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Editorial

Dear readers of *International Journal of Sanitary Engineering Research*,

We are proud to deliver this year issue although we would not complain if we could offer a least two issues per year. Currently, the IJSER is undergoing an evaluation and selection processes prior to the acceptance into SCOPUS, which will be, if we will be successful, an added value and the next step in the journal development. The current issue contains five papers covering different fields of sanitary engineering profession. Two papers are dealing with food safety issues related to food handlers at different parts of food supply chain. There is one epidemiological study dealing with the exposure to ultrafine particles, followed by health risk assessment study for dental healthcare employees and patients due to the exposure to *Legionella* spp., and one study about ergonomic burdens at the workplace of accountants.

Both papers in the field of food safety are dealing with relevant topics considering this year multi-country *Salmonella* outbreak in Europe and the *European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks* recently published by the European Food Safety Authority in collaboration with the European Centre for Disease Prevention and Control. Ambrožič et al. investigated the knowledge about foodborne viruses and found out that lack of awareness and knowledge strongly prevails among food handlers and consumers. The second paper in the field of food safety is dealing with food safety culture which is still largely unexplored and is getting more and more attention lately in scientific literature. Zabukošek et al. have done an empirical examination of different food safety culture dimensions in a food processing company, which is the first study of this kind in Slovenia and one of the first also internationally. Research of ultrafine particles' effect in outdoor air on public health is relatively a new field of research in public health. Kranjec et al. have applied epidemiological approach and found out that there was a temporal variability association between the periods with higher daily counts of deaths from respiratory diseases and heightened levels of ultrafine particle concentrations. Dental unit water systems installed in dental chairs are known potential source of Legionella exposure. Considering the large number (five hundred thirty-seven) of water samples which were microbiologically analysed is giving the relevance to the paper prepared by Grcić et al. Using the Kinney method, they demonstrated that health risk for employees and patients due to the exposure to *Legionella* is present, although it is relatively low. The intention to adapt the workplace to psychophysical abilities of the individual is not new, but according to the recent trends more relevant than ever. Also, health and safety at work in general is getting more and more attention recently. Kacjan Žgajnar et al. have investigated the ergonomic strains of accountants and suggested measures to overcome the work-related overload where necessary with the intention to improve the working conditions.

At last but not at least I wish to the readers, on behalf of complete editorial board, to find reading of the papers published in the current issue interesting. I hope you will feel encouraged to submit your own papers prepared by yourself or in collaboration with your colleagues for the next issue.

Sincerely,

Andrej Ovca, Editor

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Contents

Original scientific article

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

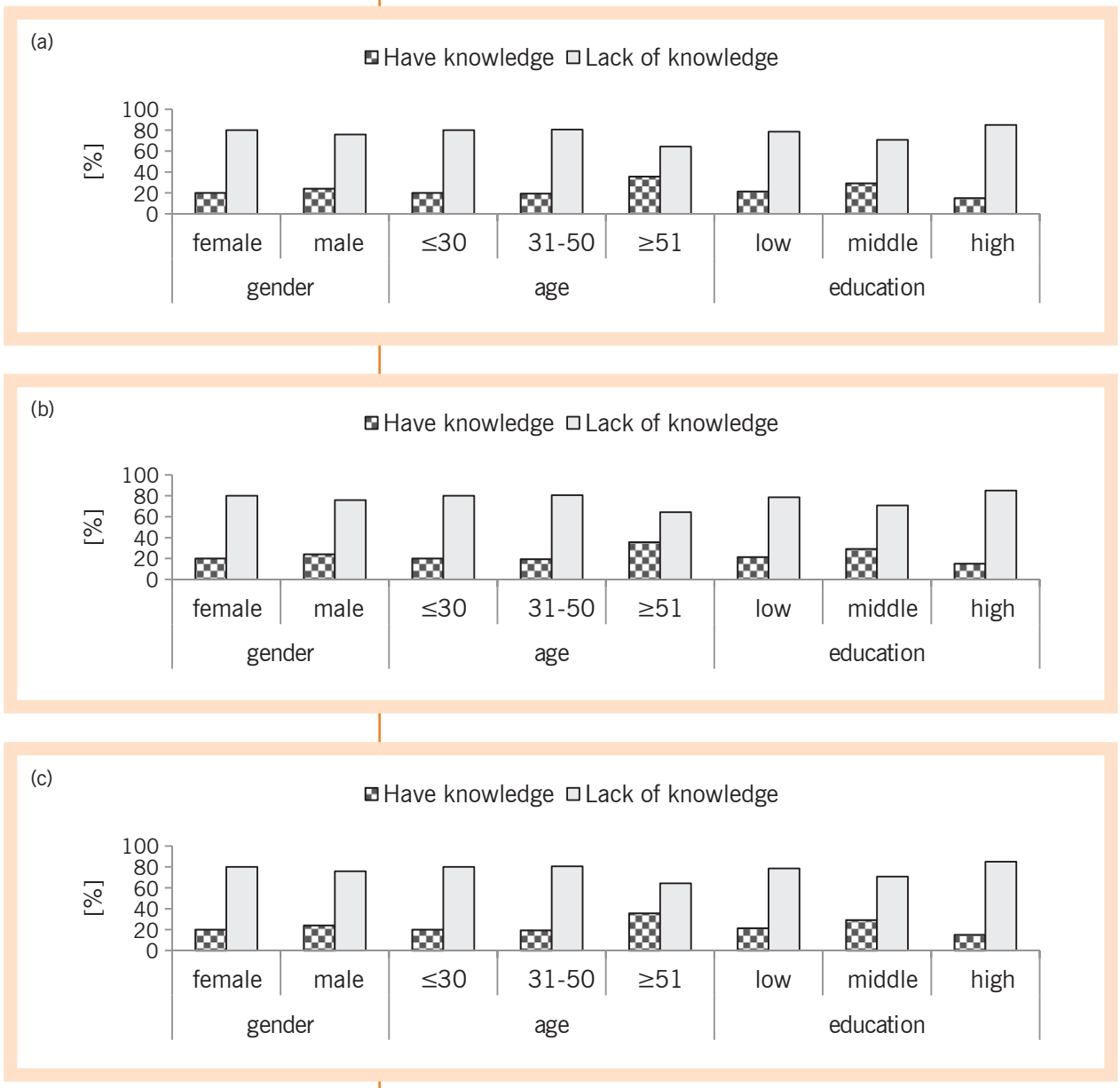

Figure 1:
Understanding food safety meaning among 61 food handlers (a); identification and recognition of the most common foodborne microbial hazards, including foodborne viruses in food supply chain (b); norovirus (c) hepatitis A virus

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

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

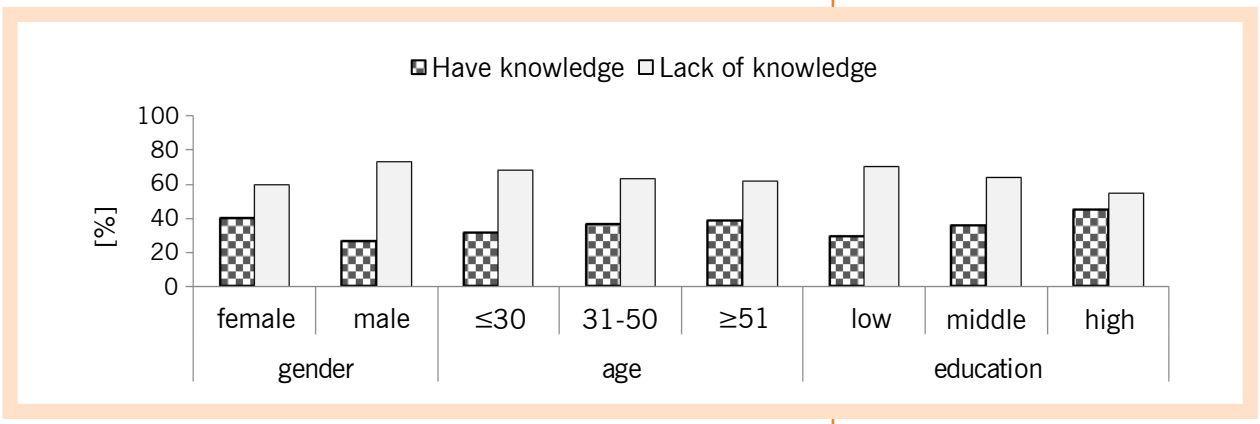

Figure 2:
Perceived awareness among 417 consumers related to viral food safety in domestic food preparation

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

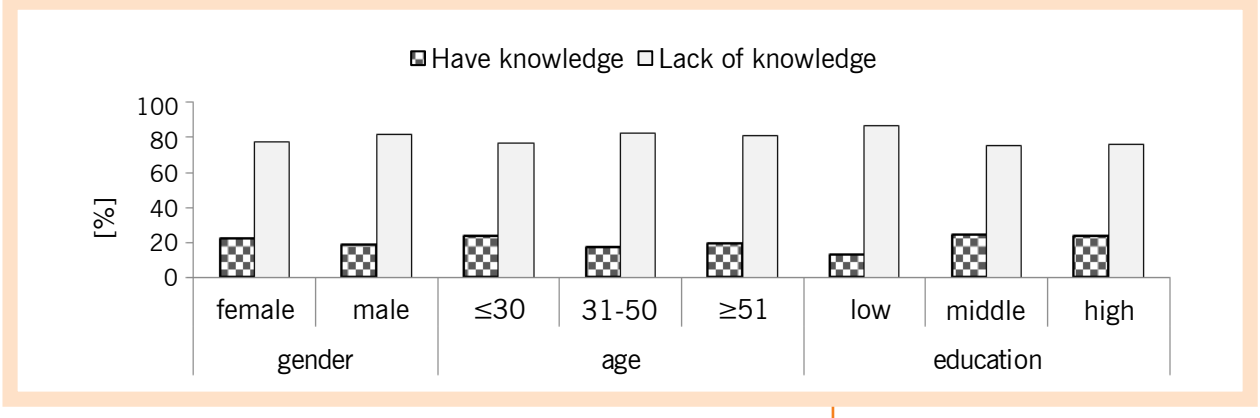

Table 2: Results of multiple logistic regression analysis of the impact of consumers' lack of knowledge on foodborne viruses in 417 consumers adjusted on gender, age, and education level

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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Original scientific article

Analysis of dimensionality of food safety culture: An empirical examination of a Slovenian food processing company

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ABSTRACT

An emerging research field called "food safety culture" is still largely unexplored. According to the identified gap in the literature, this study aims to develop and empirically validate the conceptual model of food safety culture, especially from the perspective of the employees. The research was carried out in a medium-sized food enterprise (220 employees) which has well-developed food safety management systems in order to ensure compliance with the legislation and the corresponding standards. Exploratory factor analysis was used to uncover the dimensions of food safety culture as well as to assess convergent validity. Furthermore, a multiple regression analysis was applied to assess the contribution of food safety culture dimensions to training efficiency and risk judgement. The demographical features of the employees (gender, age, education, and professional experience) revealed to have no influence on employees' food safety culture. Moreover, we empirically tested the reliability and validity of food safety measurement scales (leadership and co-worker support, communication, self-commitment of the employees, environment support, work pressure, risk awareness and training efficiency), which can all affect the employees' attitude towards food safety. Drawing upon theoretical foundations and empirical results, one can conclude that the ongoing employee training and development regarding food safety leads to the development of food safety culture and enhancement of employees' commitment to the organization.

Key words: food safety, employees, training, food safety culture, food safety management system

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INTRODUCTION

Food is essential to life and is a human right but if contaminated, it can be the cause of illness and even death. As summarized before [1], food is necessary to the life of humans and all human beings must either work to provide the food for living or obtain their food from another person (or an organization) that may specialize in the provision of food.

Today's food industry and its sophisticated processing as well as distribution technology produce a variety of foodstuffs available to the consumer in the form of various articles on shelves of fast-growing commercial centers. The knowledge of health risks is more complete with the development of food science and technology, but the new interventions in technology and distribution cause new risks. The high level of public health is one of the fundamental objectives of food legislation [2]. Strategy papers on EU food policy emphasize the importance of ensuring food safety along the food supply chain, taking into account the principles of traceability. Ensuring food safety defines various system tools and approaches, and many good practices that determine the guidelines of safe food handling.

Today, we master food safety with different good practices that are the result of human culture, history, and lifestyle [3, 4].

Tradition, practice, and vast technical and scientific knowledge helped shape the principles and techniques of how to achieve acceptable food safety in a given environment. Heterogeneous environmental conditions, an abundance of different materials, diversity of cultures and ways of practical work helped shape the principles, among which some were later involved in the legislation. Nowadays, we manage food safety through the good practices at different levels of food production, distribution, and consumption. Present maintenance of food safety in a food supply chain can be easily broken down because of different kinds of barriers or simple misunderstandings among stakeholders, including consumers [4, 5]. HACCP represents the clearest example of this development [6]. The previous quality control system was based on the finished product. A new food safety philosophy is based on the appropriateness of the technological process in the chain through which the food passes, and the indicated significantly reduces reduces the risk for safety of the final product [7, 8, 9].

Factors that have a significant impact on employers' behaviour correlate with the organizational climate in the company, the level of job satisfaction and labour conditions and with the relations between employees. Marolt and Gomišček [10] describe a new management approach towards employees, which stimulates them to be initiative, to learn, to devote themselves to the company, to be self-confident, to be more efficient and to be better at team-work. This all contributes to higher successfulness and effectiveness of the organization. The authors emphasize the function of leadership, which plays a key role in the realization of the new principles into practical work and thus can

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significantly contribute to a better usage of the existent resources. A leader with a leadership function should persuade the employees to fulfill their needs and desires by working effectively, and should enable them to use their potentials, and by doing so contribute to the achievement of the goals of a team and an organization. It would be ideal if people were motivated to such level so that they would not work only out of obligation, but would work with eagerness and trust. The following skills of a successful leader are also mentioned: motivation, communication, improvement, and introduction of modifications [10, 11]. In the review on history of motivational research and theory, Latham and Ernst [12] summarize that psychologists now know the importance of (1) taking into account a person's needs (Maslow's need hierarchy theory, Hackman and Oldham's job characteristics theory), (2) creating a job environment that is likely to facilitate self-motivation (Herzberg's job enrichment theory, Hackman and Oldham's job characteristics theory) and (3) ways to directly modify, that is, to directly increase or decrease another person's behaviour by administering environmental reinforces and punishers contingent upon a person's response (Skinner's contingency theory). They also stress the importance of attaining employees' goals, as they do not only feel satisfied, but they generalize their positive affect towards a task [13]. Jannadi [14] emphasizes that workers are the ones who carry out the work in a company and they can be an important factor in making the company profitable or bankrupt. Human behaviour is very important and difficult to control, so handling people requires situational leadership. Hazards cannot be solved and eliminated just through engineering control. They also need to be recognized by employees who will minimize their effects [14].

Ungku Fatimah et al. [15] summarize the results of several studies, which have investigated the role of knowledge and attitudes towards employees' safe food handling practices in the foodservice industry. The knowledge about and the attitudes towards food safety are important, yet factors affecting employees' practices are multidimensional and extend beyond these two constructs. Jevšnik et al. [9] studied barriers that affect safe food handling practices in foodservice operations, that is, knowledge, time constraints, availability of resources, and behavioral issues (e.g., management and coworkers' attitudes), which have been reported also in some other studies well incorporated in Ungku Fatimah et al.'s [15] study. Human behavior (e.g. the actual execution of procedures) and decision making is influenced by the perceived food safety climate in an organization [16]. Yiannas [17] defines food safety culture as "the way we do things [food safety] around here". Poor food safety culture is increasingly recognized as a risk for foodborne illness outbreaks in the food industry. It is still a question which training type will prove to be more effective in the future. Irrespective of that, the most important fact according to Seaman and Eves [18] is that training will only lead to an improvement in food safety if the knowledge imparted leads to desired changes in the behaviour in the workplace. For conscientious

hygiene, it is not important in which enterprise people work, but depends upon hygiene awareness and education of an individual person [19]. Jevšnik et al. [9] states that the human factor in organizational and execution levels is the reason for intolerable deviations in HACCP system, which are expressed in critical situations. A more effective system of primary education and a lifelong learning of food-related topics are needed. Work environment and the individual in the food supply chain need to be discussed equally as all the other hazards. To achieve total quality and safe life, a multi-disciplinary and an innovative approach that would be capable of quick and effective responding in the food supply chain is needed.

