sciendo

SANITARNO INŽENIRSTVO

INTERNATIONAL JOURNAL OF SANITARY ENGINEERING RESEARCH

Volume **17** | Issue **1** | **December 2024**

Editorial

Dear Readers,

We are pleased to present the new issue of the International Journal of Sanitary Engineering Research, featuring four scientific papers united by a common theme — a responsible approach to protecting health and the environment through evidence-based solutions and measurable outcomes.

Occupancy Impact on Air Quality in Repurposed Museum Space shows that adaptive reuse without adequate outdoor air supply fails to control CO_2 and particulate levels. Hybrid ventilation is insufficient when intake routes recirculate indoor air or occupancy spikes; rigorous redesign and continuous IAQ monitoring are required.

Disposable Gloves: Protection or Just a False Sense of Security? reveals a behavioral paradox: gloves frequently suppress handwashing and foster misplaced confidence. As a result, cross-contamination persists. Protective equipment must complement—not replace—hygiene training, supervision, and accountability.

Design of Healthcare Facilities with an Emphasis on Environmental Health Features argues for embedding environmental health criteria—ventilation effectiveness, thermal and acoustic comfort, daylight, and material choice—into clinical architecture. Such integration is preventive medicine at building scale.

Food Safety Perceptions, Knowledge, and Behavior of Hospitality Workers on Food Safety documents the gap between knowing and doing in food service. The remedy is practical, recurrent training and active managerial oversight, not one-off certification or paperwork.

We invite readers to explore the full issue, which presents current research of high relevance for both the scientific community and the practice of public and environmental health.

Aleš **KRULEC**
Executive Editor

Inštitut za sanitarno inženirstvo
Institute of Public and Environmental Health
Zaloška cesta 155, 1000 Ljubljana, Slovenia
E-mail: info@institut-isi.si

ISSN 1854-0678 (online)

INTERNATIONAL JOURNAL OF SANITARY ENGINEERING RESEARCH

SANITARNO INŽENIRSTVO

Publisher

INŠTITUT ZA SANITARNO INŽENIRSTVO
Institute of Public and Environmental Health
ZBORNICA SANITARNIH INŽENIRJEV SLOVENIJE
The Slovenian Association of Public and Environmental Health Professionals

Address of the Editorial Board and Administration

INŠTITUT ZA SANITARNO INŽENIRSTVO
Institute of Public and Environmental Health
Zaloška cesta 155, 1000 Ljubljana, Slovenia
info@sanitarc.si, www.sciendo.com/journal/IJSER

Indexed and/or abstracted in

Baidu Scholar; CNKI Scholar (China National Knowledge Infrastructure); CNPIEC – cnpLINKer; COBIB Union bibliographic/catalogue database; dLib.si Digital Library of Slovenia; Dimensions; EBSCO Discovery Service; ExLibris; FSTA - Food Science & Technology Abstracts; Google Scholar; J-Gate; KESLI-NDSL (Korean National Discovery for Science Leaders); MyScienceWork; Naver Academic; Naviga (Softweco); ReadCube; SCILIT; Scite; Semantic Scholar; Sherpa/RoMEO; TDOne (TDNet); Ulrich's Periodicals Directory/ulrichsweb; WanFang Data; WorldCat (OCLC); X-MOL; Crossref database.

Member of

sciendo

SCIENDO – Open Access Publishing at De Gruyter Open

sciendo

Contents

SANITARNO INŽENIRSTVO / International Journal of Sanitary Engineering Research 2024;17(1): 4-14 DOI: 10.2478/ijser-2024-0001

sciendo

Occupancy Impact on Air Quality in Repurposed Museum Space

Lucija Gruden and Uroš Stritih*

Original Research Article

Received: 31. 1. 2024
Accepted: 22. 4. 2024
Published: 24. 5. 2024

ABSTRACT

This study investigates the air quality and ventilation effectiveness in a repurposed museum space with a hybrid ventilation system in Ljubljana, Slovenia. Focusing on CO_2 and particulate matter concentrations, the aim is to determine the correlation between these parameters and the suitability of the ventilation system following a change in space use. Measurements were conducted over a four-month period, analyzing data during different occupancy and ventilation scenarios. The study compares observed values with World Health Organization (WHO) guidelines, specifically targeting $PM_{2.5}$, PM_{10}, and CO_2 concentrations. Findings reveal inadequate ventilation in the repurposed museum space, even with hybrid ventilation. CO_2 concentrations correlated with $PM_{2.5}$ and PM_{10} levels, suggesting CO_2 monitoring as an indirect indicator of overall air quality. Recommendations include improving ventilation efficiency and limiting occupancy to ensure adherence to air quality standards.

Keywords: air quality, ventilation, CO_2, aerosols, indoor environment

University of Ljubljana
Faculty of Mechanical Engineering
Laboratory for Heating, Sanitary, Solar and Air Conditioning Engineering - Chair of Thermal and Environmental Engineering
Aškerčeva 6
1000 Ljubljana, Slovenia

Corresponding author:
Assoc. Prof. Uroš Stritih, PhD
University of Ljubljana
Faculty of Mechanical Engineering
Aškerčeva 6
1000 Ljubljana, Slovenia
Email: uros.stritih@fs.uni-lj.si

INTRODUCTION

Indoor air quality (IAQ) is becoming an increasingly visible parameter of the internal environment. In addition to indoor temperature and relative humidity, there has been a lot of research in recent years on adequate indoor and outdoor air quality. During the SARS-CoV-2 pandemic, adequate and sufficient ventilation proved to be a key measure in preventing the spread of the disease [1, 2]. The same is true for other pathogenic particles [3]. Air quality also depends on other pollutants such as particulate matter and CO_2 concentration [4]. Some pollutants are not well perceived by humans, even though they have an impact on health [5]. It is therefore important to control the levels of pollutants that have a negative impact on humans in space. Standards are ensured by properly designed HVAC systems. Purpose-built buildings must have adequate ventilation designed in by design, based on occupancy and use, to ensure minimum standards. In high occupancy areas, more attention needs to be paid to maintenance and to assuring the adequacy of the installed systems. There are several studies carried out in teaching spaces in older buildings where the ventilation is only natural and is not sufficient to meet the minimum requirements [6, 7, 8]. Sometimes, years after construction, some buildings change use and the conditions for a suitable indoor environment change. When more people are indoors, more pollutants emitted by general human activity are trapped in the indoor environment. The amount of CO_2 emitted by an individual depends on the time spent indoors and the level of activity. CO_2 is a known indicator of the general condition of the indoor air and is an indicator of other indoor pollutants and thus of the adequacy of ventilation [9, 10]. The amount of particulate matter or PM in the air depends on the ambient air and the activity in the room. High levels of PM in the air have a negative effect on the respiratory system. Research has linked high levels of PM in the air to the development of respiratory diseases as well as cardiovascular diseases [11-14].

The amount of particulate matter or PM in the air depends on the ambient air and the activity in the room. High levels of PM in the air have a negative effect on the respiratory system.

The purpose of the study was to analyse the existing air quality in a showroom with a hybrid ventilation system. The building has been repurposed for the current use. The measurements were carried out in a museum space in Ljubljana. We were interested in the correlation between CO_2 and particulate matter concentrations and the suitability of the new ventilation with the change of use. We want to find out if it is possible to assess the air quality of the room and the adequacy of the ventilation with a known CO_2 value alone. WHO guidelines dictate particulate matter values for an 8-hour average of 15 µg/m³ for $PM_{2.5}$ and 45 µg/m³ for PM_{10} [15]. The maximum recommended indoor CO_2 concentration is 1000 ppm. The goal of this study is to assess the effectiveness of air quality and ventilation in a repurposed museum space with a hybrid ventilation system and based on the findings, recommendations for improvement will be given to the museum.

The maximum recommended indoor CO_2 concentration is 1000 ppm.

This paper consists of three more sections. The remainder of this paper is organised as follows. The location and the measurement procedure are presented in the methods section, where we also present the experimental part. In the Results and Discussion section we comment on the results of the measurement. The conclusions are drawn in the final section.

METHODS

The measurements that we want to use as the basis for the study were carried out in the semi-basement space of the museum, which is located in Ljubljana. We chose a room where a large number of people are changing, but the original design of the building did not foresee this and ventilation was retrofitted in this room. The room has dimensions of 21m x 6.3m x 2.5m (Figure 1). It has ventilation with four exhaust fans installed in sets of two under the ceiling of the room, locations are marked by red crosses (Figure 1). For heating gas condensing furnace is used and there are four radiators in the room, where the parameters were measured. Locations are marked by green numbers (Figure 1). Natural ventilation is provided by twelve hopper windows of 0.75m x 0.85m on one wall and a 1.95m x 1.3m opening leading to the adjacent room.

The experiment was carried out in the showroom during normal operation on two non-consecutive days with differrent different occupancy and ventilation modes during the heating season 2023.

The measurements were made over a longer period of time. For further analysis, we used data over a four-month period in spring. The experiment was carried out in the showroom during normal operation on two non-consecutive days with differrent different occupancy and ventilation modes during the heating season 2023. The natural ventilation mode was varied according to the needs, the mechanical ventilation was switched on all the time when people were present in the room. The measured parameters were CO_2, $PM_{2.5}$ and PM_{10} in relation to the amount of occupants and the ventilation during the heating season. The occupants in the room were exposed to normal operating conditions. The number of visitors varied between measurements. The temperature and relative humidity of the air were also measured. By monitoring the change curves of both concentrations, we tried to identify the correlation.

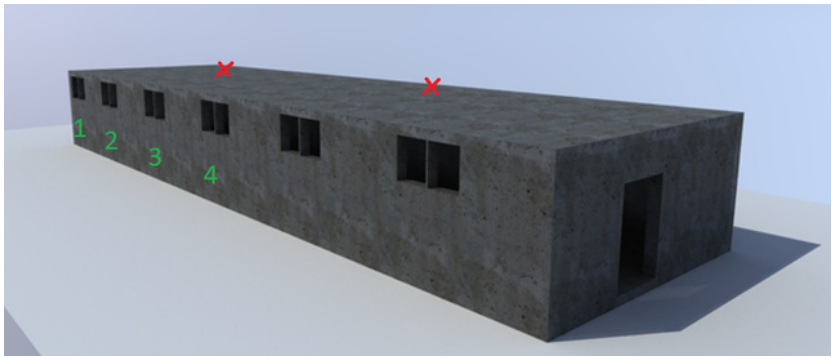


Figure 1: Model of the room in which the measurements were made

A Testo 400 sensor was used, with a CO_2 probe placed at a height of 1.6m. The measurement error of the sensor in the measurement range is ±(0.3 °C + 0.3 % of mv) for temperature measurements, ±(50 ppm + 3 % of mv) for CO_2 concentration measurements and ±(2 % RH) for relative humidity. Aerosol quantity and concentration were measured with a Grimm 11-D aerosol spectrometer at 60s intervals. The minimum counting efficiency in the measured range is 0.8. The maximum uncertainty for the magnitude in the measured range is ±(4 % nm). A Testo high precision vane probe was used to measure the air flow with a measurement accuracy of ±(0.1 m/s + 1.5 % of mv).

The maximum daily outdoor temperature on the first day was 20.4°C, while on the second day it was 9.2°C. The airborne particulate matter was 16 µg/m³ for $PM_{2.5}$ and 24 µg/m³ for PM_{10} on the first measurement day and 10 µg/m³ for $PM_{2.5}$ and 16 µg/m³ for PM_{10} on the second measurement day [16, 17].

The measured flow rate of all four outlet fans located at the centre and at the end of the room was 347 m³/h. The number of air changes is 1.05 per hour. At the maximum occupancy of 19 persons, the air change is 18.28 m³/h. The main opening through which the air enters the room is the door leading to the next showroom. This means that the exit air contains more pollutants than would be present if fresh outside air entered the room directly.

Experiment

The measurements were divided into two ventilation regimes.

Regime 1: 23.3.2023

Intensive natural ventilation at three intervals per day when the room was empty. In between, an average of 15 people were in the room at two intervals. Mechanical ventilation was on at all times.

9:15-9:30	The entrance door and all the windows in the room connected to the door are wide open, and in the room where the measurements are taken, the windows are open.
9:30-10:15	There are visitors in the room, about 15 people in the room.
11:55-12:05	The entrance door and all the windows in the room connected to the door are wide open, and in the room where the measurements are taken, the windows are open.
12:05-12:55	There are visitors in the room, about 15 people in the room.

Regime 2: 5.4.2023

In the second regime, natural ventilation was carried out in accordance with monitoring the increase in CO_2 concentration in order to keep the value at an acceptable level. On this day, the room was occupied by between 16 and 19 visitors, with pauses during which intensive cross ventilation took place. Natural ventilation with the windows open was carried out at all times and cross ventilation when the room was empty. Mechanical ventilation was on at all times.

8:40-8:50	Ventilation was carried out with the front door and all windows open.
9:45-9:55	Ventilation was carried out with the front door and all windows open.
10:45-10:55	Ventilation was carried out with the front door and all windows open.
11:45-11:55	Ventilation was carried out with the front door and all windows open.
13:45-14:25	Ventilation was carried out with the front door and all windows open.

RESULTS AND DISCUSSION

By measuring these parameters, we have confirmed that the ventilation provided in the building with its current use is inadequate and does not provide acceptable levels of pollutants in the indoor air. $PM_{2.5}$ levels of 32 µg/m³ on the first and 27 µg/m³ on the second day of measurement (Table 1) and PM_{10} levels of 57 µg/m³ on the first and 59 µg/m³ on the second day of measurement (Table 2) are well above the WHO recommended values, even with intensive hybrid ventilation [15].

The main opening through which the air enters the room is the door leading to the next showroom. This means that the exit air contains more pollutants than would be present if fresh outside air entered the room directly.

By measuring these parameters, we have confirmed that the ventilation provided in the building with its current use is inadequate and does not provide acceptable levels of pollutants in the indoor air.

The CO_2 concentration during the time when visitors are in the room does not provide the minimum recommended standards. The values of both measured quantities should be reduced, which would require improving the ventilation efficiency and installing better devices that would bring outside air into the space, not the air from the adjacent room. Limiting the maximum number of people in the room would likewise be helpful.

Table 1: Proportion of $PM_{2.5}$ aerosol measurements above the limit values during the period considered

$PM_{2.5}$ [µg/m³]	>15	>25	>35	Average
23.3. [%]	100	100	17	32
5.4. [%]	94	43	21	27

The values of both measured quantities should be reduced, which would require improving the ventilation efficiency and installing better devices that would bring outside air into the space, not the air from the adjacent room.

Table 2: Proportion of PM_{10} aerosol measurements above the limit values during the period considered

PM_{10} [µg/m³]	>45	>50	>60	Average
23.3. [%]	70	60	41	57
5.4. [%]	63	57	47	59

Average $PM_{2.5}$ values were 18% higher on the first measurement day. PM_{10} values were 3% higher on the second measurement day. The highest value measured on the second measurement day was 138 µg/m³.

The highest value measured on the second measurement day was 138 µg/m³.

Table 3: Proportion of CO_2 measurements exceeding the limit values during the period considered [15]

CO_2 [ppm]	>1000	>1500	>2000	>2500
23.3 [%]	57	27	3	0
5.4. [%]	82	55	21	4

Table 4: Average CO_2 Levels

CO_2 [ppm]	Average value	Standard deviation	Range
23.3 [%]	1162	433	614 - 2060
5.4. [%]	1625	521	576 - 2612

Compared to PM values, CO_2 concentration values vary considerably more. On a day when the occupancy was lower, the values are also significantly lower. Within the acceptable range, the concentration was applied 43% of the time on the first day and 18% of the time on the second day (Table 3). The measured minimum value vas 576 ppm at the time the visitors first entered the space. Maximum value was 2612 ppm and it was measured on the second day. It can be observed that the effect of the amount of people in the room has a stronger influence on the CO_2 concentration than on the particulate concentration and that the measurements of our study show that the concentrations do not increase linearly with the amount of people in the room.

The relative humidity and temperature graph of the first day meets the minimum requirements (Figure 2) and despite the increase in relative humidity with occupancy, the ventilation present is successful in maintaining the minimum value. The graph of the measurements on the second day, when the outside temperature was lower, illustrates the situation of inadequate relative humidity. At each ventilation the value falls below the minimum required. The minimum daily reading was 20.8% at the end of the long duration cross natural ventilation (Figure 2).

It can be observed that the effect of the amount of people in the room has a stronger influence on the CO_2 concentration than on the particulate concentration and that the measurements of our study show that the concentrations do not increase linearly with the amount of people in the room.

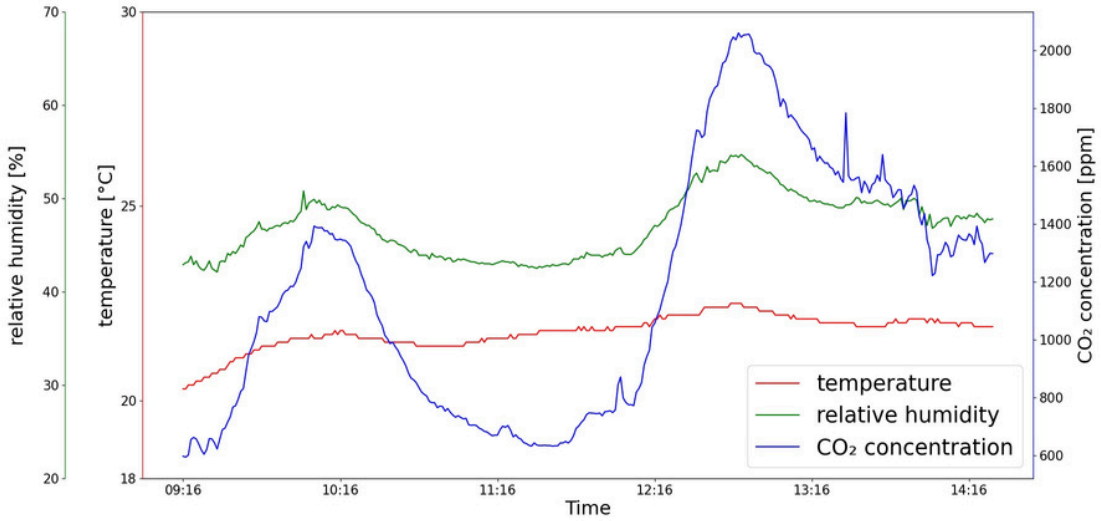


Figure 2: CO_2 concentration, temperature and RH of indoor air on 23.3.2023

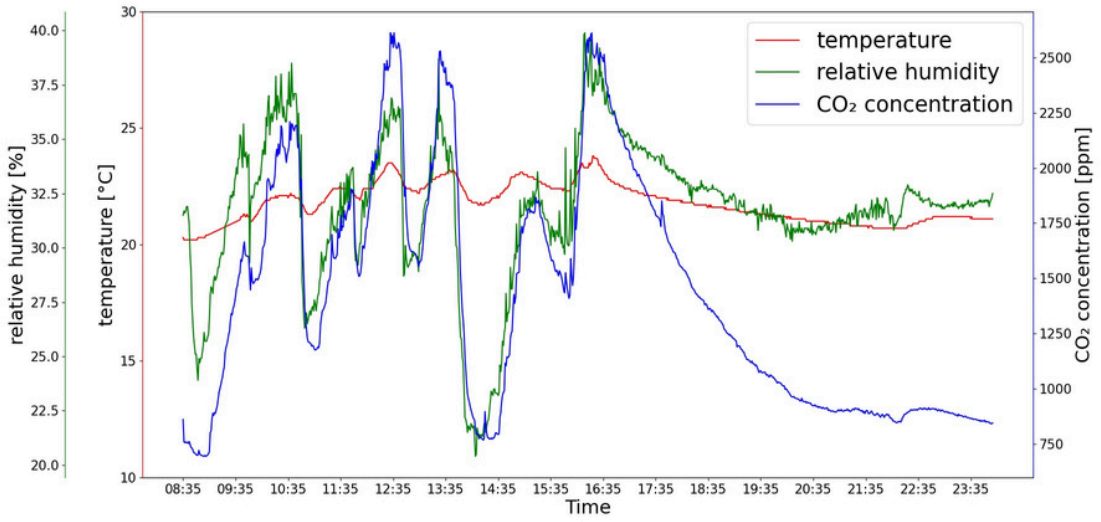


Figure 3: CO_2 concentration, temperature and RH of indoor air on 5.4.2023

From the graphs, we conclude that the concentration of 2.00 µm aerosols follows a very similar trend to that of CO_2, while the 0.65 µm aerosol curve follows this concentration more loosely, but still shows a partial pattern.

