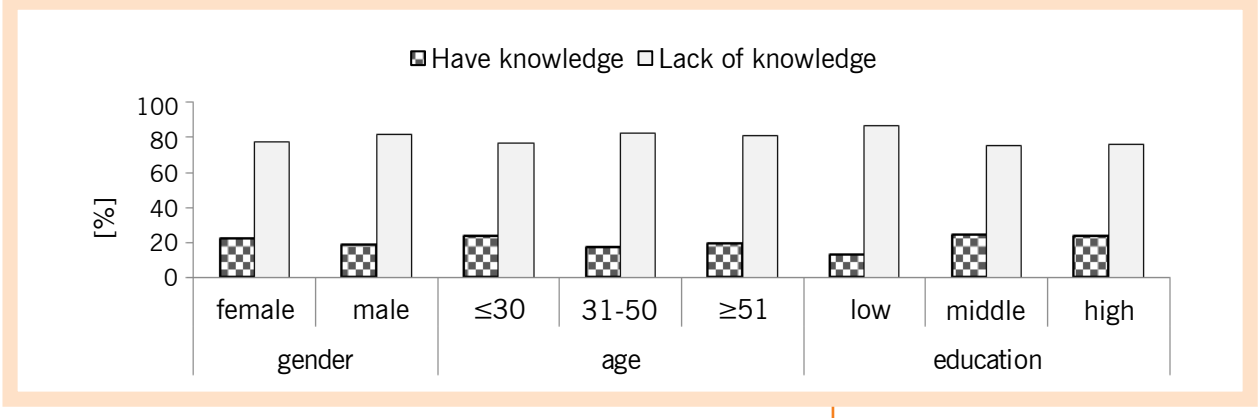

Table 2: Results of multiple logistic regression analysis of the impact of consumers' lack of knowledge on foodborne viruses in 417 consumers adjusted on gender, age, and education level

Independent variables		OR	95 % C.I. limits for OR		p
			lower	upper	
Gender	Female	1.00			
	Male	1.209	0.732	1.998	0.458
Age	≥51	1.00			
	31-50	1.099	0.874	1.383	0.420
	≤30	1.016	0.832	1.241	0.874
Education	High	1.00			
	Middle	0.991	0.791	1.241	0.934
	Low	1.277	0.975	1.672	0.076

Abbreviations: OR – odds ratio; C.I. – confidence interval; *p value ≤0.05

Table 3: Results of multiple logistic regression analysis of the impact of consumers' lack of awareness on foodborne viruses in 417 consumers adjusted on gender, age, and education level

Independent variables		OR	95 % C.I. limits for OR		p
			lower	upper	
Gender	Female	1.00			
	Male	1.805	1.169	2.785	0.008*
Age	≥51	1.00			
	31-50	1.062	0.882	1.278	0.525
	≤30	1.196	1.005	1.424	0.044*
Education	High	1.00			
	Middle	1.131	0.928	1.378	0.223
	Low	1.303	1.042	1.628	0.020*

Abbreviations: OR – odds ratio; C.I. – confidence interval; *P value ≤ 0.05

The results of multiple logistic regression analysis of the impact of consumers' awareness respectively (Table 3) of foodborne viruses in the model demonstrated that the male consumers have 1.8 times higher odds ($p = 0.008$) for the lack of viral awareness than female consumers. Compared to the above 51-year-old consumers, the consumers under 30 years of age had 1.2 times higher odds ($p = 0.044$) and low-level educated consumers (vocational level or less) had 1.3-higher odds for the lack of awareness than high-level educated consumers ($p = 0.002$). In addition, that model confirmed that viral food safety awareness is gender-, education-, and age-dependent.

Our conclusions raised the need to implement activities to raise the awareness of key viral food safety issues. Education and training about basic food safety principles are emphasized as important factors contributing to the reduction of foodborne illnesses. However, it is of crucial importance that the message is specifically tailored and task-specific with regards to the needs of the target group. Improvement becomes more significant if substantiated with practical activity in comparison to those addressed only orally [48]. For this reason, the food

safety public health campaign to enhance household food safety awareness would be a suitable solution. The best worldwide good practice to enhance food safety awareness and education is Partnership for Food Safety Education in USA (FightBAC), whose goal is to promote food safety awareness to consumers and educate them how to handle and prepare food safely. However, with this aim, European Food Information Council (EUFIC) is also established, which is poorly known to consumers.