In accordance with the reviewed literature in the field of food safety culture, it has been established that the culture in organizations is still very poorly understood. However, recent interest has led to the development of several tools to measure the food safety culture/climate in organizations [16]. Several tools for measuring the food safety culture and climate in companies with regard to food safety have already been developed. For example, the consultancy agency Greenstreet Berman, commissioned by the Food Standards Agency in the UK, has developed some sort of questionnaire to be completed by inspectors of the local authorities [16]. Jespersen and Bedard [20] present the observational methods that focus on the behavior of employees, and through those methods they want to show the maturity of the organization with regard to food safety.

Ungku Fatimah et al. [15] present a model for determining the food safety culture with the help of a questionnaire, which included nine areas: leadership, communication, self-commitment, management system and style, environment support, teamwork, accountability, work pressure and risk perception.

Yiannas [17] states that if you want to improve the food safety performance in the food supply chain, you must change the way people do things or you must change their behavior. Or even simpler – he states that food safety equals behavior [17].

If you want to improve the food safety performance in the food supply chain, you must change the way people do things or you must change their behavior.

However, limited studies have explored food safety culture in food industry using perceptual measures.

This study adds to this emerging dialogue in at least two important ways. Firstly, this paper attempts to empirically validate food safety culture dimensions. Secondly, it provides new insights into the relationship between food safety dimensions and employee training efficiency.

METHODS

Sample and data collection

The following research was carried out in a Slovenian food processing company with 220 employees. In total, 169 usable responses (out of 220) were collected during the given time window, yielding a response rate of 76.8 %. The profile of the respondents is provided in Table 1.

Table 1: Profile of the respondents in our sample (N = 169)

Sample distribution		Percentage
Respondent profile	Middle management	4.1
	Group leader	11.2
	Production worker	84.6
Gender	Female	50.3
	Male	49.7
Working experience	Less than 1 year	10.1
	1-2 years	10.7
	3-7 years	18.9
	8-12 years	7.1
	13-20 years	10.1
	More than 20 years	43.2

In terms of the gender, 50.3 % of the respondents were female, while 49.7 % of the respondents were male. Furthermore, the majority of the respondents – 43.2 % have more than 20 years of working experience, while 18.9 % have 3 to 7 years of experience, 10.7 % have 1 to 2 years, 10.1 % have less than one year of experience, and 7.1 % have 8 to 12 years of working experience.

Measures

Recognizing the multidimensional nature of food safety culture, the rapidly growing literature [e.g. 21, 22] documents a wide range of specific practices being implemented by organizations. Based on the previous studies in this area [15, 16], we developed scales for measuring the food safety culture. A resulting ten-item scale captures the extent to which leadership is devoted and committed to food hygiene and continuous improvement of food hygiene. A six-item scale measures communication. Furthermore, a seven-item scale measures the extent to which employees are engaged and self-committed towards ensuring a food safety. A five-item scale captures the extent to which top management ensures the resources needed to achieve the required level of food safety. A three-item scale was used to measure work pressure, and a four-item scale was applied to measure the perception of employees regarding the risk judgement. Additionally, a four-item scale was used to measure employee training efficiency. Drawing upon Ungku Fatimah et al. [15], several general questions were added such as gender, years of work/professional experience etc.

Validity was assessed in terms of content and convergent validity. Content validity refers to the adequacy of items in accurately addressing all dimensions of the particular construct of food safety culture. Content validity was qualitatively evaluated in the early stage of the questionnaire development process by examining the measurement items by several independent expert reviewers. Additionally, pilot testing was performed on a random sample of ten employees. We used a structured questionnaire with a seven-point Likert scales to capture the de-

gree to which respondents agree with the particular statements within food safety culture dimensions.

ANALYSIS AND RESULTS

Measurement and validation of constructs

The scales for measuring food safety culture were subjected to validity and reliability tests. The construct validity was assessed by merely using exploratory factor analysis (EFA) based on Varimax rotation. The scale reliability was tested by calculating its Cronbach's alpha. Additionally, we performed corrected item-total correlations (CITCs) in order to strengthen validity and reliability results. The results of the validity and reliability tests are presented in the following section. The result of factor analysis supports the validity of the food safety culture as indicated by the amount of variance which exceeded 50 % (for each subconstruct), and the loading factors of all items within each scale exceeded 0.5 [23].

As shown in Table 2, the results display three factors with eigenvalues greater than one, accounting for 63.414 % of the variance (Kaiser-Meyer-Olkin statistic 0.819; Bartlett statistic 496.713; $p = 0.000$). Thus, a model with three factors may be adequate to represent the data. To ensure a convergent validity, a cut-off value of 0.5 is considered in this study. The first factor shows the variables having a common underlying dimension of "top management commitment". The main variables, which load heavily on this factor, are related to the establishment of clear objectives regarding food hygiene and continuous improvement of food hygiene. The second factor named 'Employee collaboration' includes the variables related to teamwork, especially in relation to the work quality and food hygiene consideration. The third factor is related to the management control and rules (requirements) for food safety assurance.

The alpha coefficients have the acceptable value ranging from 0.64 to 0.77, with the lowest value for the variable "Management control" and the highest value for the variable "Top management commitment". Therefore, the alpha value for each subconstruct was considered as acceptable. The values are close to 0.70, which is considered satisfactory for the exploratory research [23]. As shown in Table 2, the corrected item-total correlation scores range from 0.45 to 0.62. The rules of thumb suggest that the item-to-total correlations should exceed 0.5 [23]. All items were kept in the model due to the content validity.

Regarding the dimension "Communication", the results reveal one factor with eigenvalues greater than one, accounting for 45.73 % of the variance (K-M-O statistic 0.747; Bartlett statistic 238.844; $p = 0.000$). As shown by the results presented in Table 3, all factor loadings are well above the recommended value of 0.5. Cronbach's alpha value shows the acceptable value of 0.973. In addition, the corrected item-total correlation scores support the reliability estimates with values ranging from 0.41 to 0.55.

Table 2: Scale validity and reliability for "leadership and employee support"

Construct: leadership and employee support	Factor loading	CITC
Factor 1: Top management commitment **Cronbach's alpha = 0.771**		
V11. a) The company management has clearly defined the goals regarding food hygiene (wishes to market safe product).	0.824	0.607
V11. d) The company management struggles constantly to improve food hygiene in the company.	0.783	0.615
V11. b) The company management motivates employees to consider food hygiene.	0.736	0.620
V11. c) The company management listens if we have remarks regarding food hygiene (e.g. unclean rooms, inadequate protective clothing, sterilizers not working, if someone does not wash hands ...).	0.657	0.542
Factor 2: Employee collaboration **Cronbach's alpha = 0.721**		
V11. h) When a lot of work has to be done quickly, employees collaborate so that it is done quickly and with quality.	0.807	0.546
V11. g) Skilled employees provide help to harness food hygiene maintained by newly employed workers	0.751	0.536
V11. i) Among employees, we alert each other to consider food hygiene.	0.743	0.547
Factor 3: Management control **Cronbach's alpha = 0.642**		
V11. f) We are always monitored by superiors to see food hygiene rules are respected.	0.795	0.466
V11. j) We are warned by the superior in case food hygiene is not respected.	0.702	0.458
V11. e) Superiors consistently acquaint employees about food hygiene rules.	0.627	0.491

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. CITC: corrected item-total correlations

Table 3: Scale validity and reliability for "communication"

Construct: Communication Cronbach's alpha = 0.710	Factor loading	CITC
V12. a) The company management discusses food hygiene with employees.	0.768	0.548
V12. d) All pieces of information on how to keep food hygiene are available or written in the job area (e.g. figure, posters how to use protective clothing, wash hands…).	0.707	0.546
V12. b) Superiors give directions on how to provide food hygiene.	0.662	0.423
V12. f) We can always discuss with co-workers about food hygiene problems.	0.654	0.509
V12. e) Superiors encourage us to give suggestions for food hygiene rule improvement.	0.641	0.492
V12. c) Employees can freely discuss everything we notice that could influence food hygiene.	0.614	0.406

Note: Extraction Method: Principal Component Analysis. CITC: corrected item-total correlations

Regarding the dimension "Employee engagement and self-commitment", the results provide the solution in terms of two factors with eigenvalues greater than one, accounting for 59.49 % of the variance (K-M-O statistic 0.731; Bartlett statistic 325.174; p = 0.000). As shown by the results presented in Table 4, all factor loadings exceed the value of 0.5, thus providing empirical justification for the convergent validity. Moreover, reliability tests show acceptable internal consistency with Cronbach's alpha value of 0.728 for the subconstruct named as "Compliance with rules" and 0.601 for the subconstruct "Hygiene and food safety". Additionally, the corrected item-total correlation scores range from 0.40 to 0.58, thus showing the acceptable values.

Regarding the dimension "Support", the results suggest one factor with eigenvalues greater than one, accounting for 59.21 % of the variance

(K-M-O statistic 0.809; Bartlett statistic 299.603; p = 0.000). The convergent validity assessment confirmed the convergent validity for the items of this dimension, with factor loading ranging from 0.67 to 0.83 (Table 5). A high Cronbach's alpha score of 0.815 confirmed the overall reliability of the measurement scales. Additionally, the corrected item-total correlation scores support the internal reliability. All values are above the recommended value of 0.5.

Regarding the construct "Work pressure", the results show one factor with eigenvalues greater than one, accounting for 50.83 % of the variance (K-M-O statistic 0.588; Bartlett statistic 33.639; p = 0.000). It appears to be that factor loadings are above the recommended value 0.5 [23] (Table 6). However, as given in Table 5, the reliability and consistency estimates are not above the recommended values. For instance, a Cronbach's alpha for this construct is below the recommended value of 0.7. However, one should take into account that if the number of items in a scale increases, it is more likely that the Cronbach's alpha will be high and vice versa. Additionally, one item (V15.a) is reverse coded, which could affect the correlation between the scores of this item and the combined score of the other two (i.e. low CITC).

Table 4: Scale validity and reliability for "employee engagement and self-commitment"

Construct: Employee engagement and self-commitment	Factor loading	CITC
Factor 1: Compliance with rules **Cronbach's alpha = 0.728**		
V13. e) I consider food hygiene because I think it is important.	0.791	0.578
V13. d) Food safety is very important.	0.788	0.515
V13. f) I strive to follow food hygiene rules.	0.610	0.464
V13. c) I follow food hygiene rules because it is my responsibility.	0.587	0.538
Factor 2: Hygiene and food safety **Cronbach's alpha = 0.601**		
V13. b) When there are problems influencing food hygiene, the head officer reacts quickly and effectively.	0.817	0.383
V13. a) The company management emphasizes hygiene and food safety.	0.735	0.542
V13. g) I maintain my work area clean because I do not like disorder.	0.613	0.403

Note: Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. CITC: corrected item-total correlations

Table 5: Scale validity and reliability for "support"

Construct: Support Cronbach's alpha = 0.815	Factor loading	CITC
V14. d) The company management is concerned about food hygiene training and education of employees.	0.831	0.699
V14. c) The company management provides necessary financial needs to support food hygiene and food safety.	0.821	0.689
V14. e) The guidelines to provide food hygiene are good.	0.781	0.633
V14. a) Food hygiene equipment and food safety is available (e.g. wash bins, sterilizers, protective gloves and headdress…).	0.735	0.563
V14. b) Work area is hygiene-technically appropriate to maintain food hygiene.	0.668	0.527

Note: Extraction Method: Principal Component Analysis. CITC: corrected item-total correlations

Regarding the dimension "Risk judgement", the results suggest one factor with eigenvalues greater than one, accounting for 53.82 % of the variance (K-M-O statistic 0.721; Bartlett statistic 131.831; p = 0.000). As shown in Table 7, the factor loadings range from 0.52 to 0.81, therefore showing the acceptable values. In combination with the reliability estimates, EFA provide empirical evidence regarding the unidimensionality of the scale.

Regarding the dimension "Training efficiency", the results reveal one factor with eigenvalues greater than one, accounting for 59.94 % of the variance (K-M-O statistic 0.698; Bartlett statistic 196,007; p = 0.000). As shown by the results presented in Table 8, all factor loadings are well above the recommended value of 0.5. Cronbach's alpha was above the recommended level of 0.7. In addition, the corrected item-total correlation scores support the reliability estimates with values ranging from 0.48 to 0.66.

Table 6: Scale validity and reliability "work pressure"

Construct: Work pressure **Cronbach's alpha = 0,490**	**Factor loading**	**CITC**
V15. b) I always have enough time to follow food hygiene rules even when I have a lot of work to do.	0.778	0.391
V15. c) The number of workers at work is sufficient to provide food hygiene.	0.722	0.347
V15. a) If I am loaded with work, I do not follow food hygiene rules.ʳ	0.632	0.261

Note: Extraction Method: Principal Component Analysis. CITC: corrected item-total correlations. ʳ Item was reverse coded

Table 7: Scale validity and reliability for "risk judgement"

Construct: Risk judgment **Cronbach's alpha = 0.705**	**Factor loading**	**CITC**
V16. b) Hygiene hazards are under control.	0.819	0.586
V16. a) We are aware of hygiene hazards in the company.	0.786	0.545
V16. c) In case hygiene rules are not respected, we are warned by superiors.	0.770	0.535
V16. d) When work has to be done quickly, superiors say we have to do it without taking care of food hygiene.ʳ	0.521	0.311

Note: Extraction Method: Principal Component Analysis. CITC: corrected item-total correlations. ʳ Item was reverse coded

Table 8: Scale validity and reliability for "training efficiency"

Construct: Training efficiency **Cronbach's alpha = 0.769**	**Factor loading**	**CITC**
V17. a) The food hygiene training gives me all the required knowledge I need at work.	0.825	0.644
V17. b) The knowledge obtained at the food hygiene training can be used to provide food hygiene.	0.819	0.658
V17. c) The food hygiene training in my company is often enough.	0.766	0.560
V17. d) The food hygiene training is understandable.	0.677	0.477

Note: Extraction Method: Principal Component Analysis. CITC: corrected item-total correlations

Descriptive statistics

Prior to further statistical analysis, we first investigated the descriptive statistics for study variables. Means, standard deviations, and bivariate correlations are presented in Table 9. Observing the overall subconstructs, we can see that the highest mean value corresponds to the employee engagement and self-commitment (6.84), while the lowest value corresponds to the work pressure (6.35). As shown by the results, it can be argued that respondents perceive food safety culture dimensions as highly relevant (e.g. all mean values are above 6).

As expected, the results revealed positive and significant correlations between food safety culture dimensions with correlations' coefficients ranging from 0.40 to 0.67 ($p < 0.01$). Furthermore, training efficiency shows the strongest correlation with the employee engagement and self-commitment ($r = 0.665$, $p < 0.01$) and risk judgement ($r = 0.664$, $p < 0.01$). It appears that the leadership and employee support has the strongest correlation with the communication ($r = 0.637$, $p < 0.01$). Regarding the support, the strongest correlation was observed in the case of training efficiency ($r = 0.582$, $p < 0.01$).

Table 9: Means, standard deviations, and correlations

	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)
(1) leadership and employee support	6.59	0.47						
(2) communication	6.56	0.57	0.637**					
(3) employee engagement and self-commitment	6.84	0.27	0.543**	0.582**				
(4) support	6.73	0.45	0.463**	0.488**	0.576**			
(5) work pressure	6.35	0.71	0.463**	0.404**	0.459**	0.515**		
(6) risk judgement	6.75	0.42	0.444**	0.499**	0.591**	0.495**	0.510**	
(7) training efficiency	6.73	0.46	0.446**	0.555**	0.665**	0.582**	0.476**	0.664**

Note: **Correlation is significant at the 0.01 level (2-tailed).