The graphs show the success of cross-flow natural ventilation in removing pollutants from rooms, but this can only be done when there are no people in the room due to draughts (Figure 4). On a day when there were more visitors in the room, the CO_2 content increased sharply, indicating that the capacity of the room is lower than the occupancy at the current ventilation capacity (Figure 4). We compared the trends of the concentration curves of aerosols of 0.65 µm and 2.00 µm. From the graphs, we conclude that the concentration of 2.00 µm aerosols follows a very similar trend to that of CO_2, while the 0.65 µm aerosol curve follows this concentration more loosely, but still shows a partial pattern. It can be argued that, under similar conditions with the same ventilation regimes, the CO_2 value is also an indicator of particulate matter in the air and thus, under these conditions, an increase in CO_2 is indicative of a general deterioration in air quality.

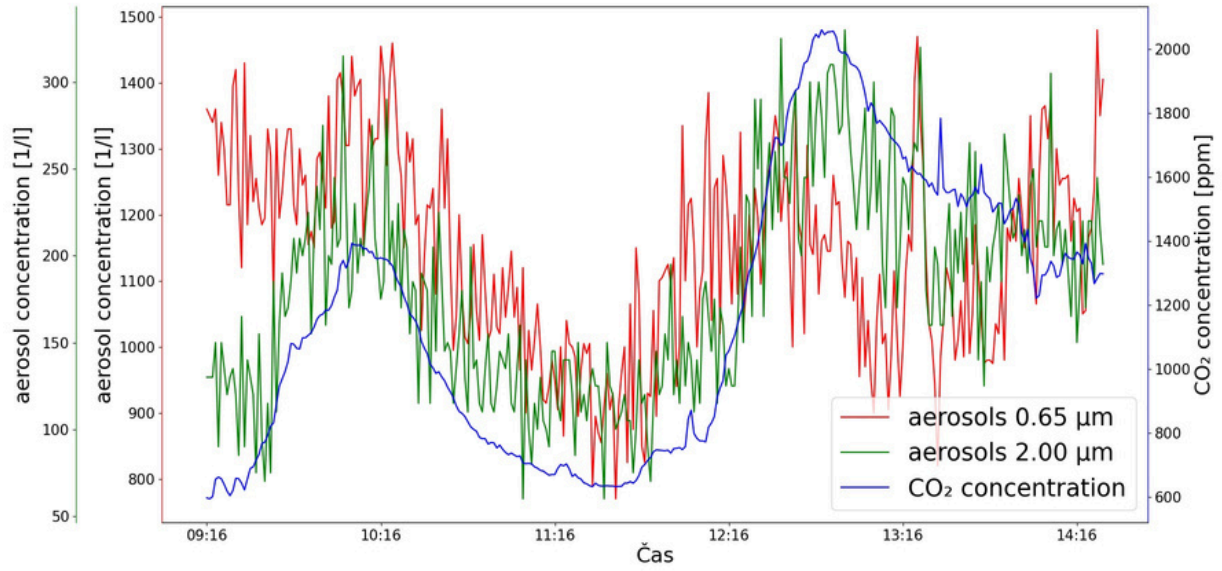


Figure 4: CO_2 and aerosol concentration of indoor air on 23.3.2023

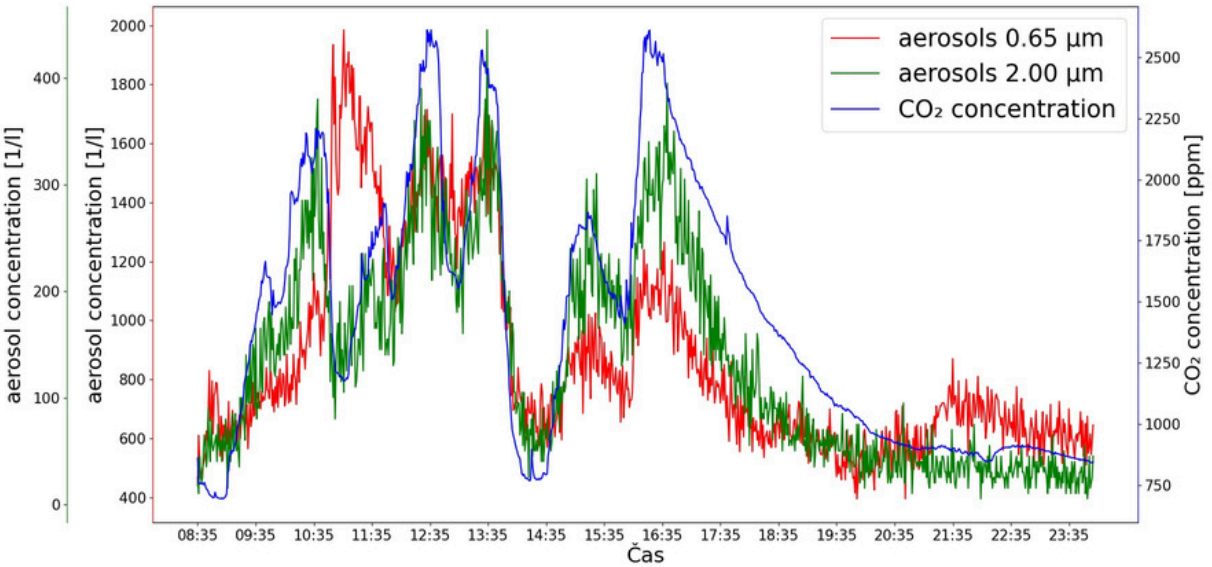


Figure 5: CO_2 and aerosol concentration of indoor air on 5.4.2023

The distribution of aerosol concentrations on the first measurement day before and during natural cross ventilation illustrates that ventilation removes most of the larger pollutants from the room and particles in range PM_1 are the most abundant in the room (Figure 6).

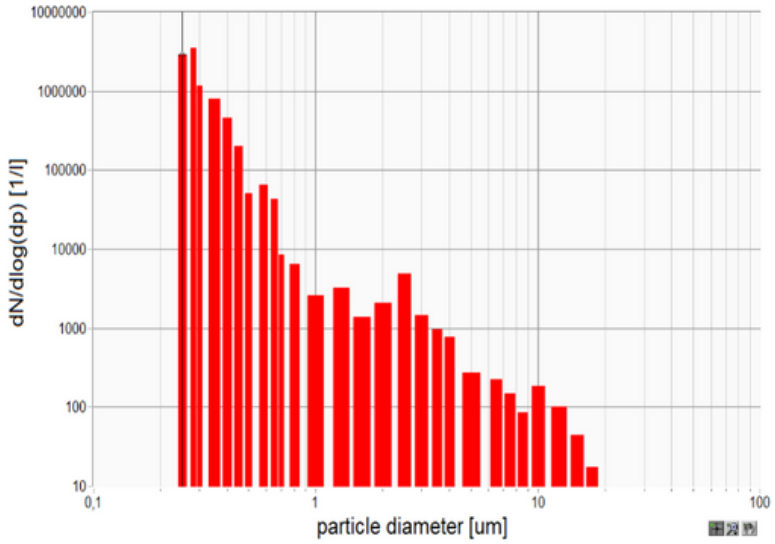


Figure 6: Particle number concentration per unit logarithmic size interval on measurement day 23.3.2023 at 10:00

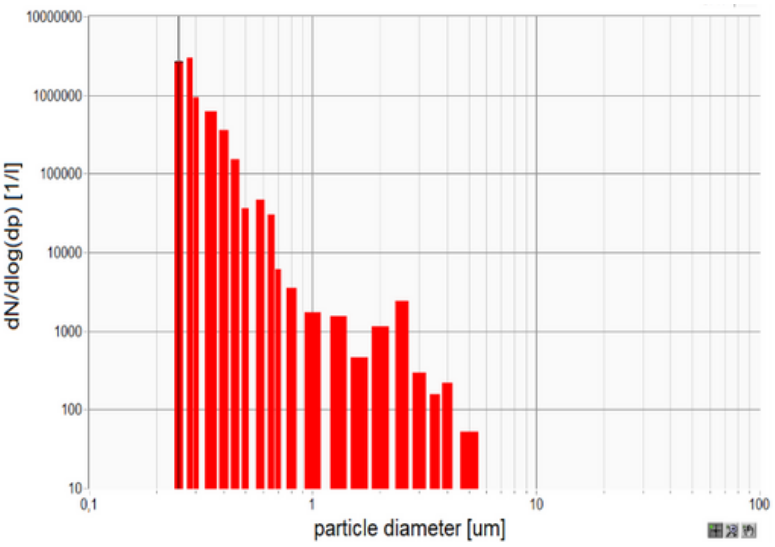


Figure 7: Particle number concentration per unit logarithmic size interval on measurement day 23.3.2023 at 11:30

Ventilation removes some pollutants from the room (Figure 7), even if it does not meet the minimum standards [15].

The findings of this study are consistent with previous research, offering similar insights into the importance of monitoring indoor air quality parameters, especially CO_2, for assessing ventilation effectiveness [6, 7, 8]. These studies collectively highlight the significance of adequate ventilation in indoor spaces for maintaining good air quality and protecting occupant health. However, they also underscore the challenges posed by inadequate ventilation and its implications for indoor air quality. Despite this alignment in findings, there remains a need for further research in diverse contexts to deepen our understanding of the relationship between ventilation effectiveness, indoor air quality, and occupant health outcomes.

Despite this alignment in findings, there remains a need for further research in diverse contexts to deepen our understanding of the relationship between ventilation effectiveness, indoor air quality, and occupant health outcomes.

CONCLUSION

The variation in airborne particulate matter levels can be estimated from a preliminary study of the spatial variation of particulate matter in the room. This method can be used to ensure adequate air quality in the museum. The finding allows us to assess the overall air quality by simply measuring the CO_2 concentration in a room where people are the main source of pollution and to take appropriate action when the values are not satisfactory. Air quality was negatively affected by increased visitor presence and inadequate ventilation. The maximum recorded CO_2 concentration in the room reached 2612 ppm during peak occupancy with 19 visitors. The minimum CO_2 level measured was on the same day, 567 ppm. On the first day, the average CO_2 concentration stood at 1162 ppm, while on the second day, it rose to 1625 ppm. The CO_2 concentration of the air is higher when there are more people in the room. This value is also an indicator of other pollutants or aerosols emitted by people. The highest PM_{10} airborne value was 138 µg/m³, also at the highest occupancy. This means that high levels of CO_2 in the air are also indicative of high levels of particulate matter.

This means that high levels of CO_2 in the air are also indicative of high levels of particulate matter.

We found that hybrid ventilation is more efficient than mechanical ventilation alone in the museum space, but it is still not adequate enough. A more efficient ventilation system needs to be installed in the space, and until then, based on the findings, we can limit the number of occupants to ensure adequate air quality with the current capacity.

We analysed the indoor air quality and the impact of human presence on it. CO_2 and aerosol levels vary in a correlated manner, so just by tracking CO_2 levels we can get indirect information about aerosol levels. When CO_2 values are too high, aerosol levels in the air are also too high. However, too high values of both parameters indicate inadequate ventilation of the room. We found that an adequate indoor environment is not guaranteed if the operation of the museum is unchanged and no additional interventions are made to the building.

CO_2 and aerosol levels vary in a correlated manner, so just by tracking CO_2 levels we can get indirect information about aerosol levels.

In conclusion, while our study offers valuable insights into air quality and ventilation in a repurposed museum space, it may lack generalizability due to its focus on a single location. Additionally, the short duration of measurements and the absence of longitudinal data limit our understanding of seasonal variations and long-term trends. Nevertheless, our study provides a comprehensive analysis of CO_2 and particulate matter concentrations, compared against WHO guidelines. Implementing practical recommendations to enhance ventilation efficiency and optimize occupancy management represents a crucial step towards fostering a healthier indoor environment within the space investigated in our study.

Future research should address these limitations by expanding sample size, conducting longer-term measurements, and including longitudinal data to provide a more nuanced understanding of indoor air quality and ventilation dynamics.

REFERENCES

[1] Elsaid AM, Mohamed HA, Abdelaziz GM, et al. A critical review of heating, ventilation, and air conditioning (HVAC) systems within the context of a global SARS-CoV-2 epidemic. Process Saf. Environ. Prot. 2021; 11(155): 230-261.

[2] Moghadam TT, Ochoa Morales CE, Lopez Zambrano MJ, et al. Energy efficient ventilation and indoor air quality in the context of COVID-19 – A systematic review. Renewable and Sustainable Energy Reviews. 2023; 182: 113356.

[3] Giampieri A, Ma Z, Ling-Chin J, et al. An overview of solutions for airborne viral transmission reduction related to HVAC systems including liquid desiccant air-scrubbing. Energy. 2022; 244(A): 122709.

[4] Mentese S, Mirici NA, Elbir T, et al. A long-term multi-parametric monitoring study: Indoor air quality (IAQ) and the sources of the pollutants, prevalence of sick building syndrome (SBS) symptoms, and respiratory health indicators. Atmospheric Pollution Research. 2020; 11(12): 2270-2281.

[5] Parhizkar H, Taddei P, Weziak-Bialowolska D, et al. Objective indoor air quality parameters and their association to respiratory health and well-being among office workers. Building and Environment. 2023; 246: 110984.

[6] Jin W, Zhang N, He J. Experimental Study on the Influence of a Ventilated Window for Indoor Air Quality and Indoor Thermal Environment. Procedia Engineering. 2015; 121: 217-224.

[7] Villanueva F, Notario A, Cabañas B, et al. Assessment of CO2 and aerosol (PM2.5, PM10, UFP) concentrations during the reopening of schools in the COVID-19 pandemic: The case of a metropolitan area in Central-Southern Spain. Environmental Research. 2021; 197: 111092.

[8] Argunhan Z, Avci AS. Statistical Evaluation of Indoor Air Quality Parameters in Classrooms of a University. Advances in Meteorology. 2018; 2018: 4391579.

[9] Schibuola L, Tambani C. Indoor environmental quality classification of school environments by monitoring PM and CO2 concentration levels. Atmos Pollut Res. 2020; 11(2): 332-342.

[10] Chatzidiakou L, Mumovic D, Summerfield A. Is CO2 a good proxy for indoor air quality in classrooms? Part 1: The interrelationships between thermal conditions, CO2 levels, ventilation rates and selected indoor pollutants. Building Services Engineering Research and Technology. 2015; 36(2): 129-161.

[11] Poirier B, Guyot G, Woloszyn M, et al. Development of an assessment methodology for IAQ ventilation performance in residential buildings: An investigation of relevant performance indicators. Journal of Building Engineering. 2021; 43: 103140.

[12] Kumar P, Singh AB, Arora T, et al. Critical review on emerging health effects associated with the indoor air quality and its sustainable management. Science of The Total Environment. 2023; 872: 162163.

[13] Chen RY, Ho KF, Hong GB, et al. Houseplant, indoor air pollution, and cardiovascular effects among elderly subjects in Taipei, Taiwan. Science of The Total Environment. 2020; 705: 135770.

[14] Henning RJ. Particulate Matter Air Pollution is a Significant Risk Factor for Cardiovascular Disease. Current Problems in Cardiology. 2024; 49(1): 102094.

[15] World Health Organization. WHO Guidelines for Indoor Air Quality: Selected Pollutants. Genevea, 2010.

[16] Agencija republike Slovenije za okolje. Povprečne dnevne ravni delcev PM2,5 v letu 2023. Ljubljana, 2024.

[17] Agencija republike Slovenije za okolje. Povprečne dnevne ravni delcev PM10 v letu 2023. Ljubljana, 2024.

SANITARNO INŽENIRSTVO / International Journal of Sanitary Engineering Research 2024;17(1): 15-42. DOI: 10.2478/ijser-2024-0002

sciendo

Disposable gloves: protection or just a false sense of security?

Nastja Vrbovšek and Mojca Jevšnik Podlesnik*

ABSTRACT

This study examines the impact of disposable glove use on food hygiene, focusing on the phenomenon of a false sense of security among food handlers in the catering establishments. A systematic literature review (2000–2024) and semi-structured interviews with nine catering employees revealed that improper glove use often results in reduced handwashing, cross-contamination, and non-compliance with hygiene standards. The literature analysis confirms that previous findings on the false sense of security associated with gloves remain relevant, while highlighting an increase in research activity on the topic in recent years. Interviews emphasized the lack of formal training on proper glove use and the need for enhanced supervision and awareness among food handlers regarding the appropriate hygiene practices for gloves and handwashing. The results indicate that gloves should not be perceived as a substitute for handwashing but rather as a complementary measure that requires strict adherence to hygiene protocols. This study highlights the importance of regular practical training, improved monitoring, and fostering accountability among food handlers to ensure food safety. A comprehensive approach to glove hygiene can significantly reduce the risk of foodborne illnesses and improve hygiene practices in the catering sector.

Keywords: disposable gloves, food handlers, catering, hand hygiene, food safety knowledge

Original Research Article

Received: 24. 10. 2024
Accepted: 2. 12. 2024
Published: 16. 12. 2024

University of Ljubljana
Faculty of Health Sciences
Zdravstvena pot 5
1000 Ljubljana, Slovenia

**Corresponding author*:
Assoc. Prof. Mojca Jevšnik Podlesnik, PhD
University of Ljubljana
Faculty of Health Sciences
Zdravstvena pot 5
1000 Ljubljana, Slovenia
Email: mojca.jevsnik@zf.uni-lj.si

INTRODUCTION

Disposable gloves have by now become a common hand hygiene practice worldwide. In food handling and healthcare organizations, they are mostly used as a measure to prevent the transmission of microorganisms [1] and they are used in numerous fields. The key factors in what type of gloves is best to choose are the quality and (raw) materials used. Most common materials used in glove manufacturing are polymers (rubber and plastic), leather, fabric or a combination of these materials. It is worth to mention that no glove material is ideal for every type of work. Rubber and plastic gloves are mostly used for hand protection from chemical or biological danger and for hand hygiene (protection against microorganisms). For protection against physical and mechanical hazards, textile or leather gloves are commonly used [2].

Food handlers tend to neglect the basic principles of hand hygiene while using gloves and this results in a reduced effectiveness of gloves as a barrier against contamination.

The use of disposable gloves is quite common in healthcare organisations where nurses, doctors and other workers have to be acquainted with the protocols of infection prevention in order to ensure safe daily care [3]. Workers in food establishments may use gloves provided they change them regularly, and care is taken to wash their hands both during the glove change and after they take the gloves off [4]. While glove use in food applications can reduce the risk of microbial contamination, it can also amplify or transfer it [5]. For example, Bencardino, Amagliani, and Brandi [6] state that the proper use of gloves is shown as an effective method for reducing the transfer level of contaminants from bare hands to foods. But as far as the effectiveness of decreasing food contamination with gloves goes, there is one major factor that needs to be addressed: the problem of improper hand hygiene when using gloves. Food handlers tend to neglect the basic principles of hand hygiene while using gloves and this results in a reduced effectiveness of gloves as a barrier against contamination [6].

Misuse of gloves could potentially lead to outbreaks of foodborne illnesses, which have been proven to have significant health and economic consequences.

Protocols and guidelines for using gloves in healthcare organisations are described in the World Health Organisation (WHO) document “Glove Use Information Leaflet”. While guidelines specific for using gloves in food handling are presented in many articles, for example in Slovenia, the correct way of using gloves is presented in a document published by NIJZ [7] titled “Basic hygiene principles for food hygiene and safety for employees in the food industry”. Guidelines advise to wash and dry hands before wearing gloves, to cover wounds with waterproof bandages, to change gloves frequently, after handling raw food, and if they are damaged, to wash hands between glove changes and after breaks and to not reuse or wash gloves. In this document, it is emphasised that gloves can become contaminated, they are not fully impermeable and they do not replace hand hygiene [7].

Considering the importance of food safety and hygiene, understanding the proper use of disposable gloves in food handling is crucial. Misuse of gloves could potentially lead to outbreaks of foodborne illnesses, which have been proven to have significant health and economic consequences [8]. In more detail, Chapman et al. [9] describe foodborne illnesses as problematic, especially in developing countries where 30% of individuals annually acquire a disease from contaminated food.