Our study showed that there are gaps in consumers' knowledge, practices, and awareness. In addition, the earlier studies conducted on adults have indicated that food safety knowledge tends to increase with age and practice: females have higher scores than males, and younger respondents show the greatest need for additional food safety education [49, 50, 51, 52]. Multiple logistic regression analysis identified education as a solution for knowledge improvement and enhanced awareness. The meta-analysis [27] has shown that food safety training increases knowledge and improves the attitudes about hand hygiene practices and that refresher training and recurrent emphasis on good food handling behaviour may have ongoing positive effects on handwashing practices. It was also emphasized [53] that special training may improve the knowledge of food safety but this does not always result in better and safer food handling behaviour. Unfortunately, we do not have many specific attempts to educate consumers about food safety after they finished obligatory education on primary level. However, consumers generally express their concerns about food safety issues, but only a few of them appear to be changing their food buying and consumption behaviours in view of their concerns [10, 26]. Nevertheless, home kitchen is recognised as a source of verified outbreaks [2, 10]. Consumer behaviour and awareness toward viral food safety have shown that the levels of understanding, motivation, and trust need to be further cultivated especially in relation to education, age, and gender. All of them are based on awareness and knowledge, which were found as limiting factors for viruses in particular, as demonstrated with this research.

Consumers play an important role in the transmission of hazards, including viruses.

Consumers play an important role in the transmission of hazards, including viruses. Consumers should be aware of potential risks, proper handling, and preparation of food for a safe and balanced everyday meal (54), however, they are not connected to food supply chain according to chain principles [54, 55, 56]. In addition, implemented viral food safety guidelines [25] are not purposely designed for informing consumers [57]. At present, we are faced with insufficient knowledge and awareness of viral food safety issues among food handlers, accompanied by consumers being insufficiently informed about food safety principles at home. The lower knowledge for viral food safety concepts indicates that food safety management failed to develop relevant and user-friendly approaches to educate both food handler and consumer about the implementation of recommended food safety practices associated with foodborne viruses as a response to globalisation and new consumption patterns.

Increased awareness of the importance of good food hygiene practice and training in the production and handling of foods is necessary to minimize the transmission of foodborne viral illnesses. Improving detection methods allows better monitoring of viruses in food and helps to improve the safety of those foods commonly associated with foodborne viral illnesses. The vast majority of publications dealing with soft elements of food safety expertise are by principle focused on bacteria and hygienic issues. However, there is really a shortage on soft element within food safety dealing with foodborne viruses [18], especially for consumers' studies.

LIMITATIONS OF THE STUDY

Although this research was carefully prepared, we are aware of its limitations due to the lack of prior research studies in viral food safety field connected to human factor and consequently to the available data. That is the reason that the comparison based on scientific results cannot be done. Further research in this field of food safety is needed.

Increased awareness of the importance of good food hygiene practice and training in the production and handling of foods is necessary to minimize the transmission of foodborne viral illnesses.

Higher educated food handlers have better knowledge of contamination agents, which indicates that education is a solution for knowledge improvement and enhanced awareness.

CONCLUSIONS

Trends in food supply chain like globalization of food supply chains, health and demographic situations, social situations (increased consumption of ready-to-eat foods on the one hand and raw and/or minimally processed foods on the other), and environmental conditions (e.g. pollution) present new challenges for food safety. Global integrated farm-to-table approach and new consumption patterns enable that a contaminated food product can be consumed by a large number of people worldwide in a short period of time. On the one hand, we are facing insufficient knowledge and awareness of food safety issues among food handlers these days. Moreover we have insufficiently informed consumers about food safety principles at home.

In our study, we drew the conclusions that food handlers, although trained, do not recognize foodborne viruses as distinctive foodborne hazards and are not sufficiently aware of the importance of foodborne viruses as transmittable pathogens for ensuring safe food for consumers. Higher educated food handlers have better knowledge of contamination agents, which indicates that education is a solution for knowledge improvement and enhanced awareness. Next to that, of consumers' knowledge strongly predominates over knowledge. Models for "*viral food safety knowledge*" and "*viral food safety awareness*" confirmed that education, age, and gender influence the viral food safety, which emphasizes the need for tailored educational programs to improve awareness with respect to viruses and to implement up-to-date findings into good practices, which will be available and easy to understand and to handle with consumers of all ages, educational background, and living circumstances.

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