Table 10: Mean values for studied variables from the perspective of the working experience

Experience / Dimension	Leadership and employee support	Communication	Employee engagement and self-commitment	Support	Work pressure	Risk judgement	Training efficiency
Less than 1 year	6.66	6.49	6.90	6.95	6.55	6.79	6.74
1-2 years	6.54	6.49	6.79	6.63	6.20	6.68	6.60
3-7 years	6.57	6.61	6.84	6.62	6.33	6.83	6.73
8-12 years	6.53	6.35	6.80	6.80	6.33	6.73	6.77
13-20 years	6.55	6.60	6.81	6.72	6.35	6.74	6.85
More than 20 years	6.61	6.60	6.86	6.73	6.34	6.72	6.72
F-ratio	0.245 ($p > 0.05$)	0.566 ($p > 0.05$)	0.489 ($p > 0.05$)	1.464 ($p > 0.05$)	0.424 ($p > 0.05$)	0.414 ($p > 0.05$)	0.555 ($p > 0.05$)

Note: F-ratio = Mean squares within Groups/Mean squares between groups

Table 10 shows the results of the analysis of variance (ANOVA) for the studied variables in the context of the groups that represent working experience (in years). As can be seen in Table 9, the differences between the means in each particular dimension are not statistically significant ($p>0.05$). One can reveal that the highest mean values correspond to the dimension "employee engagement and self-commitment", while the lowest mean values correspond to the dimension "communication". However, as already mentioned, there are no statistically significant differences between different groups of working experience.

Regression analysis

The results in Table 11 show that the overall regression model is significant with an F value of 48.205 ($p = 0.000$) and R2 value of 0.467. Furthermore, to examine multicollinearity, we calculated variance inflation factors (VIF) for the regression equation. The VIF values for the regression model were below 2, which is well below the rule-of-thumb cut-off of 10 [24].

Table 11: Results of regression analysis: employee engagement and self-commitment as dependent variables

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	3.920	0.254		15.453	0.000
leadership and employee support	0.100	0.044	0.174	2.256	0.025
communication	0.142	0.035	0.307	4.032	0.000
support	0.199	0040	0.337	4.933	0.000

Note: B = Unstandardized coefficient, Beta = Standardized coefficient

Table 12: Results of regression analysis: training efficiency as a dependent variable

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.008	0.454		4,424	0.000
leadership and employee support	0.018	0.079	0.018	0.225	0.822
communication	0.278	0.063	0.346	4.419	0.000
support	0.413	0.072	0.404	5.740	0.000

Note: B = Unstandardized coefficient, Beta = Standardized coefficient

Table 13: Results of regression analysis: risk judgement as a dependent variable

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.431	0.348		6.995	0.000
training efficiency	0.500	0.058	0.545	8.635	0000
work pressure	0.150	0.038	0.251	3.973	0.000

Note: B = Unstandardized coefficient, Beta = Standardized coefficient

As shown in Table 10, the results of the regression analysis suggest that the leadership and employee support, communication as well as support have a significant relationship with employee engagement and self-commitment ($\beta = 0.174$, $p < 0.05$; $\beta = 0.307$, $p = 0.000$, $\beta = 0.337$, $p = 0.000$, respectively).

Furthermore, regression analysis was performed concerning the influence of the independent variables above on training efficiency (Table 12). The results suggest that the model is significant with an F value of 42.295 ($p = 0.000$) and R2 value of 0.435. It appears that the support is the strongest predictor of the training efficiency ($\beta = 0.404$, $p = 0.000$). Communication is also positively and significantly related to the training efficiency ($\beta = 0.346$, $p = 0.000$), while leadership and employee support are not significantly related to the training efficiency ($\beta = 0.018$, $p > 0.05$).

Moreover, we were interested whether training efficiency and work pressure significantly influence risk judgement (Table 13). The results suggest that the model is significant with an F value of 79.523 ($p = 0.000$) and R2 value of 0.489. According to the results, both training efficiency and work pressure are significant predictors of risk judgement ($\beta = 0.545$, $p = 0.000$; $\beta = 0.251$, $p = 0.000$, respectively).

DISCUSSION AND CONCLUSIONS

Notwithstanding valuable contributions pointed out in previous studies [15, 16], both researchers and managers still struggle to understand how to measure food safety culture as well as what constitutes food safety culture. This study contributes to the current literature and management practice by conceptually and empirically increasing validated understanding about how to measure food safety culture. In this regard, we developed an empirically based and testable framework deriving from theoretical insights gained in previous studies.

Food safety culture is considered an emerging topic and is also concerned with quantification of risks associated with the given product and process [25]. Prior researches have outlined the important elements of food safety culture, namely leadership, employee support, communication, employee engagement, risk perception and work environment [15, 16].

How to measure and how to estimate food safety culture was the focal point of this study as well. In particular, the research was carried out among employees in a medium-sized Slovenian food processing company. Drawing upon literature reviews, one can notice that the questionnaire and the observation methods are the most common approaches in studying food safety culture [15, 16, 20]. This study has used the questionnaire as a primary investigation method.

Regarding the interrelationship between particular dimensions of food safety culture, our study contributes to prior literature suggesting that leadership and employee support, communication as well as the overall support are important predictors of employee engagement and self-

Prior researches have outlined the important elements of food safety culture, namely leadership, employee support, communication, employee engagement, risk perception and work environment.

commitment. Several prior studies [15, 16, 26] have highlighted the aforementioned food safety culture as the key success factors and the integral elements of building food safety culture. Furthermore, our study revealed that communication and support have a significant impact on training efficiency as well. According to prior literature, management commitment, organizational support and communication are some of the organizational factors that have been found as influential factors of food safety practices among individual employees and at the organization level [15, 21, 22]. One cannot neglect the training efficiency that is essential in building food safety culture. As argued by Stedefeldt et al. [27], it is necessary to establish the goals of employee training as well as to communicate with employees regarding the purpose and objectives of training. By doing so, an organization can improve the employees' commitment towards training [27].

Based on the results of the descriptive statistics and ANOVA, we can argue that all dimensions of food safety culture were perceived to a reasonably high extent. Employee engagement and self-commitment achieved the highest mean value from the perspective of employees. The results can be substantiated by research work of Ungku Fatimah et al. [15] who also found that self-commitment is the food safety culture dimension, which is highly ranked by respondents regardless of the gender, age, working experience, etc.

Managers should put the focus on employee training and search for mechanisms to lower work pressure in order to enhance the awareness among employees regarding the perception of risk associated with food hygiene.

Our results have therefore confirmed that employees have a positive attitude towards food safety culture. Overall, the results of this study offer several guidelines to help organizations develop and successfully deploy food safety practices. By distinguishing different fundamental dimensions of food safety culture, this study provides a basis of guidance for practitioners to adapt food safety practices. Among others, it sheds light on decisions regarding the relationship between food safety dimensions and risk judgement. In particular, managers should put the focus on employee training and search for mechanisms to lower work pressure in order to enhance the awareness among employees regarding the perception of risk associated with food hygiene.

We have entered the level of integrated food safety management based on mankind with food safety culture. Understanding all the threads and gaps on the way to establish food safety culture, it requires a systematic approach and time allocated by the management to the new rule of food safety. The one who is responsible for ensuring food safety in a food company is the key player in identifying opportunities to raise food safety culture and to identify weakness in the food safety system, changing traditions and introducing innovative approaches which are able to effectively and rapidly respond to changes in the environment [28].

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Original scientific article

The impact of ultrafine particles on daily counts of deaths from respiratory diseases in the Municipality of Ljubljana: A temporal variability study

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ABSTRACT

Ultrafine particles are outdoor air pollutants, the exposure to which is associated with morbidity and mortality for respiratory and cardiovascular diseases. The purpose of this study is to assess the temporal variability of ultrafine particle number concentrations in outdoor air and daily counts of deaths from respiratory diseases. Epidemiological ecological temporal variability study lasted 731 days. The observed population included residents of the Municipality of Ljubljana, who died of respiratory diseases in the observed period. Descriptive statistics was implemented. The highest daily counts of deaths from respiratory diseases in 2012 were in the periods February-April, May-June, and October. The next periods with the highest daily counts of deaths from respiratory diseases repeated again in the periods December 2012-April 2013, May-July 2013, and October 2013. These periods coincide with the periods of increased levels of ultrafine particle number concentrations. We concluded that there was a temporal variability association between the periods with higher daily counts of deaths from respiratory diseases and heightened levels, of ultrafine particle number concentrations. Research of the ultrafine particles' effect in outdoor air on public health is a new scientific field in public health, which because of its complexity needs an interdisciplinary approach.

Key words: ultrafine particles, respiratory diseases, health effect

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INTRODUCTION

Particulate matter is besides nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), heavy metals, volatile organic compounds and pesticides one of the most common outdoor air pollutants in Slovenia and in Europe [1, 2]. The division of particulate matter is most commonly based on aerodynamic diameter, including particles with aerodynamic diameter less than 10 μm (PM_{10}), less than 2.5 μm ($PM_{2.5}$), less than 1 μm (PM_1), and less than 0.1 μm ($PM_{0.1}$), with the last group also labeled as ultrafine particles (UFPs). Taken from the report Air quality in Slovenia 2014 [1], the main source of PM_{10} (62 %) and $PM_{2.5}$ (74 %) are small furnaces.

Nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), heavy metals, volatile organic compounds and pesticides one of the most common outdoor air pollutants in Slovenia and in Europe.

UFPs are particles of outdoor air pollution, with aerodynamic diameter less than 0.1 μm. Chemical compounds and physical shape of UFPs is dependent on the source of formation and secondary formations in outdoor air. Primary UFPs are formed directly at the emission source, whereas secondary UFPs are formed as a homogenous nucleation of gases [3-5]. The distribution and the type of UFPs are strongly dependent on the type of diesel exhaust, as traffic is counted as one of the main UFPs formation sources [6, 7]. Sources of emission of UFPs are also small furnaces, biomass boilers, and emissions from industrial coal fueled power plants [8-10]. Concentrations of ultrafine particle (UFP) number concentrations in the environment, where there are no anthropogenic sources of formation, vary between few to twenty thousand particles on cm^3 [10]. Even though UFPs have high particle number concentrations on cm^3, they add very little to total mass of particles of different sizes (total mass concentration of particles of various sizes) [11]. Variation of UFP number concentration is dependent on location and seasonal and daily temporal variability of meteorological and ecological parameters [4]. The formation of UFPs is also strongly associated with pollutants, which are formed in combustion processes, like nitrogen oxides (NO_x) and carbon monoxide (CO) [12].

One of the most important UFP characteristics, influencing public health, is chemical properties of particles, mostly elemental composition, inorganic ions and carbonaceous compounds [5, 13]. Considering bigger relative surface area of UFPs in comparison to coarse particles, it is predicted that UFPs have bigger toxicological effect on health; small particle size diameter is enabling them to enter into the bloodstream and thus spread in the whole organism through penetration into the lung tissue compartments [5, 11].

UFP deposition in the respiratory tract can be affected by physical activity, entryway – oral versus nasal breathing, disease status, and individuals age [9]. UFP deposition importantly affects the development of respiratory and cardiovascular diseases and functioning of other internal organs [11].

Exposure to total deposited fraction of UFPs is higher in asthmatic than in non-asthmatic children [14]. Health risk is also associated with heightened immune response, which may lead to the formation of blood clots and can cause myocardial infarction and stroke [10]. Heightened risks of sudden asthma exacerbation, induced allergy response, throm-

bosis, and endothelial dysfunction have also been confirmed [9, 15]. In patients with asthma, exposure to UFPs has a more significant effect on exacerbation of acute respiratory diseases [16]. Exposure to UFPs in outdoor air can reduce vascular reactivity and can significantly reduce venous nitrate (NO) concentrations [17]. The impact of the delayed and cumulative effects of UFPs pollution has also been discussed. Cumulative effects of 5-day UFPs pollution levels are stronger than health effects which appear right after the exposure [17]. Exposure to UFPs is associated with the decrease of electrical activity of the heart, which may lead to myocardial infarction [18, 19]. Exposure to UFPs exerts proinflammatory effects through oxidative stress response, and with the formation of reactive oxygen spices (ROS) stimulates the progression of atherosclerosis and precipitation of acute cardiovascular response, which involves all responses from the increased blood pressure to myocardial infarction [20]. Besides the effect on the development of respiratory diseases and cardiovascular system, UFPs have other effects on human health. Exposure to UFPs increases the levels of biomarkers for neutrophilic inflammation [21]. In patients with chronic respiratory diseases, exposure to UFPs can induce immune response of the white blood cells (monocytes) [22]. UFPs can change the structure of DNA [23]. Contradictory effects of UFPs partly come from the increased oxidative stress in the tissue and their subsequent impairment of the phagocytic ability of alveolar macrophages and phagocyte activity [20, 24].

Traffic is counted as one of the main UFPs formation sources. Sources of emission of UFPs are also small furnaces, biomass boilers, and emissions from industrial coal fueled power plants.

Confirmation for the association between exposure to UFPs and other acute health outcomes (such as mortality and dysfunction of the central nervous system) and chronic health outcomes (mortality and respiratory system dysfunction, reproductive and developmental effects, cancer, genotoxicity and mutagenicity) were conducted as inconsistent [19, 25–28].

Epidemiological studies at the population level, because of inconsistencies in their conclusions, still cannot firmly ascertain the association between exposure to UFPs in outdoor air and morbidity and mortality for either cardiovascular or respiratory diseases [9–11]. Lanki et al. [19] have confirmed positive and statistically significant temporal variable association between UFP number concentrations in outdoor air and daily number of hospital admissions because of acute myocardial infarction. Positive and statistically significant temporal variable association was proven between UFP number concentration in outdoor air and number of daily hospital admissions and daily counts of deaths because of stroke; UFP number concentrations in warmer seasons have been proven by Kettunen et al. as well [29]. Leitte et al. [16] have proven positive and statistically significant temporal variable association between daily number of emergency room visits for respiratory diseases and UFP size fraction between 0.05 in 0.10 μm. This association has not been proven for UFP size fraction smaller than 0.05 μm. Spirometric lung function was found to be non-significantly associated with concentrations of ultrafine particle (UFP) number concentrations [28, 30].

The aim of this study is to assess the temporal variable association between UFP number concentrations in outdoor air and daily counts of deaths from respiratory diseases in the Municipality of Ljubljana (MOL).

METODOLOGY

Study type and observed population

For the observation of association between UFPs and daily counts of deaths from respiratory diseases in MOL, an epidemiological ecological temporal variability study was implemented. The unit of observation was represented as a single day in the period between January 1st, 2012 and December 31st, 2013. In total, there were 731 days of observation in this period. The observed population was represented by residents of MOL aged 1 year or older, who died of respiratory diseases in the period of observation.

Area of observation

An area of observation in our study is an administrative unit of the Municipality of Ljubljana. In the first year (2012), MOL consisted of 280,278 residents; in the second year (2013) MOL consisted of 282,741 residents. Population density in 2012 counted as 1,019.2 m^2 and in 2013 as 1,028.1 m^2 [31].

MOL is situated in a basin, for which winter temperature inversion is characteristic, which causes long-term fog. Temperature inversion also creates poor airing of the basin, which further causes decreased dilution of pollutants. In the year 2013 in MOL, 17 industrial sources were presented, which yearly produce over 100 kg of total dust from combustion sources. The total dust mass of 17 industrial sources in MOL in 2013 was 62,096 kg [32].

Data collection

Health and environmental data for this temporal variability study was collected within the European project UFIREG (Ultrafine particles – cooperation with environmental and health policy). UFIREG project started in July 2011 and finished in December 2014 in four European countries – Dresden and Augsburg (Germany), Prague (Czech Republic), Ljubljana (Slovenia) and Chernivtsi (Ukraine) [33].