In this review, we focused on investigating whether the use of gloves causes a false sense of security or safety among food handlers in catering sector. The behaviour of workers who worked with gloves was also observed. The aim of the study was a systematic literature review on the use of disposable gloves when handling food and an analysis of the knowledge and attitudes of food employees in catering establishments towards disposable gloves for ensuring food safety.

METHODS

Systematic literature search

PubMed, Scopus, and Web of Science databases were searched to identify relevant scientific literature published between 2000 and 2024. The reason for choosing this time frame is the Slovenian progressive transition to the new European food safety legislation at that time. The literature was also searched on relevant websites: WHO and EU Food Safety Legislation. The search strategy was designed by using relevant keywords or strings of search terms and Boolean operators: (((disposable OR (glove OR gloves)) AND (security OR safety))) AND ((hand OR hands) AND (hygiene OR behavior)) AND (food AND (worker OR employee OR handler)) AND (hospitality OR catering OR foodservice OR "food service") where the same search strings were used for searching all three databases.

The language restitution concerned the articles published in English. Studies and review articles describing a false sense of glove security were summarized. Literature selection was made as illustrated in Table 1.

Table 1: Inclusion and exclusion criteria

	Inclusion criteria	**Exclusion criteria**
Language	English	All others
Date of publishing	2000–2024	Before 2000
Article category	Original research Systematic review Review article	Editorials Professional articles Letters
Keywords or strings of search terms and Boolean operators	((Disposable OR (glove OR gloves)) AND (security OR safety)) AND ((hand OR hands) AND (hygiene OR behavior)) AND (food AND (worker OR employee OR handler)) AND (hospitality OR catering OR foodservice OR "food service")	/
Availability	Free full access Open access	All others

Sample and semi-structured interviews

The research was conducted in July, August, and September 2024 among seven cooks and two cook assistants (three women and six men) employed in catering establishments. Using Google maps, we randomly selected catering establishments and contacted them. The data on catering establishments in Slovenia was obtained online. We called the phone number listed on their official website, got the person in charge on the phone and asked for their cooperation. Some agreed to participate, while others declined. We invited 40 restaurants. In the end, nine restaurants from Ljubljana, the capital of Slovenia, and its surroundings were included. From each establishment, one person agreed to participate in the semi-structured interviews.

The interviews were conducted immediately over the phone. Participation was voluntary, and the purpose and objectives of the study, as well as the interview process, were explained to all interviewees. All respondents verbally agreed to the recording of the interviews and the presentation of results in an anonymous format. Complete protection of personal data was ensured for all interviewees.

We invited 40 restaurants. In the end, nine restaurants from Ljubljana, the capital of Slovenia, and its surroundings were included.

Research materials were obtained through semi-structured interviews. A total of nine interviews were conducted with individuals handling food in catering establishments. The interviews included seven open-ended questions with sub-questions (Table 2), which were designed independently. Data was collected using an individual approach, with each interview lasting between 10 and 15 minutes. After reviewing the interviewees' responses, specific topics were identified. The interviews were recorded and transcribed verbatim. All personal data from the recorded interviews were anonymized. Names were coded, and any information that could reveal the identity of the speakers was omitted. Each interviewee was assigned a code (from I1 to I9, food handler number 1 to number 9). The interview quotes are presented in italics and organized according to specific topics.

Table 2: Semi-structured interview questions

Main questions	Sub-questions
1. Which work responsibilities are most demanding for you in terms of food hygiene requirements?	/
2. How often do you use disposable gloves in your work, and in what situations do you use them?	a) a. Why do you think the use of gloves is mandatory in the previously mentioned situations? b. Do you sometimes decide not to use gloves? If so, why?
3. How do you evaluate the effectiveness of disposable gloves in ensuring food hygiene?	b) What is your opinion on whether gloves prevent food contamination? c) Do you have any experience or examples where gloves did not provide adequate protection?

4. How does the use of gloves in your kitchen work affect handwashing?	d) a. Have you ever noticed that colleagues are less attentive to handwashing because of glove use?
5. Do you have any suggestions for improving the use of disposable gloves in your kitchen?	e) What advice would you give to colleagues or younger staff members entering the role of a chef regarding glove use?
6. How do you evaluate the course on food hygiene and proper personal hygiene when working with food?	/
7. Do you have any suggestions for improving the course programs? What should, in your opinion, be emphasized based on your work experience?	/

Data analysis

After conducting and transcribing the interviews, we reviewed the transcripts for accuracy. Following Vogrinec [10], we divided the data analysis into six steps: processing the material, determining the coding units, coding, selecting and defining relevant concepts and forming categories, defining the categories and forming the final theoretical formulation – topic design.

RESULTS AND DISCUSSION

Systematic literature search

The search results are shown in Figure 1. By applying time criteria and language filters, 374 electronic sources were identified. By applying the availability criteria, the number of electronic sources was reduced to 161. After reviewing the duplicates from all the databases 148 electronic sources were identified. Subsequently, the titles, abstracts, and other information about the literature, were reviewed, resulting in the elimination of 142 electronic sources. These 142 sources addressed various aspects of hand hygiene and glove use; however, for the final analysis, we included 6 sources that exclusively focused on addressing the false sense of security in the use of gloves in food handling. An overview of the studies analysed is shown in Table 3.

The results further suggest that glove use might be counterproductive because workers might wash their hands less frequently when gloved, potentially leading to a false sense of security.

Figure 1: Flowchart of the literature search and selection process

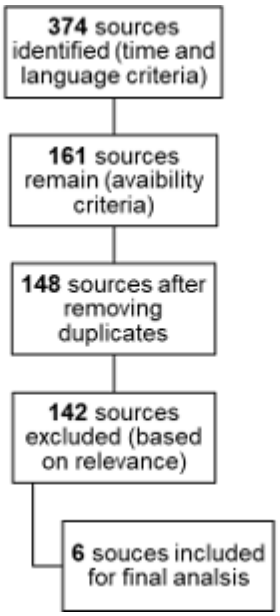


Table 3: An overview of articles included in the final analysis, addressing the false sense of security in the use of gloves by food handling employees

Authors, years	Aim	Type of study	Population	Country	Results
Rajagopal, Strohbehn [11] (2013)	To assess knowledge and behaviour related to glove use by college and university dining hall student workers and to evaluate the effectiveness of a visual intervention tool for improving proper glove use.	Case-controlled study	Student food workers	Iowa, United states of America	Knowledge was high, with 90% or more correct responses given for 6 of the 10 items. However, observational data showed non-compliance with Food Code recommendations in both groups, although non-compliance was lower in the treatment group, suggesting that the intervention was successful.
Lynch, Phillips, Elledge, Hanumanthaiah, Boatright [12] (2005)	To assess the effectiveness of glove use, compare microbiological contamination levels of food handled barehanded or with gloves and evaluate behavioural patterns of glove use among food handlers.	Observational comparative study	Food handlers in fast food restaurants	Oklahoma, United states of America	The observed tendency of food workers to wear the same pair of gloves for extended periods and complacency might account for the apparent failure of gloves to reduce or prevent bacterial contamination. The results further suggest that glove use might be counterproductive because workers might wash their hands less frequently when gloved, potentially leading to a false sense of security.

Michaels [13] (2004)	To explore the risks, limitations, and misconceptions concerning glove use in hygiene and food safety settings.	Review of literature	Food workers or/and handlers	Miami, United states of America	Gloves can create a false sense of security, mostly due to improper handwashing while gloved. Misusing gloves, not changing between tasks, increases microbiological cross-contamination potential. Proper education is needed in food safety, especially handling food with gloves.
Montville, Chen, Schaffner [14] (2001)	To evaluate the effectiveness of gloves as barriers, to quantify the bacterial transfer under different conditions, such as bare hands or with gloves used and to assess the limitations of glove use for contamination prevention.	Experimental laboratory study	University students and university staff	New Jersey, United states of America	Results indicate that gloves are permeable to bacteria although transfer from hands to food through a glove barrier was less than without a glove barrier. Our results indicate that gloves may reduce both bacterial transfer from food to the hands of food service workers and in subsequent transfer from hands back to food.
Arendt, Strohbehn, Jun [15] (2015)	To determine motivators and barriers of employees in following food safety practices in both non-commercial and commercial food service operations.	Mixed-methods observational study	Food workers	Iowa, United states of America	Indication to continue with safe food handling practices promotion among food workers, managers should infuse motivators and barriers identified in this study to effectively promote safe food handling practices.
Selvaraj, Cheng, Gan, Quan Oh, Thu Aung [1] (2023)	To assess the microbiological profile of gloves used by food handlers and to detect significant physical damage of gloves.	Quantitative laboratory-based observational study	Food handlers	Singapore	The results indicated that damaged gloves had significantly higher mean Standard Plate Counts (SPCs), suggesting an increased likelihood of bacterial transfer. Gloves with damage used to handle foods such as noodles and rice dishes exhibited notably higher mean SPCs compared to those used for handling beverages and snacks. In contrast, gloves without visible damage showed no significant differences in mean SPCs across various food types.

A systematic literature review of the 6 articles links the use of gloves in food handling environments with the false sense of security. Interestingly, Montville, Chen, and Schaffner [14] evaluated the effectiveness of gloves as barriers by quantifying the bacterial transfer under different conditions and demonstrated the ability of bacteria to pass from food through gloves to bare hand, and also from hand through gloves on food (Transfer rate through the glove barrier may be affected by inoculum size). The conclusive findings still point to the use of gloves as an effective way to decrease the transfer of a contaminant to hands. Building on this, Lynch et al. [12] pointed out that glove use might be counterproductive. Analysis of observed behaviour of food handlers showed that workers might wash their hands less frequently when gloved, also wearing the same pair of gloves for extended periods of time, which resulted in failure to prevent or decrease bacterial contamination. The review article of Michaels [13] confirmed previous conclusions as it emphasizes that glove use can create a false sense of security, mostly due to irregular and improper handwashing while gloved and also because of improper glove changes in between tasks.

Another concern about gloves discovered is a possibility of damage, which reduces their effectiveness in preventing micro-organisms from passing from hands to food.

In the first of the three more recent analysed studies, Rajagopal and Strohbehn [11], knowledge and behaviour related to glove use by college students and staff were evaluated. Observational data showed non-compliance with Food Code recommendations, although the non-compliance was lower in the treatment group, which received an intervention (educational flyer that explained when, why and how gloves are used), suggesting that the intervention was successful. Arendt, Strohbehn and Jun [15] are confirming the conclusions of Montville, Chen and Schaffner [14]; Lynch et al. [12] and Michaels [13] on food handlers having a false sense of security while gloved. Primarily they were studying motivators and barriers of employees in following food safety protocols where the barriers (forgetfulness/no habit; too busy; lack of knowledge) are connected to using gloves and ignoring proper handwashing and glove changes, which created a false sense of security for food handlers. Another concern about gloves discovered is a possibility of damage, which reduces their effectiveness in preventing micro-organisms from passing from hands to food. This was evaluated in the study of Selvaraj et al. [1] where damaged gloves were analysed. Of the collected gloves 54 % showed signs of physical damage which suggests an increase of bacterial transfer. Therefore, disposable gloves should be changed more frequently to minimize the possibility of food contamination.

Gloves should therefore be considered an adjunct and not an alternative to washing hands.

All six studies emphasized the importance of proper use and knowledge regarding the safe use of gloves from the perspective of food safety as the most effective way to prevent food contamination. Otherwise, gloves themselves can become a factor of contamination, as they create an environment where food handlers, due to a false sense of security, are not attentive to proper and sufficient handwashing or timely glove changes when necessary. Gloves should therefore be considered an adjunct and not an alternative to washing hands.

Demographic data

Due to extensive data obtained, the results include excerpts from interview transcripts with the most lucid, interesting, and intriguing quotes to illustrate the wholeness of a particular interview. Complete transcripts of interviews are available at the authors of the study.

Six men and three women participated in the interviews. The basic demographic data of the interviewees are presented in Table 4. One interviewee was less than 30 years old. Three interviewees were between 30 and 40 years old. The age of four interviewees was over 40 years, and one interviewee was exactly 50 years of age. The initial education of six interviewees was catering, while the other two had a non-catering education. The first language of three interviewees was Slovenian, one was Macedonian, and one was Serbian. As regards their work experience, one had less than half a year of professional experience; three interviewees had from six to nine years of professional experience; two from 14 to 18 years and two from 25 to 26 years of professional experience. Four interviewees last attended a food hygiene course this year in 2024, two interviewees more than 1 to 2 years ago and two interviewees more than four years ago. One interviewee had never attended a food hygiene course. Due to the small sample size, the results cannot be generalized to the whole population of chefs and cook assistants in Slovenia.

One interviewee had never attended a food hygiene course.

Table 4: Demographic characteristics of interviewees

Code identification	Gender	Age [years]	Native language	Work experience	Role in catering establishment
I1	Woman	31	Slovenian	6 years	Kitchen manager
I2	Man	45	Slovenian	26 years	Kitchen manager, cook
I3	Woman	24	Slovenian	2 months	Waiter, cook
I4	Woman	45	Macedonian	6.5 years	Kitchen manager, cook
I5	Man	40	Serbian	18 years	Kitchen manager, cook
I6	Man	48	Slovenian	25 years	Cook
I7	Man	50	Slovenian	32 years	Kitchen manager, cook
I8	Man	32	Slovenian	9 years	Kitchen manager, cook
I9	Man	36	Slovenian	14 years	Kitchen manager, cook

Qualitative analysis

In this section, the results are represented in more detail according to the most important topics developed.

Table 5: Developed topics

Proper hand washing and the use of gloves as a precondition for working in the kitchen	
Category	**Topic 1**
Practical challenges in reconciling hygiene rules and speed of work	Proper hand washing and the use of gloves as a precondition for working in the kitchen
Training on the correct use and effectiveness of gloves	
Hand washing before and after glove use	
Regular hand washing as a basic hygiene practice and routine	
Negligence and incorrect use of gloves	
Injuries and risks when using gloves	
Perception of the effectiveness of gloves and the method of use	
Category	**Topic 2**
Use of gloves and hand washing	Perception of the effectiveness of gloves and the method of use
Gloves as protection against food contamination	
Perception of false security and negligence when using gloves	
Selection and quality of gloves for specific tasks	
Improving the packaging and quality of gloves	
Emphasis on practical training and awareness-raising on the importance of food hygiene	
Category	**Topic 3**
The role of HACCP and practical food safety training	Emphasis on practical training and awareness-raising on the importance of food hygiene
Emphasis on the practical application of the HACCP system (reducing documentation, minimizing excessive writing)	
Increasing the frequency of HACCP training	
Courses on the proper use and effectiveness of gloves	
Increased awareness among staff of hygienic kitchen practices and glove use	

Lack of time and cross contamination	
Importance of cleaning to prevent the spread of microorganisms	

Strengthening responsibility among employees (responsibility for health and hygiene, consistency in compliance with food hygiene instructions and regulations)

Category	Topic 4
The importance of personal hygiene and discipline (basic hygiene education, responsibility towards work)	Strengthening responsibility among employees (responsibility for health and hygiene, consistency in compliance with food hygiene instructions and regulations)
Incorporating environmental awareness into courses for more sustainable operations in kitchens	
Hygiene and professional responsibility education in schools (hygiene awareness already in the education process)	

Lack of control and consistency in the implementation of hygiene rules

Category	Topic 5
Insufficient internal control over the strict observance of hygiene standards in kitchens	Lack of control and consistency in the implementation of hygiene rules
In the past, inspections were more frequent	
Less supervision, less compliance with hygiene rules	
Food hygiene knowledge testing is based on group testing, not individual testing	

Proper hand washing and the use of gloves as a precondition for working in the kitchen

This topic consists of 6 categories.

Practical challenges in reconciling hygiene rules and speed of work: Most interviewees pointed out that it is difficult to ensure compliance with hygiene requirements at times of increased workload or time pressure. Some interviewees reported that they struggle most with preventing cross-contamination or contamination of food due to working with different types of food on the same or adjacent counters, while others mentioned challenges such as keeping up with temperature logging on the refrigerators, thorough end-of-shift cleaning and HACCP writing. Reconciling strict hygiene rules with the rapid pace of kitchen work remains a significant challenge for food workers.

Reconciling strict hygiene rules with the rapid pace of kitchen work remains a significant challenge for food workers.

Most of our interviewees noted that time pressure is often the reason that leads to difficulties in preventing cross-contamination, especially when working with or preparing multiple different dishes in adjacent areas. These findings are also reported in the research [15, 16, 17, 30] conducted, where it was highlighted how workload and insufficient time can undermine ideal food safety practices.

Courses on the correct use and effectiveness of gloves: None of the interviewees listed any education on correct glove use, they did however all state that they trust in the effectiveness of gloves when it comes to food hygiene. While all interviewees believe and trust gloves are an effective way of securing safe food, there appears to be no formal training on correct glove use, since none of them listed any education on appropriate glove use.

Their results suggest that workers who wear gloves do not remove them and do not wash their hands as they should.

Handwashing before and after glove use: Most interviewees think that using gloves has no impact on their handwashing. But interviewees also state that they rather wash their hands multiple times and not use gloves while preparing food. I6 states that they always take their time washing and drying their hands, and then they put gloves on clean dry hands: “I always wash them, I wipe and dry them, then I put the gloves back on. Here, I always take my time, and also for the cleaning agent, if I clean something, because with a glove, it will not go on my hand… then I dry it, right.” Supporting these insights, Green et al. [21] observed that appropriate hand washing was less likely to occur during activities in which gloves were worn, compared to when gloves were not worn. Their results suggest that workers who wear gloves do not remove them and do not wash their hands as they should [12, 21, 31].

Regular handwashing as a basic hygiene practice and routine: Interviewees acknowledge that regular hand washing is a fundamental aspect of hygiene in the kitchen. Many interviewees state that they wash their hands frequently, regardless of glove use, to maintain cleanliness and prevent cross-contamination. Proper handwashing is one of the standard precautions for reducing the transmission of pathogenic microorganisms during food handling [32]. The importance of proper handwashing is also emphasised in several other scientific publications [19, 33, 34, 35, 36, 37, 38, 39].

Some interviewees show a lack of knowledge, for example about wearing the same gloves for the whole work time and not changing them in accordance with the guidelines.

Negligence and incorrect use of gloves: Opinions on glove use differ from interviewee to interviewee. I6 refuses to use gloves when handling food as he is sure regularly washed hands are a better choice: “Actually I don’t use gloves to handle foodstuffs, because I believe hands are cleaner with regular washing or each time you pick up something, that’s logical. You know, if you have a sink close-by, right”. On the other hand, I4 makes sure gloves are always used in the kitchen among all food handlers: “I always tell all the staff in the kitchen that it has to be done, one has to use gloves, there must be security, so that we do no harm to us or other people”. Some interviewees show a lack of knowledge, for example about wearing the same gloves for the whole work time and not changing them in accordance with the guidelines. In particular, the use of gloves was perceived as a safeguard and as a point of confusion. Several interviewees expressed a preference for frequent hand washing over gloves, underscoring the persistent belief that well-washed hands remain the gold standard [18]. Moreover, uneducated or rather incorrect glove usage, for example failing to change gloves between handling raw meat and ready-to-eat foods [40] or wearing the same pair throughout the entire shift, poses a risk of contamination [14, 17, 19].

Perception of the glove's effectiveness and method of use

This topic consists of 6 categories.

Use of gloves and hand washing: Only 1 in 9 interviewees describes hand washing and glove use as the most difficult part the food hygiene. Use of gloves is reported among all interviewees, but they are mostly used for cleaning purposes, when using cleaning products. Most interviewees, 6 out of 9, claim to use gloves mostly when handling fish or raw meat. I1 explained: "Well, I mostly use them with things, such as cleaning fish and such stuff, because of that smell that gets into your skin; otherwise, hem, if I have to clean". Some of interviewees report that they rather regularly wash their hands and keep them clean, since they think wearing gloves is too risky and causes too much plastic waste. The interviews highlight a diverse perspective on the effectiveness and practical use of gloves in food handling. Most participants report using disposable gloves primarily for cleaning, as a protection barrier against irritant chemicals. The next most common reason for using gloves was when handling raw meat and fish. When working in the kitchen, the guidelines [7] exempt the use of gloves for tasks such as cutting, portioning, carving, finishing, etc., when handling unprotected, finished foodstuffs, as well as when handling raw meat, especially poultry, or cleaning raw vegetables. Some research [6, 12, 33] highlight the inadequacy of gloves to prevent the transmission of microorganisms because of inadequate glove handling and rather emphasise proper and regular handwashing which is in line with the conclusions of the interviewees.