Daily counts of deaths from respiratory diseases

Health data was collected from death register, kept by the National Institute of Public Health. In the study, daily counts of deaths from respiratory diseases (ICD-10 (The International Statistical Classification of Diseases and Related Health Problems, 10th Revision), code J00 – J99) were recorded [34]. From the death register, the date of death, diagnosis of deaths, age at death, and gender were collected.

Ultrafine particles in outdoor air

UFP number concentrations were measured depending on the size (angl. Particle Number Concentration – PNC) in the time interval from 5 to 20 minutes, which were calculated to daily average concentrations. 24-hr average UFP number concentrations were calculated for five size ranges: UFP size from 0.01 to 0.02 μm, from 0.02 to 0.03 μm, from 0.03 to 0.05 μm, from 0.05 to 0.07 μm and from 0.07 to 0.10 μm as particle number/cm^3.

UFP number concentration was collected on measuring sites, on the location at The National Institute of Chemistry, Hajdrihovaulica 19, Ljubljana. Kindergarten, primary school and multistorey buildings are situated in the vicinity of the measuring site. Measuring site is situated 50 m from the nearest road. In the vicinity of the measuring site, the railway station is situated (approximately 1 km). The measuring site is situated in the urban environment, and measurements are representative for MOL [33].

Statistical analysis

Distribution and temporal variability of daily counts of deaths from respiratory diseases and daily UFP number concentrations in outdoor air are represented in tabular form with statisticaly significant parameters: mean, standard deviation, minimum and maximum value, quartile 1, median, quartile 3, total number of observed days, and total number of missing data. Temporal variability of daily counts of deaths from respiratory diseases and UFP number concentrations for each particle size diameter is displayed with sequence diagrams. For description of the observed variables and temporal variability, a statistical programme SPSS version 21.0 (SPSS Inc., Chicago, IL, ZDA) was used.

RESULTS

Data description

Daily counts of deaths from respiratory diseases

Daily counts of deaths from respiratory diseases were collected for 731/731 (100 %) observed days. Statistically significant values for data variability of daily counts of deaths from respiratory diseases for the years 2012 and 2013 are displayed in Table 1.

Ultrafine particles in outdoor air

Data for individual UFP size ranges ($UFP_{0.01-0.02}$, $UFP_{0.02-0.03}$, $UFP_{0.03-0.05}$, $UFP_{0.05-0.07}$ and $UFP_{0.07-0.10}$) was in the observed period measured for 435/731 (59,5 %) days. In total,this presents 296 (40,5 %) missing entries of UFP number concentration measurements. The chosen typical statistical values for distribution of average 24-hr UFP number concentrations for individual UFPs size ranges are displayed in Table 2.

Table 1: Distribution of statistical values data for daily counts of deaths from respiratory diseases in the Municipality of Ljubljana in years 2012 and 2013

Year	Mean	SD	Min.	Q_1	Median	Q_3	Max.	N	MD
2012	0.37	0.64	0	0.00	0.00	1.00	3	366	0
2013	0.31	0.52	0	0.00	0.00	1.00	2	365	0

Legend: SD – standard deviation; Q_1 – quartil 1;Q_3– quartil 3; N – total number of oberved days; MD– number of missing data

Table 2: Distribution of chosen typical values of average 24-hr number concentrations of $UFP_{0.01-0.02}$, $UFP_{0.02-0.03}$, $UFP_{0.03-0.05}$, $UFP_{0.05-0.07}$ and $UFP_{0.07-0.10}$ in the Municipality of Ljubljana in years 2012 and 2013

Size ranges of UFPs	Year	Average	SD	Min.	Q_1	Median	Q_3	Max.	N	MD
$UFD_{0.01-0.02}$	2012	1549.84	503.63	361	1200.28	1499.37	1903.08	3203	147	219
	2013	1303.19	518.48	29	939.32	1222.0	1584.80	3564	288	77
$UFD_{0.02-0.03}$	2012	1203.00	405.15	190	907.47	1158.59	1433.03	2462	147	219
	2013	1113.33	433.37	92	838.40	1063.84	1346.27	3360	288	77
$UFD_{0.03-0.05}$	2012	1571.23	571.64	183	1150.06	1537.13	1887.38	3897	147	219
	2013	1483.22	628.58	267	1102.01	1392.05	1752.15	4164	288	77
$UFD_{0.05-0.07}$	2012	1029.51	418.72	191	763.63	939.05	1226.13	3127	147	219
	2013	994.42	472.69	232	659.13	897.34	1189.20	3447	288	77
$UFD_{0.07-0.10}$	2012	1032.09	488.27	292	743.18	924.83	1188.02	3610	147	219
	2013	1029.71	575.63	281	683.59	886.20	1195.85	4208	288	77

Legend: SD – standard deviation; Q_1 – quartil 1;Q_3– quartil 3; N – total number of data; MD – number of missing data

Temporal variability of health and environmental data

Temporal variability of daily counts of deaths from respiratory diseases of MOL population and UFP number concentration in outdoor air for each UFP size range in the years 2012 and 2013 is displayed with sequence diagrams in Figure 1.

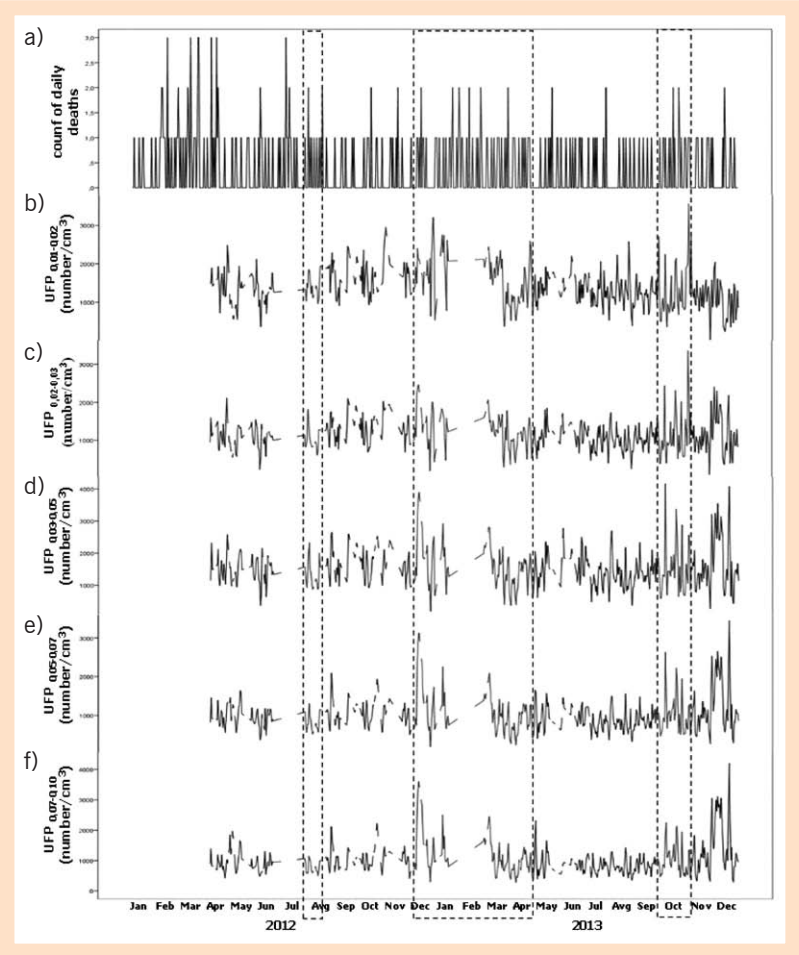

Figure 1:
Temporal variability:
a) daily counts of deaths from respiratory diseases,
b) average 24-hour number concentration of $UFP_{0.01-0.02}$(number/cm^3),
c) average 24-hour number concentration of $UFP_{0.02-0.03}$ (number/cm^3),
d) average 24-hour number concentration of $UFP_{0.03-0.05}$ (number/cm^3),
e) average 24-hour number concentration of $UFP_{0.05-0.07}$ (number/cm^3) and
f) average 24-hour number concentration of $UFP_{0.07-0.10}$ (number/cm^3) in the Municipality of Ljubljana in years 2012 and 2013.

DISCUSSION

Daily counts of deaths from respiratory diseases

Collection of health data did not present any difficulties. Data of daily counts of deaths from respiratory diseases in MOL population was collected for all days within the observed period from January the 1st, 2012 to December 31st, 2013.

The highest daily counts of deaths from respiratory diseases in 2012 were in the period between the middle of February and the middle of April and again from the beginning of May to the middle of July and in October. Daily counts of deaths from respiratory diseases increased again from December 2012 to April 2013. In the year 2013, daily counts of deaths were again higher from the middle of May to the middle of July and in October. High daily counts of deaths in the years 2012 and 2013 coincide with the period of flu epidemic, which was in 2012 between the 4th and 14th week [35] and between the 2nd and 14th week in the year 2013 [36].

The highest daily counts of deaths from respiratory diseases were three deaths per day. The period with the highest daily counts of deaths from respiratory diseases in the year 2012 started at the beginning of February and continued to the beginning of April and repeated again in the first half of July. In the year of 2013, the highest daily counts of deaths from respiratory diseases (three deaths per day) did not repeat.

The highest daily counts of deaths from respiratory diseases were three deaths per day.

Daily counts of deaths from respiratory diseases show a repetitive pattern, which is typically seasonal. Seasonal predisposition is proven in the association with the number of emergency room visits [16] and mortality for myocardial infarction [29, 37]. Leitte et al. [16] report exacerbation of health conditions on weekends and holidays.

Ultrafine particles in outdoor air

Concentration of UFPs was slightly hightened in December and January, which is followed with a slight decrease of concentration in spring and in summer. Slight winter increase of UFP number concentrations can probably be associated with combustion in small furnaces in households. Even though seasonal temporal variability of UFP number concentrations in outdoor air is recognisable, there are still only slight differences in UFP number concentrations in outdoor air. This confirms that UFP number concentrations are mostly conditioned by traffic emissions, because 90 % of the secondary UFP formation in outdoor air is associated with the combustion of dieasel exhaust [7, 38]. In risk management of heightened UFP concentrations and consequently their health effect, it is important to have in mind that environmental indicator in Slovenia “The extent and structure of public transport and traffic” shows that growth of motorized traffic is above the average in comparison to EU [39].

Temporal variability of daily counts of deaths from respiratory diseases and UFP outdoor air pollution

The length of the observed period was conditioned by the European project UFIREG. A 2-year observational period of health and UFP

number concentrations data monitoring was medium long observation period. In epidemiological ecological temporal variability studies up until now, health effect of UFPs in outdoor air at the population level was observed both in short and long observation periods. In the study of Penttinen et al. [28, 30], the period of observation was six months long, in the study of Delfinno et al. [27], Brüskeet et al. [22], Leitteet et al. [16], Karakatsaniet et al. [25] and Chung et al. [40] the period of observation was from six months to two years long. Six years and a half [41] and seven-year observation period [29] present long periods of observation.

Figure 1 shows the temporal variability association between periods with higher daily counts of deaths from respiratory diseases and higher daily UFP number concentrations. UFP health effect has already been evidenced in some previous studies. Leitte et al. [16] have proven positive association between $UFPs_{0.05\text{-}0.10}$ and emergency room visits for acute exacerbation of respiratory diseases. Penttinen et al. [30] have proven a positive association between UFP number concentrations and asthma exacerbation.

The observed temporal variability association for longer periods with heightened daily counts of deaths from respiratory diseases and higher daily UFP number concentrations can be contributed to time delayed effects from exposure to the observed health outcome, in the case of this study to the heightened daily counts of deaths from respiratory diseases. In previous studies, it has already been recognized that outdoor air pollution not only on the day of the exposure but also for several preceding days affect daily counts of deaths on a given day [42–45]. It has been discovered that long-term health effects of the outdoor air pollution can persist up until a month [45, 46].

Difficulties of data collection

We had some difficulties with collection and preparation of data of daily UFP number concentrations in outdoor air. In the years 2012 and 2013, in total, 40.5 % of data were missing. The biggest part of missing data was in the year 2012 (from January to March 2012 and the first half of July 2012), less data was missing in 2013 (the first half of February 2013). The reason behind the missing measurement data is consequential to the control and validation of measurement equipment and maintenance of measuring equipment [33]. UFPs in outdoor air and UFP health effects present in science a relatively new research field that is why it is important to know that on the European level there is no prescribed method of UFP measurement on the regulatory level [10]. Kukec et al. [47] have already emphasized the complications with the collection of environmental data, which is essential for association with health data at the population level. In the future, the availability and quality of exposure to coarse particles data in outdoor air should be improved. One of the most important challenges in future research still presents the standardization of measuring equipment and technique for UFP measurements as well as the inclusion of UFPs in the routine system of the national network for monitoring air quality [47].

In the literature review of outdoor air pollution and health effect at the population level, Galičič et al. [48] have also concluded that collection of suitable and quality environmental data presents one of the most frequent limitations in epidemiological ecological studies.

Strengths and limitations of our study

Our study is the first study in the field of the investigation of UFP effect in outdoor air on public health in Slovenia, which is why we have come to some limitations of our study. The biggest limitation of our study presents missing the environmental data of daily UFP number concentrations. The second limitation is related to the small population and consequently less daily counts of deaths from respiratory diseases. Nevertheless, our study can be considered as relevant, because the area of observation was not yet investigated in Slovenia. Even though UFP number concentration data was gathered within the UFIREG project, the authors of this study were acquainted with the use of measuring equipment, and that the acquired knowledge would be used in the future for measurements of UFP number concentrations in other parts of Slovenia, which are most burdened with outdoor air pollution.

Future research

Research of the UFP effect in outdoor air on public health is a new scientific field in public health that is why the possibilities for the future research are numerous. Studies up until now on the one hand show statistically significant association between the effect of UFPs of different sizes in outdoor air on public health at the population level [16, 30], and on the other hand the effect is not shown for some UFP sizes ranges [16, 28]. For confirmation of UFPs in outdoor air effect on public health, further temporal and spatial variability epidemiological ecological studies are needed. Galičič et al. [48] and Kukec et al. [49, 50] have already emphasized and recommended the investigation of the effect of outdoor air pollution, also of UFPs, on smaller spatial units with a thick web of the observed units, with the purpose to undertake the exact exposure assessment.

The observed population of studies on the population level was representative for the whole population. In the future, research specific population groups should be considered (children, elderly, ill and poor), because the exposure to outdoor air pollution levels in this population groups has an immense health effect [51].

In the past, UFP number concentrations in outdoor air have been collected only within the UFIREG project. Routine monitoring of UFP number concentrations in outdoor air should be enlisted in the national network for monitoring air quality, which is administered by Slovenian Environment Agency. Within the national network for monitoring air quality, in January 2016 data collection of PM_{10} concentrations was collected on 15 measuring sites, and $PM_{2.5}$ concentrations were measured on 4 measuring sites [50].

In the future, research specific population groups should be considered (children, elderly, ill and poor), because the exposure to outdoor air pollution levels in this population groups has an immense health effect.

The possibilities for future research in the field of UFP health effect in outdoor air on public health also presents chemical and microbiological composition of UFPs and UFP health effect together with other outdoor air pollutants (multiple effects, synergistic and antagonistic interactions). It has been established that UFPs of various sizes also have different chemical composition, which is also associated with the source and age of UFPs [52].

CONCLUSIONS

Temporal variability of daily counts of deaths from respiratory diseases and UFP number concentrations in outdoor air during the year have significant seasonal pattern. UFP number concentrations in outdoor air are slightly higher in winter, when also daily counts of deaths from respiratory diseases are slightly higher. Thus temporal variable association between the periods of higher daily counts of deaths from respiratory disease and higher daily UFP number concentrations has been proven. Research of the UFP effects in outdoor air on public health is a new scientific field in public health, which because of its complexity needs an interdisciplinary approach.

UFP number concentrations in outdoor air are slightly higher in winter.

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Professional paper

Health risk assessment for dental healthcare employees and patients due to the exposure to *Legionella* spp. in dental unit water systems in Slovenia

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ABSTRACT

Due to a possible *Legionella* contamination of dental unit water systems (DUWS) in dental chairs and the possibility of infection when using fast rotating parts (turbines) of dental chairs, we identified the health risks for employees and their patients in dental clinics by following the recommendations of the European Working Group for *Legionella* Infections (EWGLI), based on the Kinney methods. Five hundred thirty-seven water samples from DUWS were microbiologically analyzed. *Legionella* spp. was found in 18.3 % of the samples. In 55.9 % of contaminated samples, the concentration of *Legionella* spp. was >100 CFU/100 ml. *Legionella pneumophila* sg.1 presented 36.3 % of all isolated *Legionella* spp.

Key words: *Legionella* spp., *Legionella pneumophila*, dental healthcare, health risk

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INTRODUCTION

In the water systems of dental chairs, there are often bacteria of the genus *Legionella* which can easily present a risk to the health of employees and their patients in dental clinics. The problem already arises with the connection of terminals of dental chairs to the domestic water system, especially in large constructions where the very structure of the building or the diversification of the water network distribution allows water blockages, temperatures between 25 and 42 °C, biofilms and other conditions that are ideal for *Legionella* [1] to multiply. A high level of incidence of legionellosis in Slovenia compared to a rate of incidence in the EU may mean that the employees are in good health and they carry out their work professionally and identify and consistently report cases of infection on time. A high incidence rate of legionellosis can also mean that the precautionary measures for the prevention of legionellosis are either inadequate, inadequately carried out, or not carried out at all, which in turn poses a problem for people getting infected and sick, especially for people with weakened immune systems and the elderly, in which cases complications, permanent consequences and even death may arise.

The most common cases of infections with bacteria of the genus *Legionella* are Legionnaires' disease and Pontiac fever. Infections with *Legionella* occur most frequently by inhalation of water vapors and aerosols, small droplets that reach the lungs [2]. Inadequate implementation of measures for the prevention of the occurrence and spread of *Legionella* bacteria may also be associated with the results of sampling of 537 samples of water from DUWS, which was conducted by the Health Inspectorate of the Republic of Slovenia (HIRS) in 2010.

Legionella can easily present a risk to the health of employees and their patients in dental clinics.

Infections with *Legionella* occur most frequently by inhalation of water vapors and aerosols, small droplets that reach the lungs.

METHODS OF WORK

The inspectors from the HIRS took the water samples from DUWS. The samples were taken in accordance with the recommendations and under the following conditions: the samples were taken by using sterile packaging which was obtained in the reception office of the Department for Sanitary Microbiology of the National Laboratory of Health, Environment and Food (NLZOH); prior to the start of the sampling and in order to prevent the contamination of the sample, a socket instrument was removed from the turbine; sample collection was performed in a sterile manner (using protective masks, hand washing, sterile gloves, sterile surfaces); when the sample was taken from the spout (a part of the turbine where the water comes out), first a few jets of water were released, and the spout was disinfected with a 10 % solution of sodium hypochlorite; after the disinfection, the spout was rinsed for approximately 5 seconds; after opening the package of sterile containers, due to a possible recontamination, the package covers were either held with the interior down or placed in the same manner on the sterile surface; for the microbiological testing, approximately 350 ml of water were taken; after sample collection, the container with the water was closed; finally, when the sample was properly labeled, it was protected

from the light with aluminum foil, and temporarily stored in a cool box at the temperature up to + 5 °C; the samples were delivered to the laboratory immediately after the sampling.

The microbiological analysis of the samples for the parameter *Legionella spp*. was carried out in the laboratories of NLZOH. When determining the bacteria *Legionella,* the standard ISO 11731 was used. A genus of the bacteria *Legionella* was defined with the test Oxoid Legionella Latex. A confirmation of the strain of *Legionella spp.* with the above mentioned test means that the strain belongs to one of the following *Legionella*: *Legionella longbeachae sg.* 1 and 2, *Legionella bozemanii sg.* 1 and 2, *Legionella dumoffii*, *Legionella gormanii*, *Legionella jordanis*, *Legionella micdadei*, *Legionella anisa*. In accordance with the professional recommendations of EWGLI, the microbiological results of water samples were analytically and statistically analyzed according to the number of *Legionella* bacteria in the water sample, which should represent a particular risk to the human health.

These recommendations point to the risk of legionellosis: the concentration of <1,000 CFU/100 ml represents the low risk of outbreaks of legionellosis to human health. Most at risk are immunocompromised patients and they are advised not to use the chairs; the concentration of >1,000 CFU/100 ml – 9,999 CFU/100 ml represents the medium risk of outbreaks of legionellosis for the healthy people. Also in this case the immunocompromised patients are advised not to use the chairs; the concentration of ≥10,000 CFU/100 ml represents the high risk of outbreaks of legionellosis for the healthy people. In this case, all the patients are advised not to use the chairs until the implementation of the measures [3].

When selecting a risk assessment method for the exposure to *Legionella* which are present in DUWS, the Kinney method was chosen due to its universality of application. The risk (R) is evaluated based on the following parameters: probability (P) or the occurrence of accidents/damage, frequency (F) of the risk exposure, seriousness (S) of the consequences. The level of the risk is calculated as follows: $R = P \times F \times S$ (where the individual parameters are numerical values) [4].

When calculating the level of the risk for employees in dental services due to the exposure to *Legionella* which are present in DUWS, the following pieces of information have been taken into consideration: the probability of damage (P) due to the use of personal protective facial mask by the employees in dental services was given the rank 3 (probable or little probable) with the numerical value of 0.5 (P = 0.5); when determining the frequency of risk exposure (F) regular daily work was considered and we set the rank of 5 (regular or daily) with the numerical value of 6 (F = 6); in determining the seriousness of the consequences (S), we considered the consequences of getting sick with legionellosis and we determined the rank of 4 (very severe individual injury or illness, death) with the numerical value of 15 (S = 15). When calculating the level of risk for patients who are exposed to *Legionella* present in DUWS, we took into account the following pieces of information: for the probability of damage

(P), rank 4 was determined (unlikely but possible) with the numerical value of 1 (P = 1); when determining the frequency of risk exposure (F), regular checks and other possible visits to dental care were considered and were determined as rank 3 (monthly) with a numerical value of 2 (F = 2); in determining the gravity of the consequences (S), we considered the implications of getting sick with legionellosis and we determined the rank of 4 (very severe individual injury or illness, death) with the numerical value of 15 (G = 15).

RESULTS

Out of the total number of 537 samples that were taken, 439 or 81.7 % were negative and 98 or 18.3 % positive.

In the 80 positive samples with a concentration of *Legionella* <1.000 CFU/100 ml, the test results identified 84 different strains of bacteria of the genus *Legionella spp*. Table 2 shows that the maximum concentration of *Legionella* in <1,000 CFU/100 ml was validated with the Oxoid Legionella Latex test in 43 samples or 51.2 %. *L. pneumophila* sg. 1 was confirmed in 30 samples, representing 35.7 %.

Table 1 shows the results of water samples taken from DUWS to Legionella at RD (*regional districts) by HIRS.

RD HIRS	Number of samples taken	Negative samples		Positive samples	
		number	%	number	%
Celje	81	55	67.9	26	32.1
Dravograd	31	26	83.9	5	16.1
Kranj	70	45	64.3	25	35.7
Ljubljana	125	91	72.8	34	27.2
Maribor	80	78	97.5	2	2.5
Nova Gorica	40	38	95	2	5
Novo Mesto	40	36	90	4	10
Murska Sobota	30	30	100	0	0
Koper	40	40	100	0	0
Total	**537**	**439**	**81.7**	**98**	**18.3**

Table 2: Demonstration of the number and types of *Legionella* bacteria in water samples from DUWS with the concentration of *Legionella* <1,000 CFU/100 ml

RD HIRS	Number and types of *Legionella* bacteria with the concentration <1,000 CFU/100 ml			
	L. pneumophila sg. 1	*L. pneumophila* sg. 2-14	*Legionella* confirmed with Oxoid Legionella Latex test	*Legionella* not confirmed with Oxoid Legionella Latex test
Celje	5	1	11	1
Dravograd	0	0	3	2
Kranj	3	0	17	0
Ljubljana	16	3	11	4
Maribor	1	0	1	0
Nova Gorica	1	0	0	0
Novo mesto	4	0	0	0
Total	**30**	**4**	**43**	**7**

Table 3: Demonstration of the number and types of *Legionella* bacteria in water samples from DUWS with the concentration of *Legionella* bacteria from >1,000 CFU/100 ml to <10,000 CFU/ 100 ml

RD HIRS	Number and types of *Legionella* bacteria with the concentration from >1,000 CFU/100 ml to <10,000 CFU / 100 ml			
	***L. pneumophila* sg. 1**	***L. pneumophila* sg. 2-14**	***Legionella* confirmed with Oxoid Legionella Latex test**	***Legionella* not confirmed with Oxoid Legionella Latex test**
Celje	4	0	3	0
Kranj	1	0	2	0
Ljubljana	1	1	1	0
Total	**6**	**1**	**6**	**0**

Table 4: Demonstration of the number and types of Legionella bacteria in water samples from DUWS with the concentration of Legionella >10,000 CFU/100 ml

RD HIRS	Number and types of *Legionella* bacteria with the concentration >10,000 CFU/100 ml			
	***L. pneumophila* sg. 1**	***L. pneumophila* sg. 2-14**	***Legionella* confirmed with Oxoid Legionella Latex test**	***Legionella* not confirmed with Oxoid Legionella Latex test**
Celje	0	0	1	0
Kranj	1	0	2	0
Nova Gorica	0	1	0	0
Total	**1**	**1**	**3**	**0**

Legionella, which was not confirmed with the Oxoid Legionella Latex test was detected in 7 samples i.e., 8.3 %. The smallest number of samples in which *L. pneumophila* sg. 2-14 was confirmed, i.e. 4 samples, accounted for 4.8 %.

It is evident from Table 3 that in positive samples with a concentration of *Legionella* bacteria from >1,000 CFU/100 ml to <10,000 CFU/100 ml we identified most of *L. pneumophila* sg. 1 and *Legionella* which were confirmed by laboratory tests Oxoid Legionella Latex, each in 6 samples. The survey also identified a positive sample to *L. pneumophila* sg. 2-14. *Legionella*, which were not confirmed with the Oxoid Legionella Latex test, were not found.

From Table 4 it is evident that 5 positive samples had a concentration of legionella >10,000 CFU/100 ml. Most samples were confirmed by the test Oxoid Legionella Latex, namely 3 samples. Also one sample of *L. pneumophila* sg. 1 and one sample of *L. pneumophila* sg. 2-14 were confirmed.

From Table 5 it is evident that we mostly identified *Legionella* confirmed with the test Oxoid Legionella Latex found in water samples from DUWS, namely 52 times. *L. pneumophil*a sg. 1 was confirmed in 37 samples, followed by *Legionella* which was not confirmed by the test Oxoid Legionella Latex in 7 samples. *L. pneumophila* sg. 2-14 was proved in the lowest number of positive samples of water, namely 6.

The results indicate that the temperature has an effect on the growth of *Legionella* bacteria.

Table 5: Demonstration of search parameters in the samples from DUWS and the presentation of risk types

Parameters in DUWS samples	Risk		
	Low	Medium	High
L. pneumophila sg. 1	30	6	1
L. pneumophila sg. 2-14	4	1	1
Legionella confirmed with Oxoid Legionella Latex test	43	6	3
Legionella not confirmed with Oxoid Legionella Latex test	7	0	0
Total	**84**	**13**	**5**

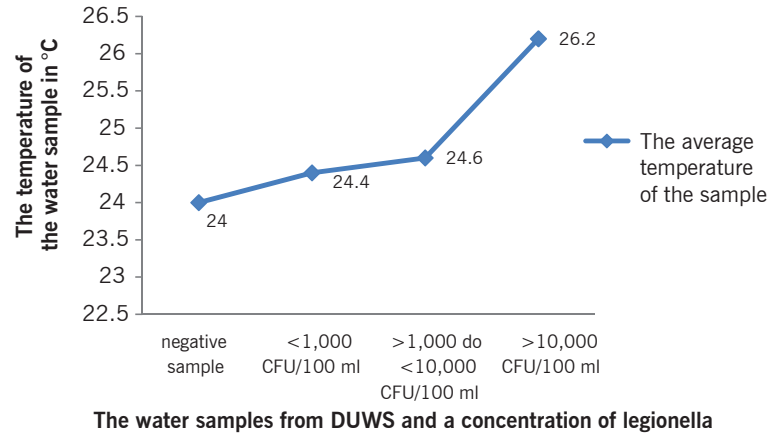

Figure 1:
Average temperature of the water samples from DUWS

The results in Figure 1 indicate that the temperature has an effect on the growth of *Legionella* bacteria. From the data obtained, the average temperature of the negative sample was the lowest. In the positive samples of water, results indicate that by increasing the temperature of the water the number of *Legionella* bacteria increases, so that the water samples with a concentration of *Legionella* >10,000 CFU/100 ml had a maximum average temperature of the water.

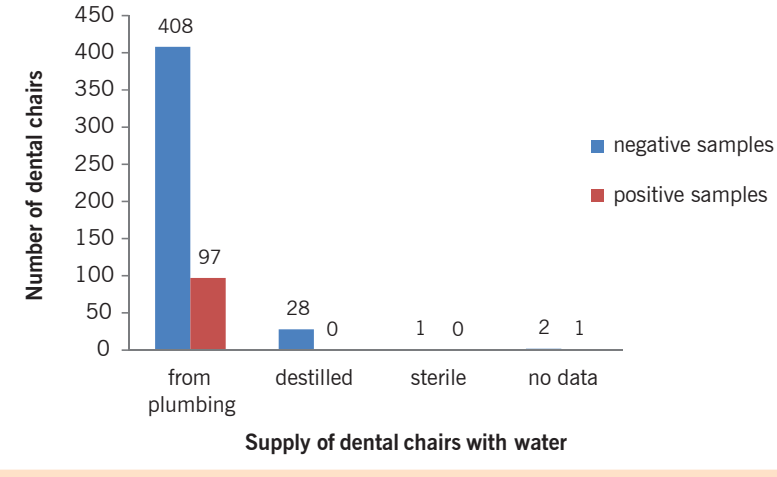

Figure 2:
Presenting connections or water usage from analyzed DC

From Figure 2 it is evident that the majority, or 94 % of all analyzed samples were taken from dental chairs (DC) which were connected to a domestic water system (DWS) and had a provision of tap water. From the samples taken from the water from DUWS, it is evident that a small part, or 5 % of DC had the supply of distilled water. There was also an example of a water sample from the DC with sterile water. For the three water samples, there was no information available as to how DC was supplied with water.

When processing and analyzing the data relating to the preparation or implementation of water disinfection in DUWS, we found that the majority (368) or 69.3 % of all treated samples (531), for which we collected data, showed that water preparation or disinfection measures had not been performed. 163 or 30.7 % samples showed that water preparation or disinfection measures had been applied. Of those 163 water samples from the DC, where disinfection was carried out, 141 samples were negative, and a disinfection measure was carried out successfully. The remaining 22 samples, where a measure of disinfection was also carried out were positive, therefore the disinfection measures were not implemented successfully. For 6 samples there was no information regarding the implementation/non-implementation of disinfection measures.

The analysis of data relating to the use of mechanical filters for cleaning the water that enters the DUWS showed that 396 or 74 % of the DCs had a mechanical filter for water purification; 115 or 21 % of DCs had no mechanical filters. For 26 DCs or 6 % there was no information with regard to the equipment with mechanical filter.

Table 6 demonstrates the implementation of disinfection of DUWS from which water samples were taken for analysis

Water samples from DUWS	Disinfection of DUWS		
	Carried out	Wasn't carried out	No data
Negative	141	294	4
Positive	22	74	2
Total	**163**	**368**	**6**

Table 7 shows the use of filters in DCs where samples of water were taken from

Water samples from DUWS	DC and mechanical filters for cleaning the water entering DUWS		
	Had a filter	Did not have a filter	No data
Negative	320	97	22
Positive	76	18	4
Total	**396**	**115**	**26**

Calculation of the level of risk

Calculation of the level of risk for employees in dental services due to the exposure to *Legionella* which are present in DUWS:

$$R = P \times F \times S = 0{,}5 \times 6 \times 15 = 45$$

Calculation of the level of risk for patients in dental services due to the exposure to *Legionella*, which are present in DUWS:

$$R = P \times F \times S = 1 \times 2 \times 15 = 30$$

The obtained numerical digits "45" for the employees in dental services and "30" for patients in dental services belong to the group from 21 to 70, representing R – II risk or "low risk". The risk to the health of patients in dental services due to the exposure to *Legionella* from DUWS is present and it is low.