Most participants report using disposable gloves primarily for cleaning, as a protection barrier against irritant chemicals. The next most common reason for using gloves was when handling raw meat and fish.

Gloves as protection against food contamination: All interviewees agree on disposable gloves being a great tool for ensuring food hygiene, or as I3 said: "To prevent contamination or some bacteria or contaminants, that's why." Three out of nine follow up with a warning, that one must ensure to change gloves regularly. Following up despite all interviewees agreeing on using gloves for food hygiene 2 out of 9 interviewees do not agree with gloves preventing food contamination. I6 states he prefers to wash his hands rather than use gloves, as gloves do not represent any hygiene to him: "Or else, in my experience, I personally think they're unhygienic; as you can see folks don't wash their hands, and that is simply an excuse not to wash". No interviewee reports a situation where gloves would not ensure an adequate protection. Even so interviewees perceive benefits of glove use differently. Several interviewees view gloves as a reliable barrier against cross-contamination, which aligns with research on how glove use can minimize pathogen transfer [20] when used correctly.

Among the other 7 interviewees, there was no awareness of a possible false sense of security. Only two respondents underlined a potential false sense of security when using gloves.

Perception of false security and negligence when using gloves: Two interviewees report, in this context, that using gloves can quickly make us think everything is safe and sterile, while it really is not. For example, I2 states, "I also think it can happen to someone with gloves on – they think their hands are clean, but there is still dirt on, right, so it's very much a double-edged sword, right?". Among the other 7 interviewees, there was no awareness of a possible false sense of security. Only two respondents underlined a potential false sense of security when using gloves. Using gloves blindly, only because it looks safe, for a prolonged period, or anyhow against the guidelines [7] or good hygiene practices [19] causes a false sense of security in a food worker, which is a widespread problem mentioned in the studies that we have also highlighted in our systematic literature review [1, 11, 12, 13, 14, 15].

Injuries and risks when using gloves: Two interviewees reported a risk when using gloves. First, risk was associated with using gloves while using a slicer for meat or salami. This is when one has no sense of where exactly one's finger is and this could lead to injury. Another risk reported was associated with using disposable gloves with hot temperatures, where the crossing of the latter may present an increased risk of injury.

Selection and quality of gloves for specific tasks: Interviewees talked about completing different tasks with gloves, such as cleaning, handling raw meat and fish, mixing large quantities of ingredients (such as when preparing a salad). I9 says: "Certain things, that is some things that can't be mixed with kitchen utensils, right; then they are mixed with hands – in that case just gloves are used". No selection of gloves or quality of gloves were mentioned for performing specific tasks.

He posited that thin gloves are more susceptible to tearing, which diminishes their efficacy, particularly during strenuous or forceful manual activities.

Improving the packaging and quality of gloves: One interviewee (I9) pointed out that gloves were fine for securing hygiene, but that the quality of the gloves themselves was problematic and bad. He also expressed concerns regarding the thickness of the gloves, stating that the current gloves are too thin. He posited that thin gloves are more susceptible to tearing, which diminishes their efficacy, particularly during strenuous or forceful manual activities. He proposed the use of thicker gloves that would be more resistant to tearing, thereby providing a better protection during work. No other interviewees mentioned the need for an improved quality of gloves neither did they mention the quality of the gloves they use themselves.

Emphasis on practical training and awareness-raising on the importance of food hygiene

This topic consists of 7 categories.

All interviewees underline the fact that, while HACCP is universally acknowledged as a cornerstone of food safety, many participants believe the system's effectiveness hinges on practical training rather than extensive paperwork.

The role of HACCP and practical food safety training: The role of HACCP was highlighted as a tool to ensure food safety. However, many interviewees highlighted the need for a stronger focus on practical training as opposed to theoretical instruction and excessive documentation. Several interviewees expressed the view that theoretical HACCP training, which often focuses on lectures and paperwork, is insufficient to prepare employees for real-life kitchen tasks. Interviewee I9 suggested that practical experience is far more valuable, stating "More, more, more of practical training than theoretical one. Well, if you are familiar with that, hem, HACCP lectures are in most cases more or less based rather on theory than on practice. But we learn much more practically than theoretically". All interviewees underline the fact that, while HACCP is universally acknowledged as a cornerstone of food safety, many participants believe the system's effectiveness hinges on practical training rather than extensive paperwork. These sentiments align with research indicating that hands-on experience and frequent refresher training foster better compliance than theoretical lectures alone [22]. In addition to the structure and content of training, studies emphasize that food safety systems are more effective when supported by a positive organizational climate. This includes clear communication, engaged leadership, supervision, continuous staff training and evaluation, as well as efforts to create a collaborative and motivated work environment [41, 42].

Interviewees collectively confirmed that they learn and understand more through practical training than through extensive theoretical training, which is in line with the conclusions of the study [43] where the learning-by-doing method was used to achieve higher levels of success in food handling practices and food safety knowledge. Similar studies [44, 45, 46, 47] highlight the importance of regular HACCP training for food handler, as food handlers with no regular HACCP training were more prone to making mistakes and to using the wrong procedures when handling food and when using disposable gloves. Although the above-mentioned studies highlight the importance of implementing regular food safety training. Aa more recent study by Palupi et al. [46] conducted in the Indonesian region found that as many as 95 % of food workers had not received any training in food safety or hygiene practices. This finding is particularly concerning when considering that food handling staff play a critical role in ensuring food safety throughout the entire production and serving chain. It therefore indicates a significant gap between the recognized importance of food safety training and its actual implementation in practice. It is also important to note that, in the case of Indonesia, the overall rate of food safety and hygiene training implementation is generally very low, which further underscores the need for systemic improvements and stronger regulatory support in this area [46].

Interviewee I2 posited that a well-managed hospitality establishment would naturally adhere to the principles of HACCP and expressed the opinion that the current amount of documentation (e.g., daily temperature logs for refrigerators) is not necessarily required.

Emphasis on the practical application of the HACCP system (reducing documentation, minimizing excessive writing): Most interviewees stated that HACCP-related documentation often represents a significant burden. They emphasised that there is an excessive focus on the completion of forms. Interviewee I2 posited that a well-managed hospitality establishment would naturally adhere to the principles of HACCP and expressed the opinion that the current amount of documentation (e.g., daily temperature logs for refrigerators) is not necessarily required.

Moreover, studies confirm that food safety training is an effective tool for improving knowledge, hygienic behaviour, and the microbiological safety and quality of prepared foods.

Increasing the frequency of HACCP training: Interviewees had similar opinions on this category and some of them mentioned the importance of frequency of HACCP training. Three interviewees are of the opinion that such training should be conducted more frequently. For instance, I7 said: “Well, how do I rate this? There’s not enough of this, there should be more of this, much more”. I2 added: “It can take place every three months. HACCP is very much needed with food, in the kitchen, for everything”. This perception is supported by Walker, Pritchard, and Forsythe [48], who found that 64 % of surveyed businesses lacked a system for updating food safety knowledge. This gap highlights the importance of ongoing training to maintain food safety standards.Similarly, a study conducted among food handlers in primary schools in Jos, Nigeria, concluded that both knowledge and hygienic practices were insufficient, and recommended the implementation of structured and continuous food safety training to address these gaps [49]. Moreover, studies confirm that food safety training is an effective tool for improving knowledge, hygienic behaviour, and the microbiological safety and quality of prepared foods [50].

Training on the proper use and effectiveness of gloves: One of interviewees expressed the need for additional information and training on the proper use of gloves.

I3 emphasized that it would be beneficial to have a better understanding of when and why the use of gloves is essential, as well as how to prevent cross-contamination: "… Yes, essentially, anything on the use of gloves, all sorts of information would be useful. Hem, I'm not sure, for example, why really to use them, how to use them correctly …" This reflects a wider challenge in food safety training—namely, that simply knowing the basics is not enough. Studies emphasize that hygiene training must go beyond instructions and include visual tools, peer support, supervisory reinforcement, and access to adequate equipment. Such integrated approaches have been shown to encourage more consistent and safer hygiene behaviors among food handlers [39].

More than half of the interviewees state that some workers who use gloves do not pay attention to proper handwashing.

Increased awareness among staff of hygienic kitchen practices and glove use: The majority of interviewees emphasize that the use of gloves is essential in food preparation and cleaning. However, some of them express the opinion that handwashing is more effective than the use of gloves. More than half of the interviewees state that some workers who use gloves do not pay attention to proper handwashing. I1 added that a prolonged use of gloves can also cause hand sweating, which may lead to the development of bacteria on the hands under the gloves. Several participants stressed the importance of proper glove use and reported inconsistent practices in the kitchen. A study conducted in Iowa State University [11] proved that targeted education, such as leaflets or demonstrations, can significantly improve correct glove use and is therefore a method worth implementing. For food handlers according to Bencardino, Amagliani, and Brandi [6] glove use is recommended when cutting, portioning, carving, finishing, etc. finished foodstuff and when handling raw poultry or cleaning raw vegetables.

The same study also found that glove use and hand washing are influenced by a variety of contextual factors, including staff training, availability and visibility of handwashing stations, and restaurant type.

Lack of time and cross contamination: The interviewees point out that that time pressure often impacts the implementation of hygienic practices in the kitchen. I2 emphasizes the necessity for unwavering vigilance, regardless of the workload, as work overload can elevate the probability of potential contamination. I9 advises that in case of time constraints, when the use of gloves is difficult, it is necessary to ensure thorough hand washing. These qualitative observations are consistent with findings from a study by Green et al. [19], which identified that food workers were more likely to follow hand hygiene protocols, such as hand washing and glove use, during food preparation activities and when not under significant time pressure. The same study also found that glove use and hand washing are influenced by a variety of contextual factors, including staff training, availability and visibility of handwashing stations, and restaurant type [21].

Importance of cleaning to prevent the spread of microorganisms: Some interviewees emphasised the importance of cleaning as to prevent the spreading of microorganisms or cross-contamination. For example, I3 states: "And at the end of the day, cleaning the whole kitchen. You know that everything is tidied up, all dishes washed, all products packed so they cannot get contaminated in some way, that they are separated". Strict separation of clean and unclean pathways was also mentioned as an important safety measurement. In addition to this, keeping the toilet facilities clean at all times was mentioned as a way of preventing bacterial growth, as it was referred to as a possible source of contamination, stated by I7: "Ah, to separate clean from unclean pathways. Hem, then taking care of toilets, by the staff; this is what I find very important, that the responsible person cleans them regularly.

Hem, then everything develops out of this. Then, people must be loyal to themselves and also to other people, one has to be clean, to have discipline regarding these things, that's the point, right". The importance of cleaning routines, highlighted by some interviewees, particularly the maintenance of surfaces, equipment, and restrooms, as central to preventing microbial spread is consistent with literature highlighting that systematic surface cleaning significantly lowers the risk of cross-contamination [23]. Overall, these insights suggest that an emphasis on practice-based HACCP training, regular awareness raising of hygiene protocols, and clear guidance on glove use and cleaning can improve food safety outcomes in hospitality settings.

Strengthening responsibility among employees (responsibility for health and hygiene, consistency in compliance with food hygiene instructions and regulations)

This topic consists of 3 categories.

The importance of personal hygiene and discipline (basic hygiene education, responsibility towards work): Personal responsibility and discipline of employees are key to a consistent adherence to hygiene practices. As I8 adds, hygiene habits are not well established among high school and university students who come to them for internships. He states: "... those who come for a traineeship, let's say, have not yet mastered that or, how to say ... They seem to forget washing their hands, I'd say. One basic thing, when one of them comes from the toilet and doesn't wash his hands, I don't know, as if they haven't learnt that at home. That's it, such things are noticed, heh-heh. Younger ones haven't got that; they come from the loo without washing their hands, these are things you notice then, well". He adds that the basic hygiene practices should be more systematically incorporated into school programs: "Basic hygiene. This is what I must say. Just hygiene, your tidiness when you come to work, it shows the type of person you are when you come for the first time to a new job or place to work, heh-heh. That, that is possible. Yes, from scratch, maybe at the school they attend, they should teach them some more, give more emphasis on hygiene, how to say, a personal approach or how I should put it". One of the interviewees (I7) mentioned a connection between illness and working in the kitchen. I7 stated that employees still come to work despite being ill. He highlighted that in his catering establishment, he advises employees with digestive issues, for example, to stay home for two to three days, if possible, to reduce the risk of disease transmission among colleagues and to food. Strengthening the employees' sense of responsibility, for their own health and hygiene practices, is crucial to maintaining consistent food safety standards. One interviewee reported a recurring lack of knowledge about basic hygiene habits, especially among less experienced or part-time workers. One of the previously mentioned studies, which discusses the importance of developing a habit for following basic rules of hygiene, observed that even among foodservice workers in a university dining setting, glove use and hand hygiene behaviours were often inconsistent, and that visual intervention tools were needed to reinforce proper practices. Their findings highlight the necessity of not only education but also ongoing, practical reinforcement of hygiene protocols in foodservice environments [11]. Another study highlights the importance of building good habits in complying with basic hygiene rules and thus ensuring food safety [25].

Overall, these insights suggest that an emphasis on practice-based HACCP training, regular awareness raising of hygiene protocols, and clear guidance on glove use and cleaning can improve food safety outcomes in hospitality settings.

Their findings highlight the necessity of not only education but also ongoing, practical reinforcement of hygiene protocols in foodservice environments.

Furthermore, Green at al. [40] shows that poor personal hygiene remains one of the main contributors to foodborne illness outbreaks, underlining the critical need to improve hygiene related behaviour among food workers [21]. Notably, one interviewee cited instances in which staff members continued to work while having an infectious disease, so the risk of disease transmission was emphasised, in support of literature that advocates for clear policies and paid sick leave to improve food safety [26, 51].

Incorporating environmental awareness into courses for more sustainable operations in kitchens: Some interviewees expressed concern about the environmental impact of glove use. I7 said: "Oceans are full of plastics, wherever you look, there's plastics. Gloves are hanging, you know, you go to the forest and you see gloves disposed". Another interviewee (I3) mentioned the importance of proper disposal of used gloves, suggesting that better guidance on this issue could reduce the environmental burden: "Hem, they should also be taught where to dispose them so that they don't burden the environment with their overuse". Building on this, two interviewees emphasized the environmental impact of glove use as this instilled a degree of hesitancy regarding the act of using the gloves themselves. The primary concern was the quantity of waste produced, and the damage caused by the gloves. The rationality of their use was called into question from an ecological perspective. It has been noted that such concerns are increasingly being given consideration in hospitality research with respect to the reduction of plastic waste [25].

The primary concern was the quantity of waste produced, and the damage caused by the gloves. The rationality of their use was called into question from an ecological perspective.

Hygiene and professional responsibility education in schools (hygiene awareness already in the education process): Two interviewees emphasized that students should be better trained in hygiene and professional responsibility in schools, so that good work habits are developed from early on. I8 suggested that there could be a dedicated subject in schools focusing on hygiene in hospitality establishments: "Yes, from scratch, maybe at school where they teach them, they should have classes focusing on the hygiene, how to say, a personal approach or how I should put it". There was a broad agreement among interviewees on the importance of including food safety awareness in school curricula at an early stage. Inadequate early school education is discussed as one of the factors causing knowledge gaps and inadequate practices among food handlers [27, 28]. Early socialisation into a profession during secondary education has shown to help shape students' motivation and adaptation to future work environments [52, 53]. A study by Majowicz et al. [54] on the effectiveness of food safety theoretical education among secondary school students found that while knowledge improved in the short term after education, interest in the topic declined, and only knowledge on safe food temperatures and storage times was retained in the long term. This finding underscores the necessity for regular, practice-oriented training, particularly within the broader context of school hygiene, which was also confirmed in the Ovca et al. (2018) study.

There was a broad agreement among interviewees on the importance of including food safety awareness in school curricula at an early stage.

Lack of control and consistency in the implementation of hygiene rules

This topic consists of 4 categories.

Insufficient internal control over the strict observance of hygiene standards in kitchens: Interviewees emphasise the importance of internal control in maintaining hygiene standards in kitchens.

One of them highlighted the need for consistent oversight and accountability to ensure compliance. According to this interviewee, the decline in regular inspections has weakened the employees' sense of responsibility.

The lack of control also extends to employees' personal health and hygiene. I7 mentioned situations when workers with clear health issues such as gastrointestinal problems, are pressured to continue working due to staff shortages. However, he emphasised that he himself does not allow such behaviour in his own kitchen but instead demonstrated a high level of trust in his colleagues, allowing them to take a few days at home to recover. Both internal and external inspections directly contribute to the prevention of foodborne illnesses. Michel and Godelieve [55] noted that establishments with strong regulatory oversight experience fewer outbreaks of foodborne diseases, as inspections help ensure that all employees follow proper food safety guidelines. Internal inspections also play a role in ensuring that the establishment has effective pest control, waste management, and sanitation procedures in place to prevent contamination from external sources.

Internal inspections also play a role in ensuring that the establishment has effective pest control, waste management, and sanitation procedures in place to prevent contamination from external sources.

In the past, inspections were more frequent: One interviewee (I7) reflected on the differences in past and present hygiene inspections with the observation that in the past, inspections were carried out more frequently: "Previously, I'm of the old school, inspections used to come more often". As Newbold et al. [56] already pointed out in 2008, merely increasing the frequency of inspections has little impact on the behaviour of repeat offenders, whereas mandatory food handler education is considered a more effective and sustainable approach. I7 also reflected on stricter past practises, highlighting the rigorous standards that existed during earlier periods. Jevšnik et al. [57] also noted that older, more structured training programmes (such as the "Hygiene Minimum" course) continue to have a lasting impact on food safety knowledge among individuals who completed them. Among the other 8 interviewees, there was no specific mention of the frequency of inspections. External inspections provide an unbiased assessment of food safety practices. Gould and Clasen [58] highlighted the importance of regulatory inspections in identifying and correcting hygiene deficiencies that may not be noticed during internal monitoring. These inspections help enforce industry-wide standards and ensure that all establishments, regardless of size, follow the required procedures to minimize foodborne risks. Bryan and Little [59] found that businesses that undergo regular inspections show better adherence to food safety practices. Both internal and external inspections positively impact employee behavior. Kumar and Ganesh [60] concluded that employees in establishments with regular inspections tend to be more diligent in their hygiene practices, as they are aware that their actions will be scrutinized. Additionally, inspections often lead to the development of clearer protocols and better management practices, fostering a food safety culture. This is particularly important in larger establishments, where the risk of improper food handling and contamination is higher due to the larger workforce and complex operations.

Bryan and Little [59] found that businesses that undergo regular inspections show better adherence to food safety practices. Both internal and external inspections positively impact employee behavior.

Additionally, inspections often lead to the development of clearer protocols and better management practices, fostering a food safety culture.

Less supervision, less compliance with hygiene rules: Only two interviewees talked about the impact of supervision on hygiene rules. As mentioned in previous paragraph, I7 notes that past hygiene practices ensured higher discipline and accountability among employees. Additionally, he contrasts this with the current situation, stating: "Today is like that, today is today, no control over it any more, right".

Internal control and regular verification is crucial for ensuring continuous adherence to hygiene standards within food service establishments. Studies have shown that regular internal inspections conducted by management can help identify potential hygiene issues before they become serious problems. Baker, McNabb, and Lee [61] emphasized that consistent internal training programs and frequent control on staff hygiene practices can significantly reduce the risks of contamination. Furthermore, Lee and Sampson [62] found that internal monitoring ensures that employees follow food safety protocols consistently, particularly in larger establishments where the complexity of operations increases the risk of non-compliance.

Studies have shown that regular internal inspections conducted by management can help identify potential hygiene issues before they become serious problems.

Food hygiene knowledge testing is based on group testing, not individual testing: Another finding is the approach used to test employee knowledge of food hygiene. One interviewee clearly highlighted the shortcomings in the methods used to assess the employees' knowledge of food hygiene. I8 highlighted that tests are often done in groups instead individually: "Hem, maybe they should be a bit stricter on these things. I say, well, it seems that those things are done pretty much on the fly. They all pass anyway. Hem, there's no serious test, that is if you are doing a test together with ten others. Hem, probably the average would be very low if they let each one do the test alone without any help, I should say".

Interviewees revealed that inconsistent supervision (both internal and external) plays a key role in how erratic the enforcement of hygiene standards in kitchens is.