The criteria for determining the level of risk based on the Kinney state that a low risk is acceptable risk and can be managed through the implementation of organizational measures in the field of security and in accordance with prescribed procedures. Following and measurement (monitoring) of danger parameters [13] is desired.

DISCUSSION

The implementation of preventive measures in order to prevent contamination of the water supply systems with *Legionella* and the prevention of reproduction and spread of *Legionella* bacteria in water distribution systems are difficult and responsible tasks, especially when it comes to the implementation of health activities and when immunocompromised patients are at risk. In the field of health services, preventive measures regarding the occurrence and the spread of infectious diseases, which include legionellosis, are carried out on the basis of the Law on infectious diseases (LID), which defines that any physical or legal person who performs medical activity should carry out the control of infectious diseases programe (CIDP). With the official controls provided by LID and the Law on health inspection (LOHI), the health inspectors deal with issues regarding the implementation of measures to prevent legionellosis, when health care services are carried out in residential, commercial or mixed activities with a number of different owners – legal and/ or physical persons who are connected to the same water supply network. If, as considered above, dental chairs do not have semi-automatic or automatic disinfection of DUWS, the risk of water contamination and the spread of *Legionella* bacteria in DUWS are greater. The responsible person or the holder of dental care in that case can execute all the preventive measures prescribed by the program of management of hospital-acquired infections (PMHAI) but has no powers to implement preventive measures related to the DWS itself. If the water in DWS is contaminated with *Legionella*, this may mean that the contaminated water has come to DUWS and will contaminate it. From the above we can conclude that even if a responsible person providing dental care performs daily DUWS disinfection measures, it cannot gua-

If dental chairs do not have semi-automatic or automatic disinfection of DUWS, the risk of water contamination and the spread of *Legionella* bacteria in DUWS are greater.

rantee that water, which at the end comes from DUWS (turbines), is not contaminated with *Legionella*.

Given the situation described and the difficulties in implementing preventive measures to prevent the occurrence and spread of *Legionella* in the DUWS in residential-business or other facilities where medical activities are also carried out, we propose a legislation on the basis of German legislation which defines that the owner, in the case of renting the premises or using them for a profitable activity, is responsible for providing health suitability of drinking water and must perform sampling of water on *Legionella* spp. in a certain period of time or on the amount of water [5].

The legislation in force in the field of drinking water in Slovenia or Regulation on Drinking Water [6] prescribes that: the drinking water should not contain microorganisms, parasites and their developmental forms in the number which might pose a risk to human health; it must not contain any substances in concentrations which alone or in a combination with other substances can pose a threat to human health, and that the drinking water is suitable if it complies with the requirements set out in Parts A and B of Annex I, which forms an integral part of that Regulation. Given the above, the monitoring of the drinking water, which is used to determine the presence of microorganisms listed in Annex I of the Regulation on Drinking Water, is being carried out in Slovenia. These analyses of the drinking water samples do not include testing for the presence of *Legionella* bacteria, which means that Slovenia has no information (type, number) on the presence of *Legionella* bacteria in the drinking water.

DUWS in Slovenia is less contaminated with bacteria of the genus *Legionella spp*. as in, for example, Germany, Italy, South Africa and Switzerland.

The problem of water contamination with *Legionella* is, except DUWS contamination, generally well known and studied by experts. DUWS contamination is another case. Here, in Slovenia, we have been paying too little attention to it, hence our focus of the research work is determining water contamination from DUWS with bacteria of the genus *Legionella spp*. Statistically and analytically, 537 samples were processed by the official control inspectors of HIRS. Water samples were taken from DUWS throughout Slovenia, from fast rotating part of the EF (turbines) or at the place where aerosols are generated. We found that 82 % of the samples taken were negative and 18 % of the samples were positive. When compared to similar studies in Europe and worldwide, we found that the results of our research are better, or that DUWS in Slovenia is less contaminated with bacteria of the genus *Legionella spp*. as in, for example, Germany, Italy, South Africa and Switzerland. A study [7] shows that in water samples from DUWS in Germany there was 28 % contamination with *Legionella* spp.; in Italy [8] and South Africa [9] 33 %; in Switzerland [10] the presence of *Legionella* bacteria was found in 24 % of water samples from DUWS.

When comparing the data of our study with a similar survey in Germany from 2013 [7], we found:

– that DUWS in Slovenia are more frequently contaminated with *L. pneumophila sg*. 1 than in Germany (Slovenia 36.3 %, Germany 28 %);

– that information about the presence of *L. pneumophila sg*. 2-14 in samples from DUWS are comparable (Slovenia 5.9 %, Germany 4 %);
– that DUWS in Slovenia are more contaminated with *Legionella* in concentrations <100 CFU/100 ml (Slovenia 44.1 %, Germany 16 %);
– that DUWS in Germany are more contaminated with *Legionella* in concentrations ≥100 to <1,000 CFU/100 ml (Slovenia 38.2 %, Germany 52 %) and in concentrations >1,000 to <10,000 CFU/100 ml (Slovenia 12.8 % Germany 28 %);
– that contamination of DUWS with *Legionella* in a concentration ≥10,000 CFU/100 ml is comparable (Slovenia 4.9 %, Germany 4 %).

CDC guidelines for dental activities recommend that water, used for routine dental care, meets the standards for drinking water (<500 CFU/ml of water for heterotrophic bacteria) [10]. Recommendations of the Commission for hospital hygiene and infection prevention at the Robert Koch Institute in Germany for all DC recommend the concentration of *Legionella* <100 CFU/100 ml and also the total number of colonies <100 CFU/ml. For the treatment of immunocompromised patients, no *Legionella spp*. may be present according to the recommendations. In order to maintain high microbiological quality, it is recommended that only water of the drinking water quality or sterile water should be used in dental chairs [7]. In selecting criteria for determining the risk for the health of employees and their patients in dentistry, based on the concentration or the number of *Legionella* bacteria in water samples from DUWS in our study, we followed the criteria based on the recommendations of EWGLI [11].

As legionelloses are life-threatening diseases that killed 22 people in Slovenia from 1997 to 2014, and as we have demonstrated in the study the possibility of infection with *Legionella* from DUWS, we suggest that in the case of an epidemiological survey when suspecting legionellosis, a question about a visit to the dentist should be included as well. The proposal can be supported with a report on the event of the death of 82-year-old patient who died due to the infection of *L. pneumophila* sg. 1, which was isolated from DUWS [8] and unvalidated data connected to the death of a dentist due to legionellosis and suspected of being infected with *Legionella* from DUWS, in other words, in the workplace [9].

Regarding the exposure to *Legionella*, which can be transmitted by aerosols during the active usage of DC and the rapid rotating parts of DC (turbines), the employed in dental services are more exposed than their patients. Exposure of employees depends on the period of the usage of fast rotating parts (turbine) of DC and varies according to the purposes of the use of DC such as: dental care for children and youth, dental practice activities for adults, orthodontic activities, maxillofacial activities, prosthetic purposes. The exposure of employees is low or nil if employees use prescribed protective equipment such as appropriate protective masks to prevent inhalation of aerosols, which may be contaminated with *Legionella*. The exposure of patients depends on the frequency of visits to

Legionelloses are life-threatening diseases that killed 22 people in Slovenia from 1997 to 2014.

The exposure of employees is low or nil if employees use prescribed protective equipment such as appropriate protective masks to prevent inhalation of aerosols, which may be contaminated with *Legionella*.

The exposure of patients depends on the frequency of visits to the dentist, the number and type of *Legionella* bacteria in the water, the type of intervention, the time of the intervention and the frequency of breathing.

the dentist, the number and type of *Legionella* bacteria in the water, the type of intervention, the time of the intervention and the frequency of breathing. From practice we know that there are individual patients who have not been at the dentist for years which means that exposure to *Legionella* from DUWS is not present. There are also patients who regularly or several times a year (monthly) visit the dentist. With such patients the exposure to *Legionella* from DUWS increases with each visit to the dentist who uses rapidly rotating parts of DC.

For sickness rate with *Legionella* and a form of legionellosis, predisposing factors for the disease are important for the employees as well as the patients: poor immunity, smoking, alcoholism, age over 65, chronic diseases, cancer, treatment with immunosuppressive drugs, particularly after transplantation [1, 12].

Predisposing factors for the disease are poor immunity, smoking, alcoholism, age over 65, chronic diseases, cancer, treatment with immunosuppressive drugs, particularly after transplantation.

The research part highlights the findings that relate to the lack of implementation of preventive measures in DUWS from which water samples are taken. From Table 6 it is evident that the majority or 69 % of water samples, for which we have data, had no prior water treatment or disinfection measures for DUWS were not implemented; 4 % of the samples showed that disinfection of DUWS was unsuccessful. It is also evident that the percentage of positive samples of water on *Legionella* from DUWS in the group of samples where prior water treatment and disinfection of DUWS had not been carried out amounts to 20.1 % and was higher than the percentage of positive samples in the sample group in which preparation of water was carried out and amounts to 13.1 %. The reason for nonperformance and failure to implement disinfection of DUWS is seen in the insufficient instructions for performing CIDP and insufficient awareness of responsible persons in dental care in 2010. Based on the results of the adequacy of water samples from DUWS that have been made public as well, a professional association of private doctors and dentists of Slovenia, together with the representatives of NIJZ and NLZOH, adopted a guidance for the preparation of a plan for the maintenance of the water network dental chair/machine in 2011. We support the provisions of the mentioned guide and suggest that a parameter *Legionella* spp. is added to the regular parameters of microbiological testing.

A weakness of the research was collecting water samples on *Legionella* just in one place or on quickly rotating part (turbine) of DC. The gathered data was used to determine the presence, type and quantity of *Legionella* bacteria in the samples, but we were unable to determine the cause of contamination in the case where *Legionella* was proven in samples. To determine the cause of the contamination (public water/DWS/DUWS) we would need comparative samples that should be taken at least: at the connecting spot to the public water supply network or nearby spout; on the spout in a dental clinic or the farthest spout at the facility; a water sample from DUWS. Having obtained the results of water sampling on *Legionella* in the above sample spouts with the method of exclusion, we would be able to determine the causes of contamination of water systems by *Legionella*.

CONCLUSION

On the basis of the results of our study, we can highlight the following major findings:

a) after the microbiological testing of water samples from DUWS, the presence of *Legionella* spp. was confirmed in 18.3 % of the samples. Fifteen percent of the samples were those with low risk; 2.4 % carried a medium risk, and 0.9 % of the samples carried a high risk of legionellosis for the healthy people;

b) in water samples from DUWS, the most virulent and most dangerous to humans *L. pneumophila* sg. 1 was identified 37 times, presenting 36.3 % of all identified *Legionella* spp.;

c) the implementation of disinfection of DUWS reduces the risk for the emergence and spread of *Legionella* in DUWS (proportion of positive water samples on *Legionella* from DUWS in the group of samples where disinfection of DUWS was not carried out amounted to 20.1 % and was higher than 13.1 % of the positive samples in the group of samples where the disinfection was performed);

d) the results indicate that by increasing the water temperature, the number of *Legionella* bacteria increases so that the water samples with a concentration of *Legionella* >10,000 CFU/100 ml had a maximum average temperature of the water;

e) using the Kinney method, we demonstrated that the risk to the health of employees and their patients due to the exposure to *Legionella* which is present in DUWS, is present, however, it is low;

f) when compared with similar studies in Germany, Italy, South Africa and Switzerland, we found that the DUWS in Slovenia is less contaminated with bacteria of the genus *Legionella spp*. as in these countries.

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Original scientific article

Ergonomic burdens and harms at the workplace of accountants

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ABSTRACT

Workers spend a lot of time at work, and therefore, it is important to ensure healthy workplaces. The aim of this study was to evaluate the ergonomic strains of accountants and suggest measures to overcome the work-related overload and improve the working conditions. We monitored the work of three accountants through the Ovako Working posture Assessment System (OWAS) methodology and measured the microclimate and lighting conditions. The results of microclimate conditions show that the room temperature was 26 °C, the humidity was 47 %, and the airflow 0.11 ms^{-1}. The results of the OWAS methodology gave us insights into the overload of the spine and the upper and lower limbs. In most cases, corrective measures are needed. Immediate measures need to be implemented for the upper limb load for all the observed subjects, while arm load needs to be further researched. Our findings could reduce the work-related discomforts if workers and employers followed our recommendations.

Key words: ergonomics, accountant, burden, OWAS, sitting at work, display screen equipment

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INTRODUCTION

For a healthy and pleasant work, a workplace needs to be properly regulated and organized. The tendency to adapt the workplace to psychophysical abilities of the individual is very old, but now more relevant than ever [1]. The awareness of importance of ensuring health and safety in the workplace occurred many years ago, as legislation in this area has existed since 1974.The legislation is called The Health and Safety at Work Act [2]. An integrated approach to workplace health-promotion programs should include attention to the work environment, especially occupational safety, health, and ergonomics. Ergonomics is the scientific study of people at work. Occupational ergonomics attempts to improve the connection between the workforce and the work environment through the optimized design of jobs and work systems [3, 4]. The most common goal is avoidance of work-related musculoskeletal disorders such as low back pain and tendonitis, which represent a major cause of morbidity and absenteeism around the world [5, 6]. The ergonomics can design good workplaces that cannot only reduce injury risks but also enhance health and capacity of workers [7].

Workplace health-promotion programs should include attention to the work environment, especially occupational safety, health, and ergonomics.

Many jobs require people to sit whilst working. Unsuitable sitting can lead to discomfort, back pain, and upper limb disorders. This may lead to staff absences from work and worse performance. Employers are required to provide seating for employees that is suitable and safe. Employers must assess risks in the workplace, including seating. A risk assessment involves identifying hazards and deciding whether enough has been done to prevent harm to people [8, 9].

Unsuitable sitting can lead to discomfort, back pain, and upper limb disorders.

The risk assessment must be comprehensive. There are five steps that may assist in assessing:

Step 1: Look for the hazards.

Step 2: Decide who might be harmed.

Step 3: Evaluate the risks.

Step 4: Record the findings.

Step 5: Review the assessment regularly [9].

Employers must assess risks in the workplace, including seating.

When choosing seating, employers need to consider the needs of the individual, the type of work being carried out and the dimensions of the workstation. It is important that a chair is comfortable for the worker, that the lower back is adequately supported, that the edges are appropriately shaped to prevent uncomfortable pressure on the thighs, that the height is adjustable, and that the backrest is properly adjusted in height and depth. However, we must not forget the armrests and in some cases the footrests as well. The aim should be to avoid employee's discomfort and to promote well-being. When people are working with computers, an employer must ensure that the seating is adjustable to allow the hands to work at the elbow height. There should be place for the legs to fit comfortably under the boards. Armrests should not prevent the user from getting close to the workstation. When using a keyboard or mouse, it should be possible to place the feet flat and comfortably on the floor [9, 10].

Display Screen Equipment (DSE) is the equipment that has a display screen, regardless of the display process involved. It includes conventional display screens, laptops, touch-screens, and other similar devices [10]. If the workplace with DSE is not adapted to the workers, various problems may occur. Some workers may experience fatigue, eyestrain, upper limb problems, and backache from overuse or improper use of DSE. These problems can also be experienced from poorly designed workstations or work environments. The causes may not always be obvious and can be due to a combination of factors. Nina et al. discovered the importance of the correct posture while using a computer when they observed 67 workers working with their own computers. They found that mouse-elbow height match was a significant predictor for discomfort of the lower back. Inappropriate keyboard height could cause discomfort of the shoulders and upper back. Also, Demure et al. [12] warn that musculoskeletal pain requires rapid intervention for improving their work posture. Therefore, DSE workplace needs to ensure the proper relation between chairs, desks, and keyboards; the height of the screen is also very important (Figure 1).

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In providing an adequate job with DSE, we can help with the following recommendations:

- Forearms should be in a horizontal position.
- The user's eyes should be at the same height as the top of the screen.
- Make sure there is enough workspace to accommodate all documents or other equipment.
- Arrange the desk and screen to avoid glare or bright reflections. This is often easiest if the screen is not directly facing windows or bright lights.
- Make sure there is space under the desk to move legs.

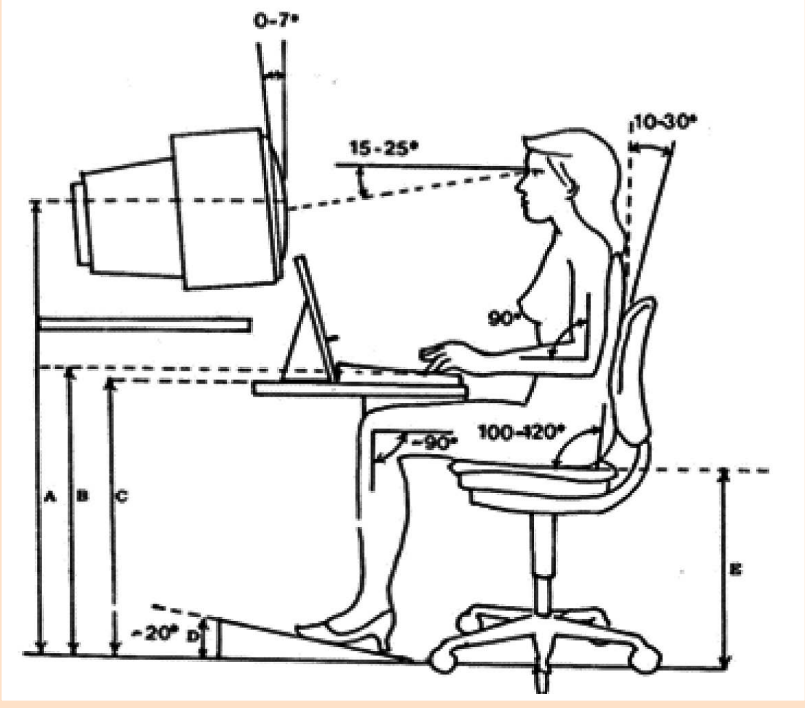


Figure 1:
The correct posture while using the computer [1]

– Avoid excess pressure from the edge of seats on the backs of legs and knees. A footrest may be helpful, particularly for smaller users.
– Adjust the brightness and contrast controls on the screen to suit the lighting conditions in the room.
– Make sure the screen surface is clean.
– Select colours that are easy on the eye [9].

While at work using a computer, fatigue, eyestrain, upper limb problems and backache may occur. This can be prevented if users make stretch and change the position, look into the distance from time to time, blink often, change the activity, and short, frequent breaks are better than longer ones. Interventions aimed at reducing the musculoskeletal disorders due to computer work should be directed at both physical/ergonomic factors and work organizational and psychosocial factors [9].

In addition, microclimatic conditions are important factors in the working environment, which can affect workers in a positive or negative way. In case of extreme conditions, they can be perceived as harmful effects on human health. Microclimatic parameters are determined by temperature, relative humidity, and airflow. These physical quantities define subjective well-being (comfort) or ill-being (discomfort). The temperature of the working environment depends on the body heat production affected by the intensity of employee's activity: sitting at work, standing at work, mechanics work, intensive, and very intensive work [13]. Humidity in the working environment is a specific factor. The scope of permissible values of relative humidity depends on the temperature of the environment. Human feelings can be negatively affected by a low value of humidity (< 20 %) and humidity in excess of 60 % [14]. People with sedentary work in confined spaces are more responsive to airflow than to the movement in the nature [15]. In addition, the airflow in workplaces is prescribed to be at the maximum levels, which are also dependent on the air temperature. The lower the temperature, the lower the permissible airflow. An air temperature of 20 °C prescribes ≤ 0.18 ms^{-1}, at 22 °C ≤ 0.22 ms^{-1}, at 24 °C ≤ 0.26 ms^{-1}, and at air temperature of 26 °C, the permitted value of airflow is ≤ 0.30 ms^{-1}[16].

Large variations of brightness in direct line of sight between the eyes and the surroundings are stressful for the body.

The eye is a sensory organ that detects the brightness of objects and surroundings and must constantly adapt to its environment. Large variations of brightness in direct line of sight between the eyes and the surroundings are stressful for the body. The consequences of these differences may be manifested as pain in the eyes and head, general discomfort and rapid and unnecessary fatigue [17]. Good lighting of workplaces has long been considered as one of the most important tasks that are associated with productivity and work efficiency. Numerous researches have indicated that good lighting will positively contribute to work performance. Optimal level of lighting is important for the comfort during continuous work of long duration [18, 19,20, 21]. Workplace in office must be designed so that light sources do not cause glare or disturbing reflections on the screen. In the office, the most suitable is natural lightning or artificial lighting, which is the closest to the natural one. Windows must have adequate shading to prevent the incidence of

sunlight on the job. Distracting reflections on the screen reduce the visibility of characters. Workers unconsciously respond by holding the head in the unnatural position and this causes neck pain [1]. The minimum required illumination at fixed positions is 200 lux. Workplaces where workers perform work with greater visual requirements (DSE definitely is) must be equipped with the additional local lighting [22].

This study explored three workplaces of accounting companies. We determined the ergonomic position of workers who work mainly sedentary work with Display Screen Equipment. The welfare of employees is also influenced by microclimatic conditions and lighting of the workplace, therefore, we also measured these parameters.

METHODS

The study was performed among a group of workers, working in a small accounting company, who had been using DSE daily. Data were obtained on the basis of a five-day observation of three accountants at work. Workers were monitored daily for eight hours. We used the OWAS method (Ovako Working posture Assessment System). The OWAS method was used to determine an improper posture during work. In the second part of the research, we measured the microclimatic conditions (temperature, humidity, airflow) in the office and lighting in all three workplaces.

The welfare of employees is also influenced by microclimatic conditions and lighting of the workplace.

In the office, the most suitable is natural lightning or artificial lighting, which is the closest to the natural one.

The OWAS method was used to determine an improper posture during work.

OWAS method

OWAS identifies the most common work postures for the back (4 postures), arms (3 postures) and legs (7 postures), and the weight of the load handled (3 categories). These postures have been classified into four categories indicating needs for ergonomic changes. The observations are made as "snapshots" with constant time intervals. The observed posture combinations are classified into four ordinal scale action categories, which are based on expert's estimates of the health hazards of each work posture or posture combination [23]. This method is suitable for different jobs, which also include sedentary job [24]. Using this method is time-consuming, as the employees must be monitored all their working day for several days. The OWAS method has its limitations, since it does not separate the right and left upper extremities: also, the assessments of the neck, elbows, and wrists are missing [25].

Temperature, humidity, airflow, and lighting measurements

Measurements of microclimatic conditions were performed using a measuring device Testo 445. The temperature, humidity, and airflow were measured 10 cm and 110 cm above the ground. The first measurements were performed at 4 pm, when the air conditioner was switched on. The outside air temperature was 26 °C, the weather was cloudy. The second measurements were performed in the evening, at 10 pm, when the outside temperature was 19 °C.

The lighting was measured with a luxmeter Testo 545. Measurements of lighting were performed at three workplaces. The measurement of the daylighting was influenced by the two windows of size 1.14 m^2

and a transparent surface 0.82 m^2. Measurement of artificial lighting was performed in the evening at 10 pm. When taking measurements of the artificial and combined lighting, four ceiling lights were turned on and additionally two table lamps at the desk.

Environmental conditions on the workplace in the office are provided by the ISO Standard 9241 [26]. ISO 9241 is a standard from the international organization for standardization covering ergonomics of human-computer interaction. According to the regulations, they must provide the following values:

- Temperature 19–23 °C
- Humidity 40–60 %
- Airflow < 0.25 ms^{-1}
- Lighting 300–500 lux [26].

RESULTS AND DISCUSSION

Results of ergonomic burdens (OWAS)

By using the OWAS methods, we were estimating ergonomic burdens of three accountants at their workplace. The results of the OWAS method showed an excessive burden for certain positions and they are shown in Figures 2–6. In determining prohibited positions, we used symbols, which are shown in Table 1. The symbols of different measures are used in Figures 2–6. Measures depend on the positions of different parts of the human body at the workplace. For each position are prescribed the maximal permitted limit values [27].

Observing the thoracolumbar spine in all three workers, we found that they were in the so-called prohibited position 1.4 (Figure 2).

In the situation 1.4, a stooped posture is noticed, since the deflection is greater than 15°, combined with a torsion or lateral flexion greater than 30°. This situation was mostly recorded when employees were sitting at the table, leaning to the side, and opening or closing drawers of the desk. The measures are necessary in the foreseeable future.

When observing the arm, we noticed that the most problematic position 2.2 occurs when one or both arms are away from the midline of the body (abducting). This position was present in all workers during all observation days, and it exceeded the physiological recommendations. Corrective measures are needed immediately (Figure 3). This situation occurs when people working with computers have a lot of documents in front of them. In this case, the keyboard is too far from

Table 1: The legend of measures and symbols used in the Figure 2–6.

Symbols	Legend
□	Measures are not required
○	Measures are needed in the short term
△	Measures are needed immediately
☆	Further research is needed

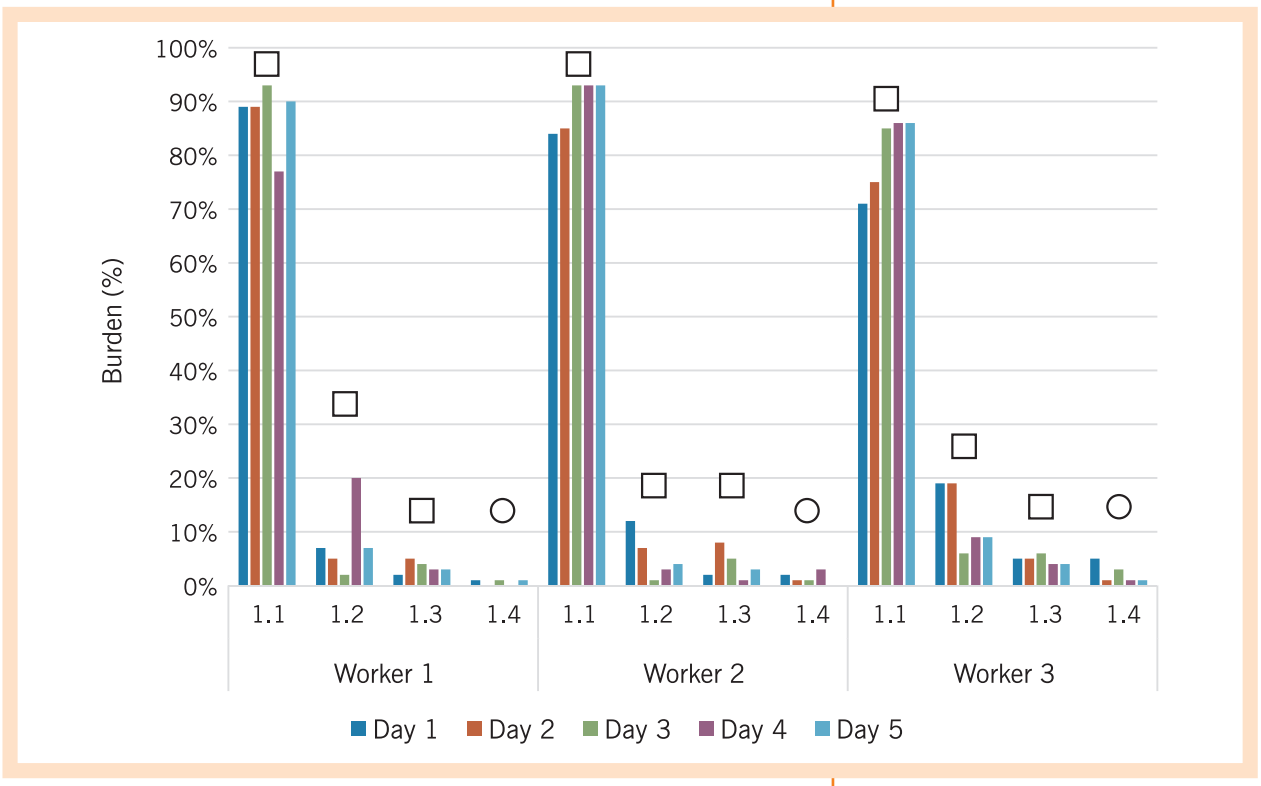
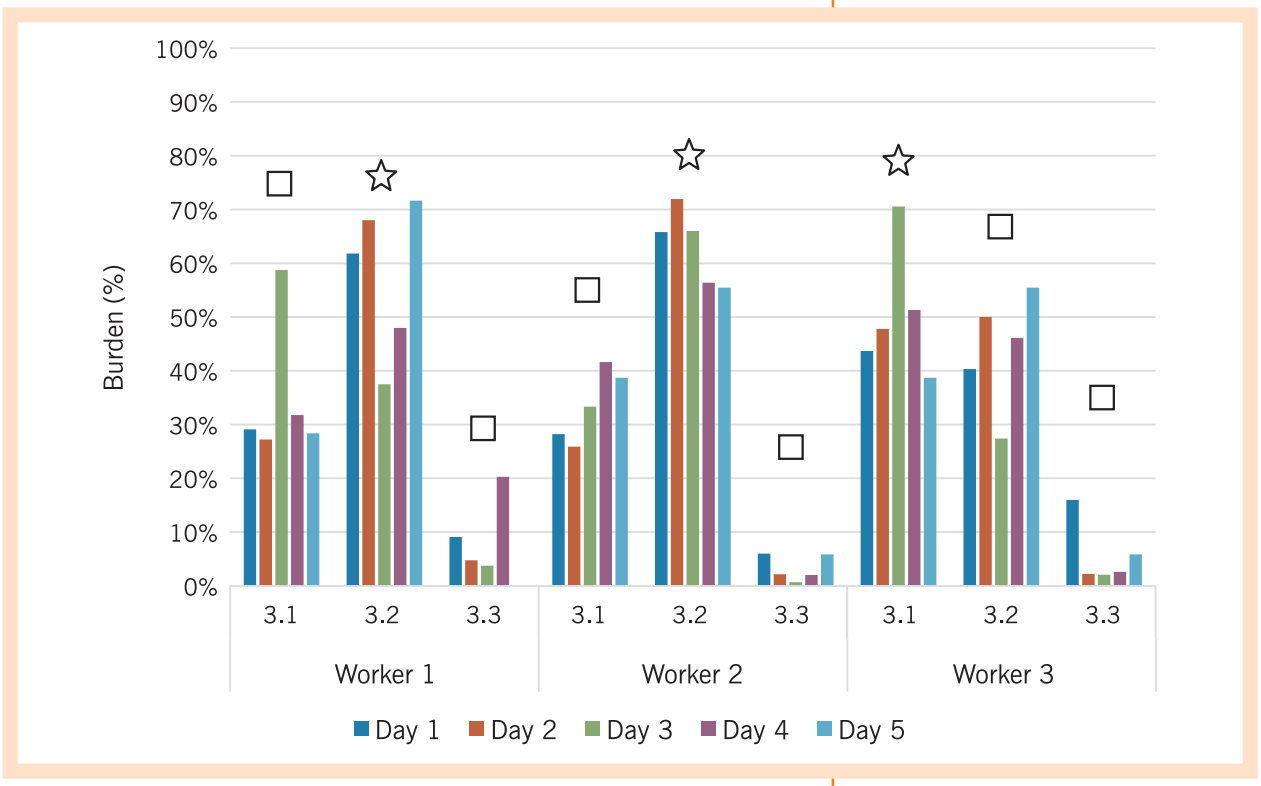


Figure 2:
The position and shape of the thoracolumbar spine of the three workers

Figure 3:
The position and shape of the arms of the three workers



the body and arm abduction occurs. We suggest the workers having only the documents they need in front of them.