Interviewees revealed that inconsistent supervision (both internal and external) plays a key role in how erratic the enforcement of hygiene standards in kitchens is. Supervisors and managers were discussed as a "great source" of knowledge and motivation in relation to the enforcement of hygiene standards [15]. One interviewee notes that reduced frequency of inspections compared to inspections in the 20th century has diluted the employees' sense of responsibility. In terms of supervision, two interviewees agree that there is now a decrease in supervision, reflecting findings consistent with interviewees' responses that there is a need to improve the supervision by managers. The lack of management control is presented as the main obstacle to the enforcement of hygiene standards [29]. Another interviewee clearly highlights the shortcomings in the methods used to assess the employees' knowledge of food hygiene, for example that the tests are taken in a group instead of individually. He thinks that testing individually would show far worse results and a more accurate and realistic level of knowledge. No studies reflecting such findings were found for this topic.

Another interviewee clearly highlights the shortcomings in the methods used to assess the employees' knowledge of food hygiene, for example that the tests are taken in a group instead of individually.

Differences in the implementation of personal hygiene and glove use in food service establishments can be significant, particularly depending on the size and type of the establishment. In larger establishments, such as hotels, high-capacity restaurants, or restaurant chains, and smaller establishments like local cafés, bars, or bistros, the approaches to ensuring hygiene can vary considerably due to different needs, requirements, and resources.

Size and capacity of food service establishments: Larger food service establishments often have higher hygiene requirements due to the greater number of employees, guests, and the larger scale of food preparation. Internal requirements governing the use of gloves and personal hygiene are stricter in these establishments to ensure safety and prevent the spread of potential infections. This means that gloves may be used in all stages of food handling, including food preparation, serving, and cleaning.

Employees also receive regular training on hand hygiene, which includes frequent handwashing and glove use when working with food [61]. In contrast, smaller food establishments generally do not have the same strict and uniform practices regarding glove use, as they tend to be less formal and more flexible in their working methods. Smaller establishments often have less frequent inspections and internal control, and employees may not always be consistent in their hygiene practices. This can lead to a higher likelihood of mistakes or negligence in adhering to hygiene standards [63].

Number of employees and work organization: Larger hospitality establishments typically employ a greater number of staff, which means tasks and responsibilities are more clearly divided. Employees in specialized departments, such as the kitchen, bar, or service, may have clearer instructions regarding glove use and hygiene in general. This division of labor allows for more consistent monitoring of personal hygiene practices and the use of protective equipment. According to Bryan and Little [59], the effectiveness of task performance and responsibility is crucial for ensuring consistent hygiene practices in larger hospitality establishments. In smaller venues, however, employees are often multi-functional, meaning they handle various tasks simultaneously, such as food preparation, service, and cleaning. This makes it more difficult to maintain uniform hygiene standards, as tasks may be carried out without specific protocols, such as using gloves for serving or food handling [58]. Due to greater flexibility but also fewer resources, smaller establishments may face reduced availability of protective materials, such as gloves [64].

Smaller establishments often have less frequent inspections and internal control, and employees may not always be consistent in their hygiene practices.

Availability of resources and training: In addition, larger establishments typically have more resources to ensure proper hygiene, as they can afford it. This includes larger quantities of gloves, disinfectants, regular employee training, and access to advanced hygiene procedures. Employees in larger venues often receive more frequent and detailed training on glove use and hygiene protocols, which enables more consistent implementation of tasks [60].

In smaller venues, however, employees are often multi-functional, meaning they handle various tasks simultaneously, such as food preparation, service, and cleaning.

In smaller establishments, resources for education and training, as well as the purchase of hygiene supplies, are often limited. This can mean that employees are less frequently trained on the proper use of gloves or may not be aware of the latest standards for personal hygiene. As a result, there may be less consistent implementation of hygiene practices, increasing the risk of mistakes such as improper glove use or forgotten hand hygiene [65].

Protocols and supervision: Larger food service establishments are subject to more oversight, both from internal and external bodies. Inspections, regular internal control, and more structured control procedures ensure that hygiene standards in larger establishments are often more consistent and in line with regulations. This includes specific instructions regarding the use of gloves and other protective equipment when handling food. However, even in larger establishments, discrepancies may occasionally arise due to errors in supervision or non-compliance with hygiene protocols within the team [62]. Smaller establishments may be under less stringent supervision, meaning that their operational protocols are less formalized and often not aligned with the latest hygiene guidelines. As a result, supervision is less likely to be consistent, which may increase the risk of inadvertently spreading microorganisms through surfaces, utensils, and employees' hands [55].

Smaller establishments may be under less stringent supervision, meaning that their operational protocols are less formalized and often not aligned with the latest hygiene guidelines.

CONCLUSION

The results of this study show that the use of disposable gloves can often create a false sense of security among hospitality workers. Although gloves are an important part of hygiene practices, they are often perceived by workers as a substitute for basic hand hygiene, leading to reduced hand washing frequency and increased risk of cross-contamination. This misperception poses a serious threat to food safety and consumer health.

A review of scientific studies on misperception confirms that the findings of older studies on this topic are still relevant, while at the same time there has been an increase in research activity in recent years. This reflects the growing interest of the professional community and the need for improvements in the use of protective gloves. The analysis of the literature and the results of the interviews underline the critical importance of improving the link between proper hand washing and glove use, as the correct implementation of these practices can effectively reduce the risk of cross-contamination.

Practical and frequent training focusing on the correct use of gloves and the importance of hand hygiene is of key importance to reduce risk.

Raising awareness among food workers that gloves are not a substitute for hand hygiene, but a complement that requires strict adherence to the rules, is essential to address this issue. Practical and frequent training focusing on the correct use of gloves and the importance of hand hygiene is of key importance to reduce risk. In addition to this, supervision and internal control mechanisms need to be improved to ensure that hygiene standards are consistently applied.

This study provides insight into attitudes, knowledge and understanding of the use of disposable gloves and highlights the need for a holistic approach that includes awareness raising, training and improved monitoring. This is the only way to reduce the false sense of security created by incorrect glove use and improve food safety in the catering sector. Differences in the implementation of personal hygiene and disposable glove use in food service establishments largely depend on the size and organizational structure. Larger establishments typically provide more resources and consistent internal control and monitoring protocols, which enable better adherence to hygiene standards. In smaller food service establishments additional efforts are required to ensure the same standards, despite limited resources. Regardless of the size of the establishment, it is crucial to adhere strictly to regulations and provide regular employee training to ensure the highest hygiene standards and food safety. The combination of internal control and external regulatory inspections is essential for maintaining the highest standards of food safety and hygiene. Regular control not only help prevent foodborne outbreaks but also foster a food safety culture within food service establishments.

The combination of internal control and external regulatory inspections is essential for maintaining the highest standards of food safety and hygiene.

RESEARCH LIMITATION

Due to the small and homogeneous sample located in Ljubljana and its surroundings, the results are not representative and cannot be generalized to the entire population of food handlers in catering establishments in Slovenia. It would be beneficial to include a larger sample in future studies, covering different regions and demographic groups, to grain more representative and general conclusions on the false sense of security associated with the use of disposable gloves. Further research employing a mixed methodology is required with a broader and more graphical presentation of the issues influencing the perception and behaviour of food handlers regarding disposable glove usage.

One of the main challenges encountered in this study was the recruitment of interviewees. Some individuals were reluctant to participate in the study due to concerns about the potential impact on their employment status or the reputation of the catering establishment. Interviewees were reassured that the data would be kept strictly confidential. The results would be presented in summary form only.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to all food handlers who participated in the study.

FUNDING

This research was supported by the Slovenian Research Agency (research core funding No. P3-0388).

REFERENCES

[1] Selvaraj R, Cheng EJ, Gan P, et al. Microbiological profiles of disposable gloves used for handling ready-to-eat foods. Journal of Food Protection. 2023; 86(11): 100146. DOI: https://doi.org/10.1016/j.jfp.2023.100146.

[2] Li BS, Estlander T, Jolanki R, et al. Advantages and disadvantages of gloves. In: John S, Johansen J, Rustemeyer T, Elsner P, Maibach H, eds. Kanerva's Occupational Dermatology. Springer, Cham. 2020. DOI: https://doi.org/10.1007/978-3-319-68617-2_204.

[3] Dekker M, van Mansfeld R, Borgert M, et al. The combined application of hand hygiene and non-sterile gloves by nurses in a tertiary hospital: a multi methods study. Antimicrobial Resistance & Infection Control. 2024; 13:23. DOI: https://doi.org/10.1186/s13756-024-01378-5.

[4] World Health Organization [WHO], Food and Agriculture Organization of the United Nations [FAO]. Covid-19 and food safety: guidance for food businesses. (7. 4. 2020).

[5] Michaels BS, Ayers T, Brooks-McLaughlin J, et al. Potential for glove risk amplification via direct physical, chemical, and microbiological contamination. Journal of Food Protection. 2024; 87(7): 100283. DOI: https://doi.org/10.1016/j.jfp.2024.100283.

[6] Bencardino D, Amagliani G, Brandi G. Carriage of Staphylococcus aureus among food handlers: An ongoing challenge in public health. Food Control. 2021; 130: 108362. DOI: https://doi.org/10.1016/j.foodcont.2021.108362.

[7] National Institute of Public Health (Nacionalni inštitut za javno zdravje [NIJZ]). Osnovna higienska stališča za higieno in varnost živil za zaposlene v živilski dejavnosti. 2014. https://nijz.si/wp-content/uploads/2015/07/osnovna_higienska_stalisca_nov_2014.pdf.

[8] Traynor M, Douglas AC, Lee YM, et al. Enhancing food safety and sanitation education: Developing an immersive learning platform using virtual simulation. Journal of Culinary Science & Technology. 2024; 1–17. DOI: https://doi.org/10.1080/15428052.2024.2379331.

[9] Chapman B, Eversley T, Fillion K, et al. Assessment of food safety practices of food service food handlers (risk assessment data): Testing a communication intervention (evaluation of tools). Journal of Food Protection. 2010; 73(6): 1101-1107. DOI: https://doi.org/10.4315/0362-028X-73.6.1101.

[10] Vogrinc J. Kvalitativno raziskovanje na pedagoškem področju. Ljubljana: Univerza v Ljubljani, Pedagoška fakulteta, 2008: http://pefprints.pef.uni-lj.si/179/1/Vogrinc1.pdf.

[11] Rajagopal L, Strohbehn CH. Observational assessment of glove use behaviors among foodservice workers in a university dining setting: Testing a visual intervention tool. Food Protection Trends. 2013; 33: 315-324.

[12] Lynch RA, Phillips ML, Elledge BL, et al. A preliminary evaluation of the effect of glove use by food handlers in fast food restaurants. Journal of Food Protection. 2005; 68(1): 187–190. DOI: https://doi.org/10.4315/0362-028x-68.1.187.

[13] Michaels B. Understanding the Glove Risk - Paradigm: Part I. Food Safety Magazine. 2004: 10.

[14] Montville R, Chen Y, Schaffner DW. Glove barriers to bacterial cross-contamination between hands to food. Journal of food protection. 2001; 64(6): 845-849. DOI: https://doi.org/10.4315/0362-028x-64.6.845.

[15] Arendt S, Strohbehn C, Jun J. Motivators and barriers to safe food practices: Observation and interview. Food protection trends. 2015; 35(5): 365-376. https://www.foodprotection.org/files/food-protection-trends/Sep-Oct-15-arendt.pdf.

[16] Arendt SW, Paez P, Strohbehn C. Food safety practices and managers' perceptions: A qualitative study in hospitality. International Journal of Contemporary Hospitality Management. 2013; 75(6): 8-14. DOI: https://doi.org/10.1108/09596111311290255.

[17] Green-Brown L, Selman C. Factors impacting food workers' and managers' safe food preparation practices: A qualitative study. Food Policy. 2005; 25(12): 981–
990.file:///C:/Users/mojca/Downloads/Factors_impacting_food_workers_and_managers_safe.pdf.

[18] Montville R, Chen Y, Schaffner DW. Risk assessment of hand washing efficacy using literature and experimental data. International Journal of Food Microbiology. 2002; 73(2-3): 305-313. DOI: https://doi.org/10.1016/S0168-1605(01)00666-3.

[19] Green LR, Selman CA, Radke V, et al. Food Worker Hand Washing Practices: An Observation Study. Journal of Food Protection. 2006; 69(10): 2417-2423. DOI: https://doi.org/10.4315/0362-028X-69.10.2417.

[20] Todd ECD, Michaels BS, Greig JD, et al. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 8. Gloves as barriers to prevent contamination of food by workers. Journal of Food Protection. 2010; 73(9): 1762-1773. DOI: https://doi.org/10.4315/0362-028X-73.9.1762.

[21] Green LR, Redke V, Mason R, et al. Factors related to food worker hand hygiene practices. Journal of food protection. 2007; 70(3): 661–666. DOI: https://doi.org/10.4315/0362-028x-70.3.661.

[22] Seaman P. Food hygiene training: Introducing the Food Hygiene Training Model. Food Control. 2010; 21(4): 381-387. DOI: https://doi.org/10.1016/j.foodcont.2009.08.005.

[23] Powell DA, Jacob CJ, Chapman BJ. Enhancing food safety culture to reduce rates of foodborne illness. Food Control. 2011; 22(6): 817-822. DOI: https://doi.org/10.1016/j.foodcont.2010.12.009.

[24] Mullan B, Wong C, Todd J, et al. Food hygiene knowledge in adolescents and young adults. British Food Journal. 2014; 117(1): 50-61. DOI: https://doi.org/10.1108/BFJ-03-2013-0060.

[25] Filimonau V. The prospects of waste management in the hospitality sector post COVID-19. Resources, Conservation and Recycling. 2021; 168: 105272. DOI: https://doi.org/10.1016/j.resconrec.2020.105272.

[26] Todd ECD, Greig JD, Bartleson CA, et al. Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 2. Description of Outbreaks by Size, Severity, and Settings. Journal of Food Protection. 2007; 70(8): 1975-1993. DOI: https://doi.org/10.4315/0362-028X-70.8.1975.

[27] Ovca A, Jevšnik M, Kavčič M, et al. Food safety knowledge and attitudes among future professional food handlers. Food Control. 2018; 84: 345-353. DOI: https://doi.org/10.1016/j.foodcont.2017.08.011.

[28] Ovca A, Jevšnik M, Raspor P. Food safety awareness, knowledge and practices among students in Slovenia. Food Control. 2014; 42: 144-151. DOI: https://doi.org/10.1016/j.foodcont.2014.01.036.

[29] Garayoa R, Vitas AI, Díez-Leturia M, et al. Food safety and the contract catering companies: Food handlers, facilities and HACCP evaluation. Food Control. 2011; 22(12): 2006-2012. DOI: https://doi.org/10.1016/j.foodcont.2011.05.021.

[30] Abidin UF, Fatimah U. Measuring food safety culture: Insights from onsite foodservice operations. Iowa Sate University. 2013. DOI: https://doi.org/10.31274/etd-180810-4328.

[31] Yap M, Chau ML, Pahm Hartantyo SH, et al. Microbial Quality and Safety of Sushi Prepared with Gloved or Bare Hands: Food Handlers' Impact on Retail Food Hygiene and Safety. Journal of Food Protection. 2018; 82(4): 615-622. DOI: https://doi.org/10.4315/0362-028X.JFP-18-349.

[32] Michaels B, Keller C, Blevins M, et al. Prevention of food worker transmission of foodborne pathogens: Risk assessment and evaluation of effective hygiene intervention strategies. Food Service Technology. 2004b; 4(1): 31-49. DOI: http://dx.doi.org/10.1111/j.1471-5740.2004.00088.x.

[33] Robinson A, Jung Lee H, Kwon J, et al. Adequate Hand Washing and Glove Use Are Necessary To Reduce Cross-Contamination from Hands with High Bacterial Loads. Journal of Food Protection. 2016; 79(2): 304-308. DOI: https://doi.org/10.4315/0362-028X.JFP-15-342.

[34] Possas A, Pérez-Rodríguez F. New insights into cross-contamination of fresh-produce. Current Opinion in Food Science. 2023; 49: 100954. DOI: https://doi.org/10.1016/j.cofs.2022.100954.

[35] Huang Y, Kim DY, Liu P. Applying a hypocrite strategy to improve restaurant food safety practices in the U.S. Food Control. 2023; 143: 109280. DOI: https://doi.org/10.1016/j.foodcont.2022.109280.

[36] Halim-Lim SA, Mohamed K, Muhammad Sukki F, et al. Food Safety Knowledge, Attitude, and Practices of Food Handlers in Restaurants in Malé, Maldives. Sustainability. 2023; 15(17): 12695. DOI: https://doi.org/10.3390/su151712695.

[37] Saveanu CI, Anistoroaei D, Todireasa S, et al. Evaluation of the Efficiency of Hand Hygiene Technique with Hydroalcoholic Solution by Image Color Summarize. Medicina. 2022; 58(8): 1108. DOI: https://doi.org/10.3390/medicina58081108.

[38] Lee HK, Abdul Halim H, Thong KL, et al. Assessment of Food Safety Knowledge, Attitude, Self-Reported Practices, and Microbiological Hand Hygiene of Food Handlers. International Journal of Environmental Research and Public Health. 2017; 14(1): 55. DOI: 10.3390/ijerph14010055.

[39] Soares LS, Almeida RCC, Cerqueira ES, et al. Knowledge, attitudes and practices in food safety and the presence of coagulase-positive staphylococci on hands of food handlers in the schools of Camaçari, Brazil. Food Control. 2012; 27(1): 206–213. DOI: 10.1016/j.foodcont.2012.03.016.

[40] Green L, Selman C, Banerjee A, et al. Food service worker´s self-reported food prepration practices: an EHS-Net study. International Journal of Hygiene and Environmental Health. 2005; 208(1-2): 27 - 35. DOI: http://dx.doi.org/10.1016/j.ijheh.2005.01.005.

[41] Ungku Zainal Abidin UF, Strohbehn CH, Arendt SW. An empirical investigation of food safety culture in onsite foodservice operations. Food Control. 2014; 46: 255–263. DOI: 10.1016/j.foodcont.2014.05.029.

[42] Taha S, Osaili TM, Vij M, et al. Measuring management practices impact on hygiene practices of food handlers: The mediating role of commitment and training perception. Food Control. 2021; 130: 108313. DOI: 10.1016/j.foodcont.2021.108313.

[43] Alqurashi NA, Priyadarshini A, Jaiswal AK. Evaluating Food Safety Knowledge and Practices among Foodservice Staff in Al Madinah Hospitals, Saudi Arabia. Safety. 2019; 5(1): 9. DOI: https://doi.org/10.3390/safety5030054.

[44] Veiros MB, Proença RPC, Santos MCT, et al. Food safety practices in a Portuguese canteen. Food Control. 2009; 20(10): 936–941. DOI: https://doi.org/10.1016/j.foodcont.2008.04.007.

[45] McIntyre L, Vallaster L, Wilcott L, et al. Evaluation of food safety knowledge, attitudes and self-reported hand washing practices in FOODSAFE trained and untrained food handlers in British Columbia, Canada. Food Control. 2013; 30(1): 150–156. DOI: https://doi.org/10.1016/j.foodcont.2012.09.035.

[46] Palupi IR, Budiningsari RD, Khoirunnisa FAA, et al. Food safety knowledge, hygiene practices among food handlers, and microbiological quality of animal side dishes in contract catering. Italian Journal of Food Safety. 2024; 13(2). DOI: https://doi.org/10.4081/ijfs.2024.10656.

[47] Putri M, Susanna D. Food safety knowledge, attitudes, and practices of food handlers at kitchen premises in the Port 'X' area, North Jakarta, Indonesia 2018. Italian Journal of Food Safety. 2021; 10(4). DOI: 10.4081/ijfs.2021.9215.

[48] Walker E, Pritchard C, Forsythe SJ. Food handlers' hygiene knowledge in small food businesses. Food Control. 2003; 14(5): 339–343. DOI: 10.1016/S0956-7135(02)00101-9.

[49] Afolaranmi TO, Hassan ZI, Bello DA, et al. Knowledge and practice of food safety and hygiene among food vendors in primary schools in Jos, Plateau State, North Central Nigeria. E3 Journal of Medical Research. 2015; 4(2): 016–022. DOI: https://doi.org/10.18685/e3jmr(5)2_59-64.