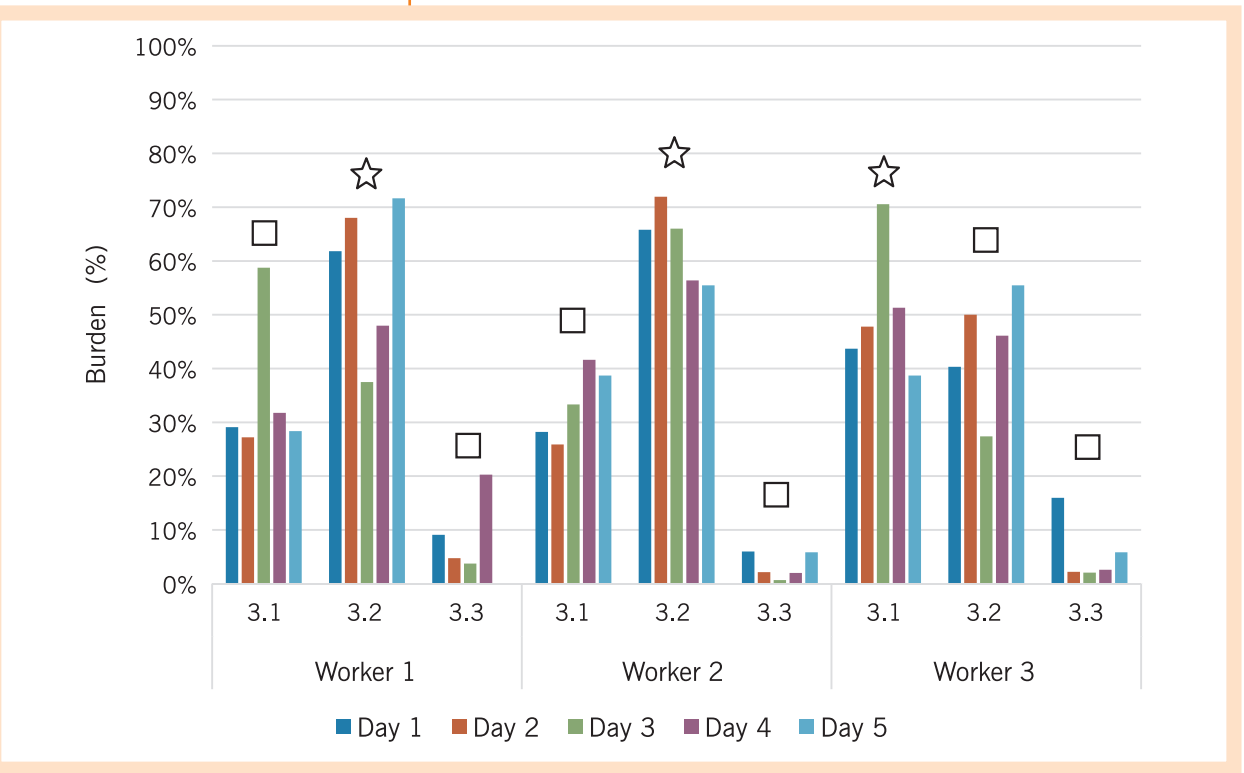
Concerning hands positioning, load was detected in the position 3.2., which was the result of typing. Because of the nature of work, the workers cannot avoid these situations; therefore, it is difficult to provide adequate measures (Figure 4). It would be necessary to do additional research. One of the options is that the employer would adapt computer programs in the way workers could be able to do more work with a computer mouse.

Figure 5 shows the position of the legs. It can be seen that it often comes to a position 4.1, which represents physiological or non-physiological seating. Taking measures is necessary shortly. By doing so, the workers could change positions of the lower limbs. Part of the work could be done in the sitting position (work on the computer) and a part in the standing position (while organizing documents). On the fourth day, the worker 1 was repeatedly observed in the situation 4.4. This position means standing on one or both legs, which are highly curved in the hips, knees, and ankles.

On the fourth day, the worker 1 greatly exceeded the physiological recommendations for this position, because she was cleaning up the warehouse, which is not part of the everyday tasks. This situation occurred during the cleaning of the lower shelves and that caused curves in the hips, knees, and ankles.

Figure 6 shows the positions of the cervical spine. In all subjects, there was a load in the position 5.2. In this situation, the head is bent forward for more than 30°. The excessive burden of cervical spine in this position

Figure 4:
The position and shape of the hands of the three workers



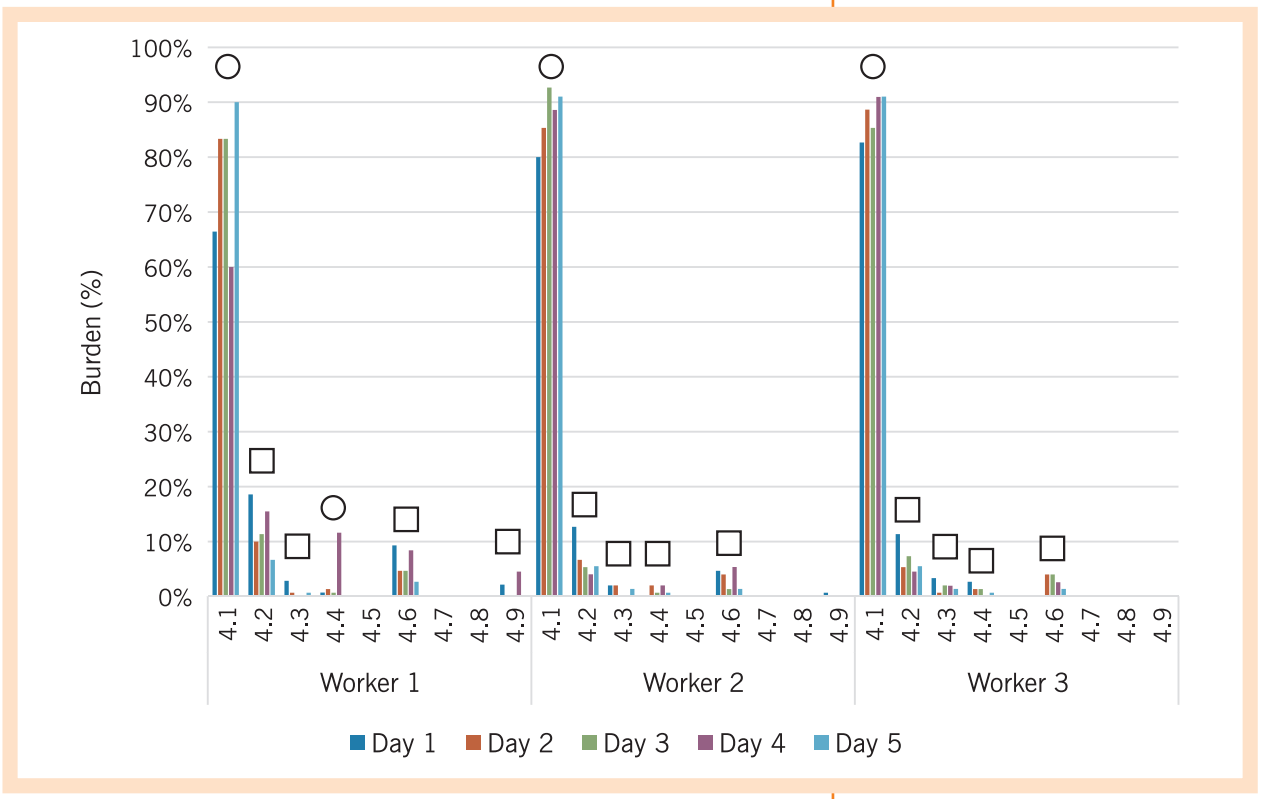
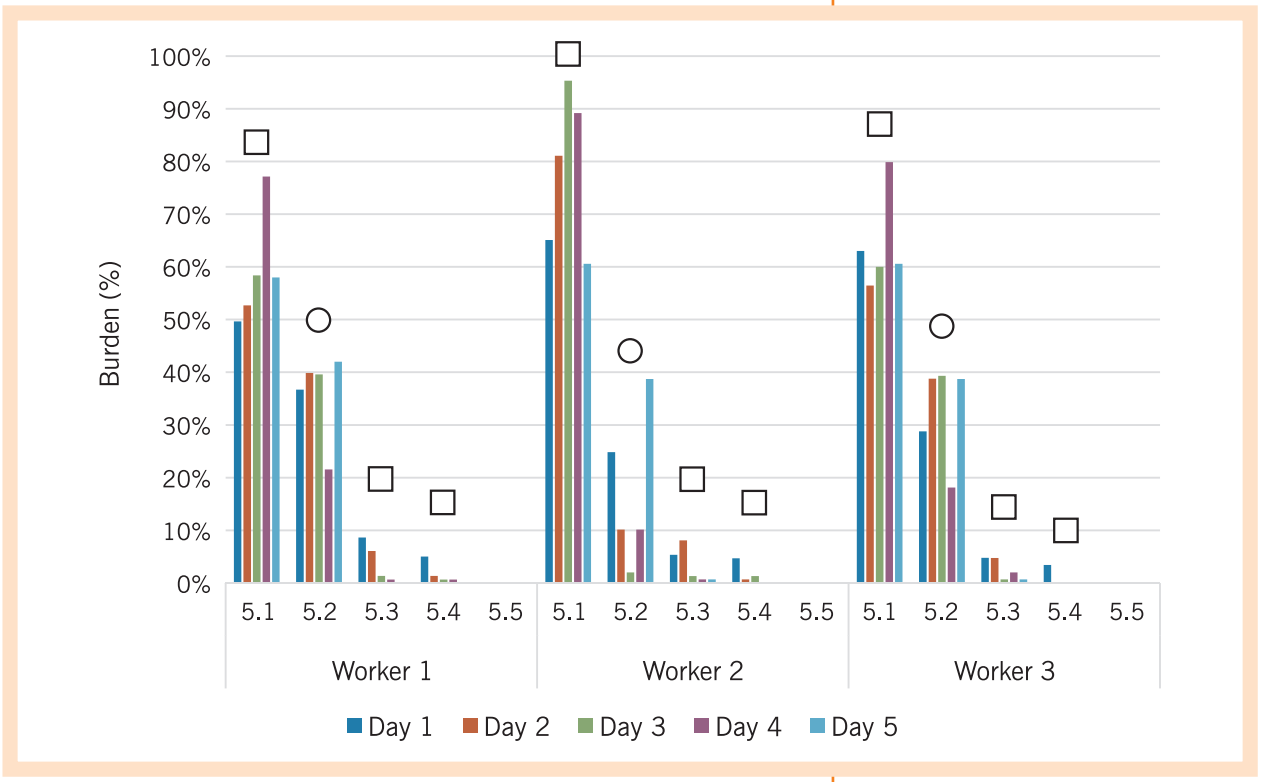


Figure 5:
The position and shape of the legs of the three workers

Figure 6:
The position and shape of the cervical spine of the three workers



is due to viewing of documents that are placed too close to the body of the worker, which is on the edge of the table. Thus, the workers' heads were heavily bent forward. The burden in the position 5.2 is also due to inadequate height of a screen. Annex to the Rules on safety and health requirements for work with visual display units [28] states the necessity of guaranteed possibility of adjusting the height of the screen in the way that the upper row on the screen is approximately 5cm below the eye level of a worker. Screens at workstations in the accounting firm have no possibility of adjusting the height, they are positioned too low and this does not meet the policy requirements. We recommend the employees to raise the screen or the monitor by putting it on a shelf.

Results of microclimatic conditions and lighting at workplaces

Table 2 shows the results of measurement of microclimate conditions in the office in the three workplaces. Microclimate conditions in the work area were measured when employees were there (4 pm), and in the evening, when the office was empty (10 pm). The average air temperature at 4 pm was 26.2 °C, and at 10 pm 27.1 °C. When the employees were present at the workplace, the air conditioning was turned on. Rules on requirements for ensuring the safety and health of workers at the workplace [22] say that the air temperature should not exceed 28 °C. The measured values were not exceeded.

According to the standard ISO 9241 [26], which sets more stringent range of permissible levels of air temperature in the office premises, the values of air temperatures were exceeded. The standard requires a temperature range of 19–23 °C. In the office with air-conditioning, we could meet the criteria of this standard by increasing the cooling activity of air conditioners. Considering the fact that employees do not feel the discomfort because of the temperature, these measured values will not be highlighted as problematic.

When workers were present, the average measured humidity in the work area was 47 % and 50 % when the office was empty and the air conditioner was turned off. According to the Regulation on requirements to ensure the safety and health of workers at the workplace [22], the value of humidity was not exceeded. We also measured the airflow during working hours, which was 0.11 ms^{-1}, which means it does not pose a risk to workers' health. Based on the measured parameters and an interview conducted with the employees, the accountants feel good in their workplaces.

Table 2: The results of microclimate conditions in the office at three workplaces

Microclimatic conditions		Humidity [%]		Air temperature [°C]		Airflow [ms^{-1}]	
		10 cm	110 cm	10 cm	110 cm	10 cm	110 cm
Workplace 1	at 4 pm	46.10	47.10	26.1	26.2	0.2	0.03
	at 10 pm	49.20	49.20	27.1	27.1	0.01	0.04
Workplace 2	at 4 pm	46.30	46.60	26.3	26.4	0.03	0.02
	at 10 pm	49.30	49.50	27.1	27.1	0.02	0.01
Workplace 3	at 4 pm	47.00	46.90	26	26	0.26	0.1
	at 10 pm	49.60	50.20	27.1	27.1	0.09	0.03

Table 3: The results of lighting in the office at three workplaces

	Daylighting [lx]	Artificial lighting [lx]	Combined lighting [lx]
Workplace 1	1925	349	2180
Workplace 2	326	245 (822)*	562 (1025)*
Workplace 3	1055	545	1426

*Value in the bracket is lighting with extra table lamp

Table 3 shows the results of measurements of daylighting, artificial lighting, and the combined lighting at three workplaces. In the Annex of the Rules on safety and health requirements for work with visual display units [28], it is indicated that the overall lighting of the workplace should be 400 lx ± 100 lx, which would ensure satisfactory lighting conditions. We found out that daylighting at the workplace 2 does not meet the conditions laid down in the Rules on safety and health at work on a display unit [28], but the employer had an additional lamp, which reached the prescribed value of the combined lighting.

CONCLUSION

The ergonomic arrangement of the working environment is a concern of an employer. The accounting firm is aware of the problem of overload in the workplace and is taking care of the realignment, improvements, and appropriate measures. We spend a great part of our life at the workplace, therefore, it is important that the work conditions are good and the work itself does not pose a risk to health. The study of ergonomic strains in the workplace of three accountants showed that the workers are in some inadequate positions. Due to improper seating, abduction of arms, and long-term and excessively bent position of the head, employees feel discomfort in the shoulders, back of the neck, upper back, lower back, and on the buttocks. Because of using the computer and incorrect position of the forearm, they have pain in the wrists. The measurement of microclimate conditions showed a deviation of an air temperature in the office, which was too high according to the standard ISO 9241. However, the workers feel good at the workplace; therefore, this failure has no particular meaning. Furthermore, they have an option for cooling the office using air conditioners.

We spend a great part of our life at the workplace, therefore, it is important that the work conditions are good and the work itself does not pose a risk to health.

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[2] American college of physicians. Clinical Ecology. An Int Med 1989; 111:168–78.

[3] Vivian VL, ed. Child abuse and neglect: a medical community response. Proceedings of the first AMA national conference on child abuse and neglect. 1984 Mar 30-31; Chicago. Chicago: American Medical Assotiation, 1985.

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[5] Evaluation of the European Agency for Safety and Health at Work: http://osha.europa.eu/publications/other/20010315/index_1.htm (20. 12. 2006).

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