[50] Malavi DN, Abong GO, Muzhingi T. Effect of food safety training on behavior change of food handlers: A case of orange-fleshed sweetpotato purée processing in Kenya. Food Control. 2021; 119: 107500. DOI: 10.1016/j.foodcont.2020.107500.

[51] Todd ECD, Greig JD, Bartleson CA, et al. Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 3. Factors contributing to outbreaks and description of outbreak categories. Journal of Food Protection. 2007; 70(9): 2199–2217. DOI: 10.4315/0362-028X-70.9.2199.

[52] Amaiach R, El Ouali Lalami A, Fadil M, et al. Food safety knowledge, attitudes, and practices among food handlers in collective catering in central Morocco. Heliyon. 2024; 10(23): e40739. DOI: 10.1016/j.heliyon.2024.e40739.

[53] Ovca A, Jevšnik M, Kavčič M, et al. Food safety knowledge and attitudes among future professional food handlers. Food Control. 2018; 84: 345–353. DOI: 10.1016/j.foodcont.2017.08.011.

[54] Majowicz S, Hammond D, Dubin JA, et al. A longitudinal evaluation of food safety knowledge and attitudes among Ontario high school students following a food handler training program. Food Control. 2017; 76(3). DOI: 10.1016/j.foodcont.2017.01.011.

[55] Michel V, Godelieve L. Effectiveness of food hygiene regulations and training programs in small food establishments. Food Protection Trends. 2011; 31(4): 233–239. DOI: https://doi.org/10.4315/0362-028X.JFP-10-295.

[56] Newbold KB, McKeary M, Hart R, et al. Restaurant inspection frequency and food safety compliance. Journal of Environmental Health. 2008; 71(4): 56–61. DOI: https://doi.org/10.1007/BF02294956.

[57] Jevšnik M, Kirbiš A, Vadnjal Š, et al. Food safety knowledge among professional food handlers in Slovenia: The results of a nation-wide survey. Foods. 2023; 12(14): 2735. DOI: 10.3390/foods12142735.

[58] Gould LH, Clasen T. Preventing foodborne illness in restaurants: A review of current literature. Food Control. 2015; 53: 177–184. DOI: https://doi.org/10.1016/j.foodcont.2014.12.010.

[59] Bryan FL, Little CL. Foodborne disease outbreaks due to improper food handling. Journal of Food Protection. 2004; 67(6): 1134–1145. DOI: https://doi.org/10.4315/0362-028X-67.6.1134.

[60] Kumar S, Ganesh P. Food safety training and its impact on food handlers' behavior in large restaurants. Food Safety Journal. 2017; 11(3): 211–220. DOI: https://doi.org/10.1080/15428145.2017.1324011.

[61] Baker M, McNabb S, Lee S. Hygiene practices in food service settings: A systematic review of interventions. Journal of Food Protection. 2015; 78(4): 853–860. DOI: https://doi.org/10.4315/0362-028X.JFP-14-527.

[62] Lee CH, Sampson A. Assessment of food safety compliance in the hospitality industry. Journal of Food Safety. 2015; 35(3): 203–210. DOI: https://doi.org/10.1111/jfs.12181.

[63] Prevolšek V, Ovca A, Jevšnik M. Fulfilment of technical and hygienic requirements among street food vendors in Slovenia. British Food Journal. 2020; 122(11): 3614-3627. DOI: https://doi.org/10.1108/BFJ-11-2020-1056.

[64] Hussain M, Karim R, Iqbal Z. Challenges in food hygiene practices in small food businesses: A case study. Food Control. 2013; 29(2): 507–514. DOI: https://doi.org/10.1016/j.foodcont.2012.05.034.

[65] Clarke A, Anderson M, Brown G. Training and practices in hygiene standards in small catering businesses. International Journal of Hospitality Management. 2012; 31(2): 473–480. DOI: https://doi.org/10.1016/j.ijhm.2011.06.005.

SANITARNO INŽENIRSTVO / International Journal of Sanitary Engineering Research 2024;17(1): 43-62. DOI: 10.2478/ijser-2024-0003

Design of healthcare facilities with an emphasis on environmental health features

Sedina Kalender – Smajlović[1] and Mateja Dovjak*[2]

ABSTRACT

This study aims to critically analyze the integration of environmental health features into the design and construction processes of healthcare facilities in Slovenia, evaluate their impact on the well-being of patients and staff, and develop more holistic and sustainable design approaches. A mixed-methods research approach was employed, beginning with a qualitative analysis of national and international legal requirements and recommendations for constructing healthcare facilities in Slovenia, focusing on environmental health. The second step involved qualitative research through a case study, including short interviews with stakeholders to gather insights on applying environmental health criteria in construction projects. In the third step, recommendations for constructing healthcare facilities were defined, synthesizing findings from previous steps. By applying the six-step engineering design methodology and evidence-based approach, we presented the most critical areas of environmental health using the example of a 400-bed hospital. Our research results have significant practical value for all phases of healthcare facility construction, effectively raising stakeholder awareness

Keywords: environmental health, indoor environmental quality, healthcare facilities, sustainable design, well-being, recommendations

sciendo

Review Article

Received: 21. 10. 2024
Accepted: 2. 12. 2024
Published: 16. 12. 2024

[1]Angela Boškin Faculty of Health Care
Spodnji Plavž 3
4270 Jesenice, Slovenia

[2]University of Ljubljana
Faculty of Civil and Geodetic Engineering
Jamova cesta 2
1000 Ljubljana, Slovenia

Corresponding author:
Assoc. Prof. Mateja Dovjak, PhD, BSc Sanitary Engineering
University of Ljubljana
Faculty of Civil and Geodetic Engineering
Jamova cesta 2
1000 Ljubljana, Slovenia
Email: mdovjak@fgg.uni-lj.si

INTRODUCTION

Healthcare facilities are intricate environments that necessitate the creation of healthy, comfortable, stimulating, and healing-oriented conditions for patients, staff, and visitors [1, 2]. Consequently, designing such buildings is among the most challenging processes compared to other types and requires a transdisciplinary approach involving collaboration across various disciplines. This context's performance criteria pertain to building design and environmental health. Key determinants of environmental health include indoor environmental quality (IEQ), which encompasses optimal thermal conditions, air quality, daylight, ergonomics, universal design, sound insulation, and room acoustics. Environmental factors significantly impact human health [3, 4]. The Ministry of Health of the Republic of Slovenia [5] and the World Health Organization [6] emphasize that the most critical environmental factors of the built environment, which represent the most significant burden of disease, include air pollution, ambient noise, electromagnetic radiation, light pollution, and contaminated water and soil. This aspect is particularly crucial in the design of healthcare facilities where there are vulnerable users.

Research in environmental psychology underscores that the physical environment affects psychological well-being, directly influencing the healing process.

To broaden the academic discourse on the impact of optimal IEQ on patient treatment, a closer examination of historical and contemporary perspectives is necessary. As early as 1859, Florence Nightingale laid the foundation for understanding that IEQ is not merely an aesthetic enhancement but a crucial element of the therapeutic process [7]. Her pioneering work highlighted the importance of hygiene, ventilation, and natural light in hospital rooms, representing a revolutionary shift in medical practice. In modern times, this concept continues to evolve and deepen. An interdisciplinary approach, integrating engineers, architects, consultants, healthcare professionals, and environmental psychologists [8], facilitates a comprehensive understanding of the complex interactions between patients and their environment. Research in environmental psychology underscores that the physical environment affects psychological well-being, directly influencing the healing process.

This means that a high-quality indoor environment is not just a passive element but an active factor that enhances the effectiveness of healthcare.

Anåker et al. [9] explored the concept of healthcare facility design based on the premise that optimal physical environments can promote the health and well-being of patients and staff. The study highlights the growing demand for patient-centered, accessible, safe healthcare environments grounded in research and evaluations. The conclusions emphasize that stakeholder awareness contributes to the creation of evidence-based healthcare environments, focusing on three main themes: (i) environmental sustainability and ecological values, (ii) social and cultural interactions and values, and (iii) resilience in engineering and building construction. The Donabedian classification, cited by Fadda [10], provides a structured framework for assessing the quality of healthcare provision. The hospital environment's design, technology, and equipment are key factors in this context. This means that a high-quality indoor environment is not just a passive element but an active factor that enhances the effectiveness of healthcare. The study by Capolongo et al. [11], based on an analysis of the response of healthcare systems to the COVID-19 pandemic, proposed a decalogue to improve environmental factors, including the establishment of a territorial health network, implementation of risk control protocols, use of visual signs and other forms of orientation to improve safety, adequate ventilation, adaptability of technological systems to needs, use of high-performance, easy-to-clean materials that reduce bacterial and viral load, and use of digital technologies to support patient treatment and care, including telemedicine and remote monitoring.

Research by Gao et al. [12] also demonstrates that a proactive approach focusing on intrinsic health can significantly reduce the risk of adverse health outcomes as early as the building design phase.

In today's rapidly evolving healthcare landscape, the design of healthcare facilities is becoming increasingly crucial for ensuring high-quality and efficient healthcare delivery. Beyond functionality and aesthetic appeal, the role of environmental health in designing these spaces is gaining prominence. This aspect impacts not only the well-being of patients and staff but also the sustainability and efficiency of the entire facility. Environmental health aspects related to IEQ are often overlooked in the construction of healthcare buildings, leading to discomfort and other adverse health outcomes. Key findings from research on sick building syndrome (SBS) in hospital environments highlight the significant connection between environmental factors and SBS symptoms among hospital staff. Studies demonstrate an etiological correlation between the prevalence of SBS symptoms and environmental factors such as air quality and ventilation (volatile organic compounds - VOCs, microbes, odors), thermal comfort, and daylight [13-15]. The prevalence of SBS in hospitals varies widely, ranging from 21% to 86%, according to different studies worldwide [13, 16-21].

Key findings from research on sick building syndrome (SBS) in hospital environments highlight the significant connection between environmental factors and SBS symptoms among hospital staff.

The design of healthcare facilities presents a complex challenge that necessitates an interdisciplinary approach and the consideration of numerous factors, including environmental health aspects. Despite the growing recognition of the importance of a high-quality indoor environment for the health and well-being of users, these aspects are frequently overlooked in the construction of healthcare buildings. This study investigates how these aspects are integrated into current practices and regulatory frameworks and evaluates the potential for enhancing these practices. The research question posed is: To what extent are environmental health aspects incorporated into the planning and construction processes of healthcare facilities in Slovenia, and how does this integration impact the well-being of patients and staff? The goal is to contribute to developing more holistic and sustainable approaches to healthcare facility design that will positively influence the health and well-being of users.

MATERIALS AND METHODS

Despite the growing recognition of the importance of a high-quality indoor environment for the health and well-being of users, these aspects are frequently overlooked in the construction of healthcare buildings.

A mixed-methods research approach was employed, comprising three distinct steps. The first step involved a qualitative analysis of the legal requirements and recommendations for constructing healthcare facilities in Slovenia, with a particular focus on environmental health. National legal requirements were sourced from the legislation of the Ministry of Health of the Republic of Slovenia, the Ministry of Natural Resources and Spatial Planning of the Republic of Slovenia, the Official Gazette of the Republic of Slovenia, and the Register of Regulations. International legal requirements and recommendations were examined through resources such as the Official Journal of the EU, EUR-Lex, the European Commission (EC), and websites of organizations including the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and the Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA).

The second step entailed qualitative research through a case study to gain preliminary insights.

Short interviews were conducted with selected stakeholders involved in the construction process to understand their perspectives and needs better (professional planners, internal hygienists specialized in healthcare facilities, and experts). The interviews aimed to gather information on the application of recommendations in the construction sector that also consider environmental health criteria. The following questions were posed to the selected stakeholders: i. To what extent have you considered the requirements and recommendations for environmental health in the construction projects for healthcare facilities in which you have been involved? Was the technical guideline for constructing healthcare buildings [22] requested or recommended by the project client? If you did not use the TSG-12640-002:2021 [22], what relevant guidelines did you use besides existing legislation? ii. Were the current requirements and recommendations for constructing healthcare facilities sufficient, or did you need to use other sources of information and additional expertise? iii. To what extent was environmental health considered in this project? Which areas were well-considered, less considered, or not considered? iv. Who was involved in the expert team for the project, and who do you think would still be needed if the project were undertaken again?

In the third step, we developed guidelines for constructing healthcare facilities, emphasizing the importance of considering environmental health criteria. This step synthesizes the findings from the previous two steps, resulting in concrete guidelines formulated based on the analysis and interviews.

RESULTS AND DISCUSSION

The design of healthcare buildings is particularly complex, requiring stakeholders to be well-versed in the functioning of individual hospital services, medical technologies, hygiene requirements, and materials suitable for hospital environments.

Asimow [23], in his work "Introduction to Design," emphasized that the engineering design of a product necessitates a synthesis of human, technical, and economic factors alongside social, political, and other considerations. The process of building design morphology, as outlined by Krainer [24], progresses from abstract concepts to concrete implementations and comprises six steps: 1) defining the purpose; 2) assessing geomorphological, climatic, and site conditions; 3) determining geometry and orientation; 4) defining active areas (spaces with specific purposes) and their required conditions; 5) specifying functional areas (structural assemblies, building envelope), composition, and intersections; and 6) establishing technical systems for building operations (e.g., heating, ventilation, and air conditioning, HVAC). The design of healthcare buildings is particularly complex, requiring stakeholders to be well-versed in the functioning of individual hospital services, medical technologies, hygiene requirements, and materials suitable for hospital environments.

The following outlines the key design recommendations of the Technical construction guideline for healthcare buildings [22] using a step-by-step approach to building design [24]. A hospital with up to 400 beds serves as an example. A similar methodology would be applied when summarizing the recommendations for a health center or emergency center. The quality of implementing these steps significantly impacts all components of environmental health within a healthcare facility, as evidenced by various studies.

1. Defining the Purpose

Healthcare facilities, particularly hospitals, are highly demanding buildings, and their construction process differs significantly from that of buildings with other purposes, as highlighted by numerous studies [25-27].

This complexity is primarily due to strict hygiene requirements, specific usage patterns, and the characteristics of users who spend up to 100% of their time indoors [28].

The classification of buildings according to their purpose [29, 30] includes healthcare buildings (1264) and (12640). Classifying a building based on its surface area is demanding (surface area over 2,000 m², height over 10 m). According to the Healthcare Activities Act [31], hospitals can be general or specialized. Specialized hospital activities encompass in-depth diagnostics, treatment, medical rehabilitation, health care, and nursing (accommodation, nutrition) in general or specialized hospitals. The definition of a building's purpose and its characteristics dictates general and specific legal requirements and recommendations, which must be meticulously specified during the project documentation preparation phase.

The overarching international legal act is Regulation 305/2022 [32], which mandates that buildings must be designed and constructed to ensure they do not endanger people's or property's safety and not harm the environment. This requirement applies to the entire life cycle of a building, encompassing the successive and interconnected phases of a construction product's life, from raw material procurement and extraction from natural resources to final disposal. According to Regulation 305/2011 [32], a construction product is any product or group of products manufactured and placed on the market for permanent incorporation into construction works or parts thereof, where the characteristics of the construction products influence the characteristics of the construction works concerning the basic requirements.

The essential requirements according to Regulation 305/2011 [32] and the Construction Act [33], which apply to all installed construction products (i.e., building materials, HVAC equipment, etc.), include mechanical strength and stability, fire safety, hygiene and health protection, environmental protection, safety in use, noise protection, energy saving and thermal insulation, universal construction and use of buildings, and sustainable use of natural resources. In addition to the eight basic requirements, specific requirements are also considered, such as special functional, environmental, and other characteristics that individual types of buildings must meet depending on their intended use and building classification [29].

The Technical construction guideline for healthcare buildings, TSG-12640-002:2021 [22], issued by the Ministry of Health in agreement with the Ministry of Environment and Spatial Planning, is a document that provides a more precise definition of the essential requirements, design conditions, selected levels or classes of construction products and materials that may be incorporated, and the construction method to ensure the reliability of the building throughout its service life. If necessary, it also outlines the procedures to determine whether these requirements are met.

2. Assessing geomorphological, climatic, and site conditions

The primary factors in the design of buildings, including healthcare facilities, are the site conditions and associated challenges or burdens. These include insolation, which we aim to leverage by incorporating elements of passive solar architecture, essential for both the energy efficiency of the building and the provision of natural daylight.

During the non-heating season, it is crucial to ensure optimal building shading to prevent overheating. An example of a geomorphological challenge is constructing a building in a radon-risk area. In such cases, the parts of the building envelope in contact with the soil must be meticulously designed, and additional radon mitigation measures [34, 35] must be implemented to prevent radon ingress into the building. Another important site-related factor is air quality, which is the basis for designing effective ventilation systems with air purification capabilities. Noise maps are also vital for planning the building's acoustic protection elements.

Another important site-related factor is air quality, which is the basis for designing effective ventilation systems with air purification capabilities.

In addition to the aforementioned factors, TSG-12640-002:2021 [22] outlines additional locational and urban planning requirements that must be considered at the outset of the planning process. These include compliance with municipal spatial plans, building typology and dimensions, transport strategy with parking arrangements for employees, patients, and visitors, connection to public transport infrastructure, integration of the building with accessibility to central activities, adaptation of the design to local bioclimatic conditions—such as solar exposure, orientation, and ventilation—adaptation of the design to fire safety requirements, energy and utility provisions, proximity to and integration of green areas with trees, and allocation of space for the long-term development of the public health institution's activities.

When dimensioning a hospital [22], it is essential to consider the gravity area and its population size, the characteristics of the population served by the hospital (health status, age, and social structure), the annual number of hospital admissions, accounting for the average length of stay, the annual number of examinations, procedures, or treatments, the content of the programs and the corresponding structure and number of staff required for their implementation. This includes the structure and number of medical, paramedical, service, administrative, and technical staff, as well as the operational schedule of the individual services. Incorrect baselines or inadequate information will impact all subsequent construction and use phases.

3. Determining geometry and orientation

In hospitals, daylighting notably affects healthcare outcomes by reducing depression among patients, shortening hospital stays, and improving sleep and circadian rhythms.

The geometric design of a hospital, including its floor layout and room size, significantly impacts the control and prevention of hospital-acquired infections (HAIs) [36] and airborne transmission, which has become a particularly relevant area of research in the COVID-19 era [37]. Optimal orientation of the facility and rooms is crucial to ensure both qualitative and quantitative aspects of daylighting [38] while also considering other indoor environmental quality (IEQ) factors such as air quality and soundproofing. Research indicates that optimal daylighting in a room is associated with improved performance of complex visual tasks and regulation of the body's circadian system. In hospitals, daylighting notably affects healthcare outcomes by reducing depression among patients, shortening hospital stays, and improving sleep and circadian rhythms [39]. A study by Ulrich [40] compared the recovery times of surgical patients who viewed a brick wall through a window with those who viewed green surfaces. Patients who viewed green surfaces experienced fewer post-operative complications, required less pain medication, and had hospital stays that were nearly 9% shorter than those who viewed a brick wall.

TSG-12640-002:2021 [22] emphasizes that the functional design of a general hospital, including the floor plans of individual service areas and common and communication areas, must account for technological requirements and the needs of users (patients, visitors, and staff). The characteristics of individual services (clean, unclean, sterile) must be consistently considered, with routes separated according to priority to avoid crossing paths. Access, parking, entrances, doors, and communication areas must comply fully with the Rules on the universal construction and use of buildings [41] and universal construction standards. To prevent hospital-acquired infections and ensure the smooth operation of various services, special attention must be given to limiting encounters between hospitalized and outside patients, controlling visitor movement within the hospital, transporting materials that pose a potential risk of hospital-acquired infections in a controlled manner, and implementing all necessary protective measures.

4. Defining active areas and their required conditions

Research consistently demonstrates a significant association between overcrowding in hospital wards and rooms and an increased risk of infections, particularly hospital-acquired infections (HAIs) or nosocomial infections. Overcrowded wards have been linked to a higher prevalence of nosocomial infections than non-crowded wards [42]. Kaier [43] reports that most studies (75%) indicate hospital bed occupancy rates and staff shortages directly impact nosocomial infections. Studies investigating infrastructure factors, such as the use of hospital beds and staff shortages, have shown that the prevalence of nosocomial infections is higher in these contexts. Research on infrastructure (e.g., the age of the unit) and organizational risk factors (e.g., corridor bed utilization) for Clostridioides difficile infection (CDI) and methicillin-resistant Staphylococcus aureus (MRSA) in hospitals found that older units were associated with higher rates of infection risk factors [44, 45]. Sartini et al. [45] also highlight that overcrowding in emergency centers contributes to numerous negative consequences affecting the quality of care. Among these consequences is an increased risk of nosocomial infections, as overcrowding can lead to reduced staff attention to infection prevention protocols, longer waiting times for patients in crowded areas—thereby increasing potential exposure to pathogens—and difficulties adequately isolating patients with infectious diseases. Borg [46] also found a significant positive correlation between new cases of MRSA infections and overall bed occupancy rates, suggesting that overcrowding may be an essential factor in the spread of MRSA within hospitals, even in non-ICU settings. Lowe et al. [47] state that inadequate hospital infrastructure, lack of resources and staff, insufficient in-service training and supervision on infection prevention and control, and high visitor numbers are barriers to effective infection prevention programs in hospitals.

Borg [46] also found a significant positive correlation between new cases of MRSA infections and overall bed occupancy rates, suggesting that overcrowding may be an essential factor in the spread of MRSA within hospitals, even in non-ICU settings.

TSG-12640-002:2021 [22] highlights that inpatient wards are typically situated in a separate building within a general hospital. The number of inpatient wards should reflect annual patient admission rates, the duration of inpatient stays, local needs, and future developments, particularly as the number of day patients (post-intervention day patients) increases. The functional design of the inpatient building should accommodate one or more inpatient wards per floor, designated as active zones. Connections between the inpatient ward and other wards should be facilitated through internal, heated corridors directly linked to services for the supply of medicines, sterile and medical supplies, food, linen, clean beds, and other necessities, as well as services for cleanliness, hygiene, and maintenance.

The functional design of the inpatient building should accommodate one or more inpatient wards per floor, designated as active zones.

A sick ward's most commonly used organizational unit comprises 24-30 beds. Inpatient wards can be designed as single, double, or multi-corridor units.

Patient rooms are classified as active spaces. The ratio of patients to rooms has shifted significantly in recent years within the EU, favoring single rooms due to their superior effectiveness in infection control, reduction of infection transmission, alleviation of patient stress, enhancement of patient-staff communication, and assurance of patient privacy [48]. The TSG-12640-002:2021 [22] recommends a ratio of 70% single rooms and 30% double rooms. Multi-bedded rooms are designated for day hospitals, short-term observation up to 24 hours, and intensive care units. Each ward should include at least one room for isolation (ventilation regime). The number of isolation rooms should be determined according to professional requirements. For calculating the size of patient rooms, 19 m² per bed in single rooms, 17.5 m² per bed in double rooms, and 16 m² per bed in multi-bed rooms should be considered. Patient rooms should be designed to allow a supine patient to be wheeled in without moving or obstructing other patients. For access, hygiene, infection prevention, and patient privacy, the distance between beds should be at least 150 cm.

The ratio of patients to rooms has shifted significantly in recent years within the EU, favoring single rooms due to their superior effectiveness in infection control, reduction of infection transmission, alleviation of patient stress, enhancement of patient-staff communication, and assurance of patient privacy.

The indoor room conditions are defined according to the specifics of the user (health condition, activities) and support the treatment. For instance, the recommended air temperature for a burn patient with extensive burns is 32 °C (optimally also a sensible temperature of 32 °C) with a relative humidity of 80% [1, 49, 50]. A room for newborns also requires a different temperature. Certain specific medical procedures necessitate their air temperature settings. Scientific knowledge is employed through the evidence-based design (EBD) approach to determine the optimal requirements. In addition to legislative requirements, the designer must also consider the client's needs. It is emphasized that conditions should be defined to meet the highest indoor environmental quality category [2].

5. Specifying functional areas, composition, and intersections

In the European Union and the European Economic Area (EU/EEA), more than 3.5 million cases of HAIs occur each year, resulting in over 90,000 deaths and approximately 2.5 million disability-adjusted life years (DALYs).

Designing buildings, spaces, and materials is crucial for preventing infections in healthcare settings. These infections include catheter-associated urinary tract infections, central venous catheter-associated bloodstream infections, surgical wound infections, ventilator-associated pneumonia, hospital-acquired pneumonia, and Clostridium difficile infections [51]. In the European Union and the European Economic Area (EU/EEA), more than 3.5 million cases of HAIs occur each year, resulting in over 90,000 deaths and approximately 2.5 million disability-adjusted life years (DALYs). Additionally, HAIs account for 71% of cases of antibiotic-resistant bacterial infections [52]. Raoofi et al. [53] state in a systematic review and meta-analysis that the rate of universal HAIs was 0.14 percent, with the rate of HAIs increasing by 0.06 percent annually. The rate of HAIs and the most common microorganisms vary across different settings. A multifaceted approach addressing various modes of pathogen spread is essential, as airborne transmission can be mitigated through appropriately designed strategies.

Based on a systematic literature review, Chair et al. [53] determined that most studies advocate for controlled airflow without recirculation, 12 air changes per hour, and high-efficiency particulate air (HEPA) filters to remove contaminated air from isolation rooms. Additionally, maintaining humidity levels at or below 60% and temperatures between 18-30 °C is recommended.

The paper concludes that further interdisciplinary research is essential to quantify the optimal range of HVAC system parameters, considering door types, vestibules, and bed management, to mitigate infection transmission in isolation rooms effectively. Ashe [54] emphasizes that properly designing materials, buildings, and rooms, particularly concerning HVAC systems, is crucial for controlling the spread of infections in healthcare settings. A thorough understanding of these design principles enables clinical staff to optimize the use of spaces and systems, thereby reducing the risk of infection transmission to patients and healthcare workers.

TSG-12640-002:2021 [22] stipulates that the design must adhere to the treatment criteria of the room based on the following requirements: cleanliness classification concerning the process (rooms with no special requirements, clean, unclean, sterile), air cleanliness classification, level of risk of nosocomial infections (no/low/medium/high risk), and user requirements (patients, employees, visitors, service workers, etc.). The selection of materials and the construction of structural units, including their composition and design, must be tailored to the specific requirements of the space, such as indoor conditions, sound insulation between rooms, fire separation between rooms or fire sectors, water resistance in wet rooms, protection against ionizing radiation, and resistance to mechanical influences. The procedure for determining the final treatment concerning hygiene requirements is summarized in Table 1.

Ashe emphasizes that properly designing materials, buildings, and rooms, particularly concerning HVAC systems, is crucial for controlling the spread of infections in healthcare settings.

Table 1: Finishing of walls, floors, and ceilings based on the function of the rooms, categorized according to hygiene requirements (adapted from TSG-12640-002:2021 [22])

Type of Active Space	Level of Infection Risk	Example	Materials	Cleaning
Spaces with special hygiene requirements	Very high	Operating rooms, transplantation rooms, burn units, neonatology units, isolation rooms, cytostatic preparation areas, and similar spaces.	The materials used for final finishes in these spaces must ensure bacteriostasis. Surfaces must be smooth and resistant to the required type and frequency of cleaning and disinfection. Wall and floor ceramics are not permissible in these areas. The quality of materials must allow cleaning and disinfection procedures to be carried out for a minimum of 5 years.	Ability to prevent bacterial growth, thorough cleaning and disinfection, and high-pressure cleaning.
	High	Intensive care units, recovery rooms, delivery rooms, neonatal units, hemodialysis units, endoscopy rooms, sterile areas of sterilization, autopsy rooms, and similar spaces, as well as spaces where procedures producing harmful substances are conducted (such as laboratories).	The final surfaces of the spaces must be completely smooth, resistant to mechanical damage, and capable of withstanding the demanding type and frequency of cleaning.	Regular, thorough cleaning with detergents and disinfectants.

Spaces with general hygiene requirements	Average	Waiting rooms, examination rooms, non-sterile areas of central sterilization, pharmacies without medication preparation, laundries, restrooms, corridors, elevators, staircases, and similar spaces.	The final surfaces of the spaces must facilitate the required cleaning and disinfection.	Occasional wet cleaning and disinfection.
Spaces without special hygiene requirements	Low	Lobbies, administrative offices and services, technical rooms, and similar spaces.	The final surfaces of the spaces must facilitate the required type and frequency of cleaning.	Basic hygiene maintenance and easy cleaning. Cleaning and hygiene maintenance in the spaces must be carried out under the guidance and constant supervision of the hospital infection control service.

In addition to hygiene, the finish and color of walls, floors, and ceilings significantly impact the illuminance of rooms. It is essential to ensure that the recommended values for the reflectance coefficients of surfaces in rooms are met, following SIST EN 12464-1:2015 [55], and to achieve the minimum class of reaction to fire for the cladding. Another critical aspect in the design of structural assemblies is providing acoustic protection for buildings and spaces through room acoustics, as stipulated by the Rules on protection against noise in buildings [56, 57]. This aspect is often overlooked in design practice despite the necessity for full compliance with legislative requirements.

Another critical aspect in the design of structural assemblies is providing acoustic protection for buildings and spaces through room acoustics, as stipulated by the Rules on protection against noise in buildings.

From the perspective of preventing HAIs, advanced materials and technologies are also being developed, which include: a. Antimicrobial coatings, b. "Skin shark" surface structure prevents microbial attachment and allows self-cleaning, and c. Multifunctional coatings, which combine "skin shark" and antimicrobial agents. Antimicrobial agents are characterized by their selectivity [58].

6. Establishing technical systems for building operations

Tecnical systems such as HVAC are paramount in designing healthcare facilities, as they influence environmental health characteristics for several key reasons related to achieving optimal IEQ for all user groups (patients, employees, visitors). The diversity of thermal requirements (parameters: air temperature, relative humidity, operative temperature, mean radiant temperature, air velocity, metabolic rate, clothing insulation level), depending on activity and health status, has been highlighted by numerous studies [1, 2]. Therefore, it is essential to pay special attention to the design, selection, and proper functioning of HVAC systems when planning healthcare facilities, as they have a direct impact on the health, safety, and well-being of all occupants, as well as on the environmental sustainability of the facility itself [59].

As highlighted by interviewees in continuation, innovative cyber-physical systems for heating, cooling, and ventilation simultaneously ensure an optimal thermal environment and efficient energy use. In a study by Dovjak et al. [1, 2], a user-centered integrated cyber-physical system (UCCPS) was developed for a room dedicated to burn patients.

The UCCPS system creates optimal thermal conditions that support treating burn patients while providing thermally comfortable conditions for healthcare workers and visitors. Adequate ventilation in hospitals has become a significant area of research, especially following the COVID-19 pandemic. The primary objective has been to define qualitative and quantitative ventilation criteria to prevent microbiological risks and ensure optimal air quality. Wu et al. [37] modeled the transmission of COVID-19 in an isolation room at the Royal Brompton Hospital in London, UK. They aimed to investigate the optimal room layout to reduce the risk of infection for healthcare staff.

Their findings play a crucial role in determining the location of the air extractor, filtration rates, and the placement of the patient bed while also considering the health and safety of the staff working in the area. Research indicates that an appropriate ventilation system with suitable filters helps remove pathogens such as bacteria and viruses from the air, thereby reducing the risk of infection transmission among patients, visitors, and healthcare personnel. Emphasis is placed on adhering to recommendations defined by ASHRAE, REHVA, and WELL Building Standard [60-62]. Understanding and considering various parameters related to the efficiency of new and existing HVAC systems are essential for ensuring healthy, energy-efficient, and economical options for different types of buildings [63].

Research indicates that an appropriate ventilation system with suitable filters helps remove pathogens such as bacteria and viruses from the air, thereby reducing the risk of infection transmission among patients, visitors, and healthcare personnel.

Opinions

In the interviews, the selected stakeholders indicated that their role in the healthcare facility renovation project was primarily to ensure the hygiene regime, representing a specific but limited aspect of environmental health. Comprehensive adherence to the requirements and recommendations in the field of environmental health, as outlined in current guidelines (e.g., IEQ), was entrusted mainly to the external project office chosen for its expertise in this area. No information is available on whether the investor requested or recommended using TSG-12640-002:2021 [22]. Consequently, it is impossible to determine whether TSG-12640-002:2021 [22] was utilized as a key reference document in the design and implementation of the renovation. The external expert emphasizes that if TSG-12640-002:2021 [22] was not employed, it is essential to identify and analyze alternative sources of information used by the external office to accurately assess the environmental health aspects. These sources could include an analysis of the project's compliance with relevant national and international environmental health regulations, expert guidelines, and standards [e.g., 25, 36, 60-62] in the field of IEQ, an analysis of the application of scientific research and findings in the field of environmental health to the design and implementation of the project, an analysis of project documents, and a detailed analysis of the conceptual design and final project to evaluate the integration of environmental health principles. It was also noted that environmental health is not comprehensively considered in the legislation and implementation of healthcare facility construction. The need to address the working environment following the cyber-physical system (CPS), which includes the external and internal environment, building architecture, HVAC systems, and their management and control, was emphasized. The composition of the expert team should be regulated to ensure adherence to CPS principles.

It was also noted that environmental health is not comprehensively considered in the legislation and implementation of healthcare facility construction.

The most significant changes occurred during the COVID-19 pandemic, primarily concerning stricter conditions in spaces (entry and exit filters, air filtration, air pressure, number of air exchanges per room, monitoring conditions in the room, and remote monitoring of patients with infectious diseases).

The Certified Engineering Technologist involved in healthcare facility projects emphasizes that the introduction of the Technical guidelines for construction (TSG) under section 0.1.2 describes the circumstances in which these guidelines are applied to facilitate the preparation of documentation for the construction of healthcare facilities and the construction process itself. These guidelines have been adhered to in all previous projects. Simultaneously, all changes in European legislation have been taken into account. The most significant changes occurred during the COVID-19 pandemic, primarily concerning stricter conditions in spaces (entry and exit filters, air filtration, air pressure, number of air exchanges per room, monitoring conditions in the room, and remote monitoring of patients with infectious diseases). There have also been some changes regarding the preparation of medications in hospital wards.

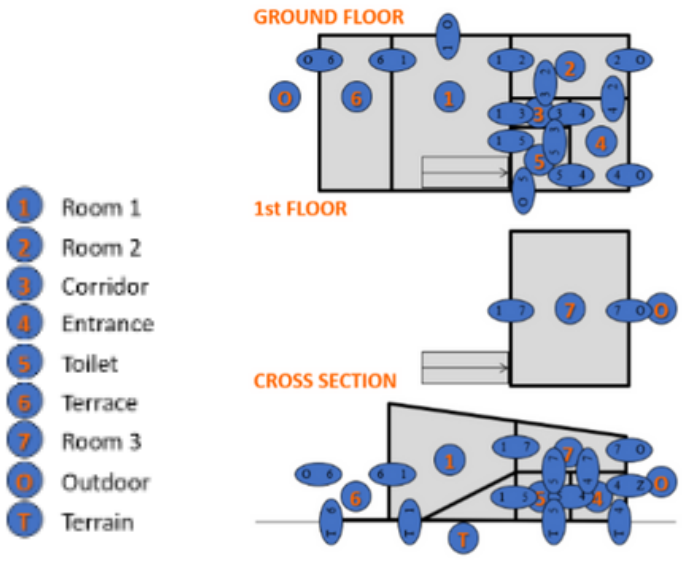
It is crucial to consider the requirements for neutralization and disinfection of sewage from infectious disease wards in all healthcare facilities (which is already mandated by legislation but is not always adhered to in the construction of new facilities).

Recommendations

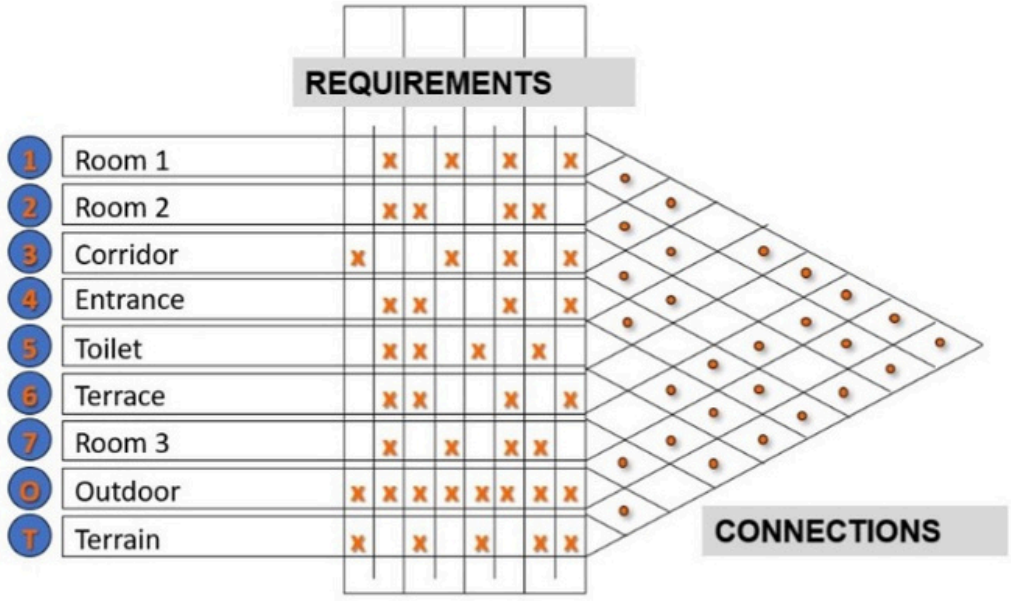
»The engineering design of a hospital building is a purposeful activity directed toward fulfilling human needs, particularly those that can be met by the technological factors of our culture« [23].

In the following, we have outlined recommendations applicable to the design phase of new buildings or renovations. When determining the composition of structural assemblies (Step 5), adhering to the procedure presented in Scheme 1 is crucial. Initially, we define the active spaces and functional zones, representing our concerns. In their horizontal and vertical distribution, we consider zoning criteria following the requirements detailed in planning morphology. We specify the requirements and recommendations for each space for all IEQ parameters. Based on this, we establish a set of desired characteristics for the composition of structural assemblies by function (load-bearing and protective structures). Special attention should be given to the final finishes, joints, and connections.

Determination of active spaces.



Requirements and recommendations by areas of indoor environmental quality.



A set of desired characteristics for the composition of structural assemblies by function (load-bearing and protective structures). Special attention should be given to those vertical and horizontal assemblies that separate spaces with higher levels of risk.

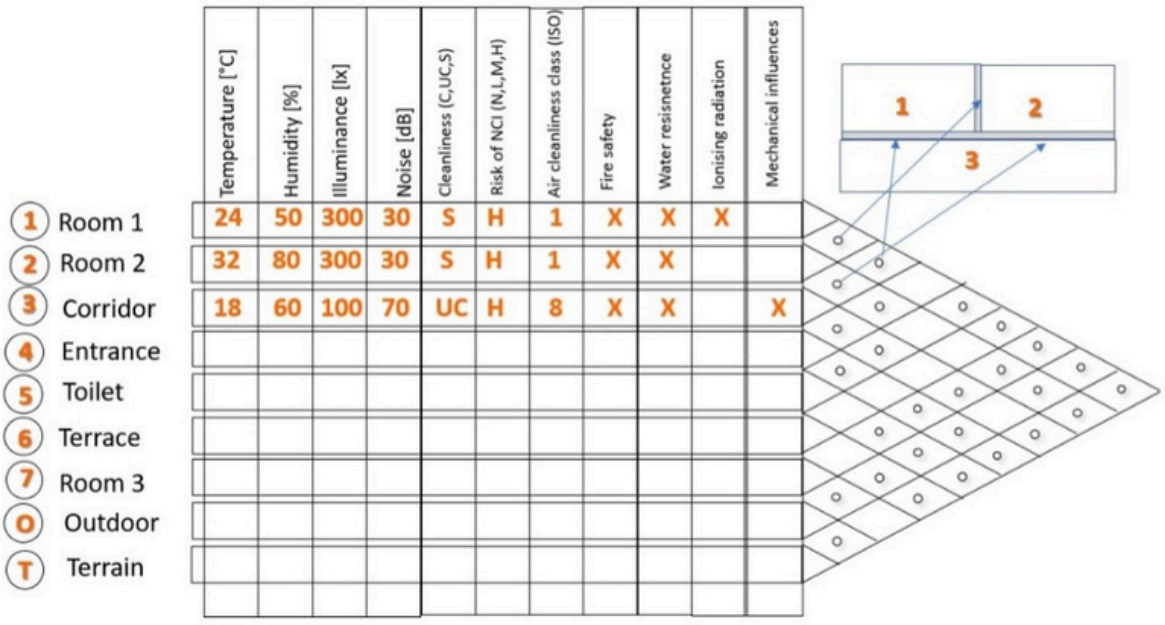


Figure 1: Illustration of the process for determining the characteristics of structural assemblies (adapted from [24, 64])

When determining the desired characteristics for structural assemblies that adhere to the presented scheme, the probability of errors in the final material selection is significantly reduced. This methodology is particularly advantageous in public procurement contexts where specific characteristics are mandated.

To realize the objectives of sustainable and healthy healthcare facilities, further educating the stakeholders involved in their construction is imperative. Enhancing awareness of the importance of environmental health among all stakeholders—architects, civil engineers, sanitary engineers, acousticians, electricians, healthcare professionals, investors, and others—is crucial. Additionally, promoting the adoption of innovative and sustainable solutions that ensure an optimal indoor environment is essential. In this regard, models such as the Integrated Healthcare Architecture Framework (IHAF) by Jaušovec and Garbrovec [65] are of substantial value. This comprehensive model encapsulates the multifaceted aspects of healthcare architecture, including critical categories such as architectural and design guidelines, user experience and satisfaction, and sustainability and environmental impact.

In conclusion, historical evidence supports the validity of the correct planning approach, which is grounded in basic needs [23], locational givens, and burdens. The first health center in Slovenia was established in Lukovica in 1926. This health station was named after Ms. Jelka Reven Komotar, a nurse who worked there. Regrettably, it was the first health facility named after a nurse and remains the only one [66]. The construction of this building adhered to the morphology of the design process, beginning with both the site conditions and the burdens [24].

Enhancing awareness of the importance of environmental health among all stakeholders—architects, civil engineers, sanitary engineers, acousticians, electricians, healthcare professionals, investors, and others—is crucial.

Specifically, the village surroundings had unregulated hygienic conditions, a high incidence of typhoid and other infectious diseases, and a high infant mortality rate. The preventive work of Ms. Jelka Reven Komotar's social-health treatment was reflected in the purpose of the newly constructed health building. The health center offered a wide range of services to improve public health. In addition to general healthcare, the center included maternal and child consultation centers, children's dispensaries, school polyclinics, a dairy kitchen, and public bathing facilities [67]. The institution's entire focus was on prevention, encompassing sanitation measures such as the construction of water and sewage systems, which contributed to eradicating typhoid fever. Statistics indicate that from 1926 to 1935, infant mortality rates were halved [68]. Hygiene courses on infant care and nutrition, along with exhibitions and lectures, significantly elevated the health culture of the population. Ms. Jelka Reven Komotar was an indispensable link between families and the health center [67-70]. Contemporary health facilities must revive the philosophy of prevention and strengthen the bond between patients and the healthcare environment.

Ensuring optimal air quality, thermal environment, natural lighting, and appropriate acoustic conditions improves comfort. These factors also contribute to faster patient recovery and reduce staff stress.

CONCLUSIONS

Designing healthcare facilities focusing on environmental health is crucial to ensuring a safe, healthy, and sustainable environment for patients, staff, and visitors. This article has emphasized the importance of integrating environmental health features into the planning process, focusing on key areas of environmental health that are directly related to the quality of healthcare facility design.

Thoughtful design can significantly impact the well-being and health of healthcare facility users. Ensuring optimal air quality, thermal environment, natural lighting, and appropriate acoustic conditions improves comfort. These factors also contribute to faster patient recovery and reduce staff stress.

Choosing sustainable materials and including natural elements in the design underscore a commitment to environmental protection. These choices also promote biophilic design principles, fostering a sense of connection to nature [62].

Future research and development of innovative solutions in environmentally responsible healthcare facility design will be essential. Raising awareness of the importance of these environmental health features among planners, investors, and users is also necessary. Only through collective efforts can we create healthcare facilities that provide top-quality healthcare and contribute to a better environment and health for all. Integrating environmental health features into the design of healthcare facilities is an ethical and socially responsible practice and a key strategy for improving the quality of healthcare services and promoting sustainable development.

Only through collective efforts can we create healthcare facilities that provide top-quality healthcare and contribute to a better environment and health for all.

ACKNOWLEDGEMENT

The authors acknowledge the financial support from the Slovenian Research Agency (research core funding No. P2-0158, Structural Engineering and Building Physics).

CONFLICT OF INTEREST

The authors report no conflicts of interest. The manuscript has not been published and is not being considered for publication elsewhere.

REFERENCES

[1] Dovjak M. Individualization of personal space in hospital environment. Doktorska disertacija. Nova Gorica: Univerza v Novi Gorici, Slovenija, 2012.

[2] Dovjak M, Shukuya M, Krainer A. User-centred healing-oriented conditions in the design of hospital environments. Int J Environ Res Public Health. 2018; 15: 2140. DOI: https://doi.org/10.3390/ijerph15102140.

[3] Rojas-Rueda D, Morales-Zamora E, Alsufyani WA, et al. Environmental risk factors and health: an umbrella review of meta-analyses. Int J Environ Res Public Health. 2021; 18(2): 704. DOI: https://doi.org/10.3390/ijerph18020704.

[4] Xu H, Jia Y, Sun Z, et al. Environmental pollution, a hidden culprit for health issues. Eco-Environ Health. 2022; 1(1): 31-45.

[5] Ministry of Health of the Republic of Slovenia, 2013. Criteria for determining the acceptability of plans from the perspective of protecting human health from environmental impacts in the procedures of comprehensive environmental impact assessment (Version 2): https://www.gov.si/assets/ministrstva/MZ/DOKUMENTI/Preventiva-in-skrb-za-zdravje/okolje-in-zdravje/Kriteriji_MZ_CPVO-2013.pdf (21. 04. 2025).

[6] WHO, World Health Organization, 2025. Environmntal helath impacts: https://www.who.int/activities/environmental-health-impacts (21. 04. 2025).

[7] Nightingale F. Notes on Nursing: what it is and what is not. Philadelphia: J.B. Lippincott Company, 1992.

[8] Shajahan A, Culp CH, Williamson B. Effects of indoor environmental parameters related to building heating, ventilation, and air conditioning systems on patients' medical outcomes: a review of scientific research on hospital buildings. Indoor Air. 2018; 29: 161–176. DOI: https://doi.org/10.1111/ina.12531.

[9] Anåker A, Heylighen A, Nordin S, et al. Design quality in the context of healthcare environments: a scoping review. HERD. 2017; 10(4): 136-150. DOI: https://doi.org/10.1177/1937586716679404.

[10] Fadda J. Quality of healthcare: a review of the impact of the hospital physical environment on improving quality of care. In: Sayigh A, eds. Sustainable building for a cleaner environment. Innovative renewable energy. S. l.: Springer, 2019.

[11] Capolongo S, Gola M, Brambilla A, et al. COVID-19 and healthcare facilities: a decalogue of design strategies for resilient hospitals. Acta Biomed. 2020; 91(9-S): 50-60. DOI: https://doi.org/10.23750/abm.v91i9-S.10117.

[12] Gao X, Mat Jali Z, Abdul Aziz AR, et al. Inherent health oriented design for preventing sick building syndrome during planning stage. J Build Eng. 2021; 44: 103285.

[13] Kalender-Smajlović S, Dovjak M, Kukec A. Sick building syndrome among healthcare workers and healthcare associates at observed general hospital in Slovenia. Cent Eur J Public Health. 2021; 29(1): 28-37. DOI: https://doi.org/10.21101/cejph.a6108.

[14] Sayan HE, Dülger S. Evaluation of the relationship between sick building syndrome complaints among hospital employees and indoor environmental quality. Med Lav. 2021; 112(2): 153-161. DOI: https://doi.org/10.23749/mdl.v112i2.11012.

[15] Salvaraji L, Shamsudin SB, Avoi R, et al. Ecological study of sick building syndrome among healthcare workers at Johor primary care facilities. Int J Environ Res Public Health. 2022; 19(24): 17099. DOI: https://doi.org/10.3390/ijerph192417099.

[16] Nordström K, Norbäck D, Akselsson R. Effect of air humidification on the sick building syndrome and perceived indoor air quality in hospitals: a four month longitudinal study. Occup Environ Med. 1994; 51: 683–688. DOI: https://doi.org/10.1136/oem.51.10.683.

[17] Chang CJ, Yang HH, Wang YF, et al. Prevalence of sick building syndrome related symptoms among hospital workers in confined and open working spaces. Aerosol Air Qual Res. 2015; 15: 2378–2384. DOI: https://doi.org/10.4209/aaqr.2015.01.0040.

[18] Vafaeenasab MR, Morowatisharifabad MA, Taghi Ghaneian M, et al. Assessment of sick building syndrome and its associating factors among nurses in the educational hospitals of Shahid Sadoughi University of Medical Sciences, Yazd, Iran. Glob J Health Sci. 2015; 7: 247–253.

[19] Aljeesh Y, Al Madhoun W, Abu Shamh I, et al. Assessment of indoor air quality in neonatal intensive care units in government hospitals in Gaza Strip, Palestine. Public Health Res. 2016; 6: 24–30.

[20] Arikan I, Tekin ÖF, Erbas O. Relationship between sick building syndrome and indoor air quality among hospital staff. Med Lav. 2018; 109: 435–443. DOI: https://doi.org/10.23749/mdl.v110i6.7628.

[21] Akova İ, Kiliç E, Sümer H, et al. Prevalence of sick building syndrome in hospital staff and its relationship with indoor environmental quality. Int J Environ Health Res. 2022; 32(6): 1204-1219. DOI: https://doi.org/10.1080/09603123.2020.1862067.

[22] TSG-12640-002:2021. Ministry of Health, Republic of Slovenia. Technical guideline for construction of healthcare buildings: https://www.gov.si/assets/ministrstva/MZ/DOKUMENTI/Novice/TSG_12640_002_2021_ZDRAVSTVENE-STAVBE.pdf (21. 04. 2025)

[23] Asimow M. Introduction to Design. Englewood Cliffs: Prentice-Hall, 1962.

[24] Krainer A. Toward smart buildings. Building science and environment-conscious design, Module 1: Design principles. London: European Commission, 1993.

[25] CDC, Centers for Disease Control and Prevention, 2023. Healthcare assiciated infections: https://www.cdc.gov/healthcare-associated-infections/php/data/progress-report.html (21. 04. 2025).

[26] Fronczek-Munter A. Usability briefing for hospital architecture – exploring user needs and experiences to improve complex buildings. European healthcare design conference – London, 11-14 June 2017. https://www.ntnu.edu/documents/20960912/21573761/EHD%202017%20Fronczek-Munter_Usability%20briefing%20for%20hospital%20architecture.pdf/d807f290-d15e-4beb-967f-e68b86d16d77 (21. 04. 2025).

[27] Saeidi M, Siyahkali MD, Moradinasab H, et al. Investigating the role of path architecture complexity in users' movement patterns in hospital circulation systems: case studies in Golestan, Iran. Facilities. 2024; 42(13/14): 949-968. DOI: https://doi.org/10.1108/F-01-2024-0004.

[28] Dovjak M, Kukec A. Creating healthy and sustainable buildings: an assessment of health risk factors. Cham: Springer Open, 2019.

[29] Rules on the classification of buildings, O.J. RS, No. 96/22: https://pisrs.si/pregledPredpisa?id=URED8497 (21. 04. 2025).

[30] TSG-V-006:2022. Technical guideline for the classification of buildings. Ministry of Environment and Spatial Planning, Republic of Slovenia: https://www.gov.si/assets/ministrstva/MNVP/Dokumenti/Graditev/TSG-V-006_2022_razvrscanje_objektov.pdf (21. 04. 2025).

[31] Healthcare Activities Act, O.J. RS, No. 23/05 with amendments: https://pisrs.si/pregledPredpisa?id=ZAKO214 (21. 04. 2025).

[32] Regulation (EU) 2024/3110 of the European Parliament and of the Council of 27 November 2024 laying down harmonised rules for the marketing of construction products and repealing Regulation (EU) No 305/2011: https://eur-lex.europa.eu/eli/reg/2024/3110/oj/eng (21. 04. 2025).

[33] Construction Act, O.J. RS, No. 199/21 with amendments: https://pisrs.si/pregledPredpisa?id=ZAKO8244 (21. 04. 2025).

[34] Rules on requirements for new buildings, interventions in existing buildings, and renovation of existing buildings to protect human health from the harmful effects of radon, O.J. RS, No. 14/22 with amendments: https://pisrs.si/pregledPredpisa?id=PRAV14259 (21. 04. 2025).

[35] TSG-1-007:2023. Technical guideline for construction - protection against radon in buildings, designated. Ministry of Natural Resources and Spatial Planning, Republic of Slovenia: https://www.gov.si/assets/organi-v-sestavi/URSVS/Smernice-Radon/Tehnicna-smernica-za-graditev-Zascita-pred-radonom-v-stavbah-TSG-1-0072023.pdf.

[36] CDC, Centers for Disease Control and Prevention, 2023. Recommendations for environmental infection control in healthcare facilities: https://www.cdc.gov/infection-control/hcp/environmental-control/recommendations.html (21. 04. 2025).

[37] Wu X, Abubakar-Waziri H, Fang F, et al. Modeling for understanding of coronavirus disease-2019 (COVID-19) spread and design of an isolation room in a hospital. Phys Fluids. 2023; 35: 025111. DOI: https://doi.org/10.1063/5.0135247.

[38] Aydin D, Sungur M. Accessibility, orientation and scenery as natural and physical environmental factors in hospital design case of Konya hospitals. Journal of Fine Arts. 2018; 1(2): 24-37.

[39] Joseph A. Impact of light on outcomes in healthcare settings. The Center for Health Design, 2006: https://www.healthdesign.org/chd/research/impact-light-outcomes-healthcare-settings (21. 04. 2025).

[40] Ulrich RS. View through a window may influence recovery from surgery. Science. 1984; 224(4647): 420-1.

[41] Rules on universal construction and use of buildings, O.J. RS, No. 41/18: https://pisrs.si/pregledPredpisa?id=PRAV12693 (21. 04. 2025).

[42] Humphreys H. Overcrowding, understaffing and infection in hospitals. Ir Med J. 2006; 99(4): 102.

[43] Kaier K, Mutters NT, Frank U, et al. Bed occupancy rates and hospital-acquired infections—should beds be kept empty? Clin Microbiol Infect. 2012; 18(10): 941-945. DOI: https://doi.org/10.1016/j.ajic.2024.08.013.

[44] Wang X, Garrod M, Duncombe T, et al. Organizational and infrastructural risk factors for health care-associated Clostridioides difficile infections or methicillin-resistant Staphylococcus aureus in hospitals. Am J Infect Control. 2025; 53(1): 93-97. DOI: https://doi.org/10.1016/j.ajic.2024.08.013.

[45] Sartini M, Carbone A, Demartini A, et al. Overcrowding in emergency department: causes, consequences, and solutions-a narrative review. Healthcare (Basel). 2022; 10(9): 1625. DOI: https://doi.org/10.3390/healthcare10091625.

[46] Borg MA. Bed occupancy and overcrowding as determinant factors in the incidence of MRSA infections within general ward settings. J Hosp Infect. 2003; 54(4): 316-318.

[47] Lowe H, Woodd S, Lange IL, et al. Challenges and opportunities for infection prevention and control in hospitals in conflict-affected settings: a qualitative study. Confl Health. 2021; 15: 94. DOI: https://doi.org/10.1186/s13031-021-00428-8.

[48] Maben J, Griffiths P, Penfold C, et al. Evaluating a major innovation in hospital design: workforce implications and impact on patient and staff experiences of all single room hospital accommodation. Southampton: NIHR Journals Library, 2015.

[49] Herndon DN. Total Burn Care, 1st ed. London: Sunders, 1996.

[50] Wilmore DW, Mason AD, Johnson DW, et al. Effect of ambient temperature on heat production and heat loss in burn patients. J Appl Physiol. 1975; 38: 593-597.

[51] Monegro AF, Muppidi V, Regunath H, et al. Hospital-acquired infections. StatPearls, 2023: https://www.ncbi.nlm.nih.gov/books/NBK441857/ (21. 04. 2025).

[52] ECDC, European Centre for Disease Prevention and Control, 2024. Each year, 4.3 million patients in hospitals in the EU/EEA are affected by healthcare-associated infections: https://www.ecdc.europa.eu/en/news-events/each-year-43-million-patients-hospitals-eueea-are-affected-healthcare-associated (21. 04. 2025).

[53] Raoofi S, Pashazadeh Kan F, Rafiei S, et al. Global prevalence of nosocomial infection: A systematic review and meta-analysis. PLoS One. 2023; 18(1): e0274248. DOI: https://doi.org/10.1371/journal.pone.0274248.

[54] Chair SY, Ng ST, Chao CYH, et al. Heating, ventilation, and air-conditioning systems in healthcare: a scoping review. J Hosp Infect. 2023; 141:33-40.

[55] Ashe, 2022. Infection Control Guide on HVAC for Nurse Managers and Clinicians: https://www.ashe.org/system/files/media/file/2022/04/02-Nurse-Manager-Clinicians-Guide_FINAL.pdf (21. 04. 2025).

[56] SIST EN 12464-1:2015. Light and lighting – Lighting of work places – Part 1: Indoor work places.

[57] Rules on protection against noise in buildings, O.J. RS, No. 10/12 with amendments. https://pisrs.si/pregledPredpisa?id=PRAV10622 (21. 04. 2025).

[58] TSG-1-005:2012. Technical guideline for protection against noise in buildings, Ministry of Environment and Spatial Planning, Republic of Slovenia: https://www.gov.si/assets/ministrstva/MNVP/Dokumenti/Graditev/tsg_005_zascita_pred_hrupom.pdf.

[59] Rosenberg M, Ilic K, Juganson K, et al. Potential ecotoxicological effects of antimicrobial surface coatings: a literature survey backed up by analysis of market reports. PeerJ. 2019; 34: 6315. DOI: https://doi.org/10.7717/peerj.6315.

[60] Lenzer B, Rupprecht M, Hoffmann C, et al. Health effects of heating, ventilation and air conditioning on hospital patients: a scoping review. BMC Public Health. 2020; 20(1): 1287. DOI: https://doi.org/10.1186/s12889-020-09358-1.

[61] ASHRAE, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. ASHRAE Handbook HVAC Applications: Health Care Facilities. ASHRAE: Atlanta, GA, 2007.

[62] REHVA, Federation of European Heating, Ventilation and Air Conditioning Associations, 2025. For better health, indoor climate quality and energy performance in all buildings and communities: https://www.rehva.eu/ (21. 04. 2025).

[63] IWBI, International WELL Building Institute, 2024. WELL Building Standard, WELL v2. New York: International WELL Building Institute: https://www.wellcertified.com/ (21. 04. 2025).

[64] Asim N, Badiei M, Mohammad M, et al. Sustainability of Heating, Ventilation and Air-Conditioning (HVAC) Systems in Buildings-An Overview. Int J Environ Res Public Health. 2022; 19(2): 1016. DOI: https://doi.org/10.3390/ijerph19021016.

[65] KSKE, 2025. Constructional Complexes. Lectures for Sanitary Engineers, Faculty of Health Sciences, University of Ljubljana. Faculty of Civil and Geodetic Engineering, University of Ljubljana: Ljubljana.

[66] Jaušovec M, Gabrovec B. Architectural evaluation of healthcare facilities: a comprehensive review and implications for building design. Buildings. 2023; 13: 2926. DOI: https://doi.org/10.3390/buildings13122926.

[67] Keršič I, Marovšek I. Health Center Lukovica named after a nurse. UTRIP. 2017; 19-20.

[68] Dovjak S (Family name Komotar). 2025. Unpublished source.

[69] Zupanič Slavec Z. Zgodovina zdravstva in medicine na Slovenskem. Slovenska matica: Ljubljana, 2017.

[70] Dragaš B. Zgodovina in delo sestrstva v Sloveniji od prevrata do leta 1934. Ljubljana: Balsnik.

[71] Jarnovič N. Ob 50-tletnici je zdravstvena postaja v Lukovici dobila ime med. sestre Jelke Komotar. Zdravstveni obz. 1977; 11(1): 68-70.

SANITARNO INŽENIRSTVO / International Journal of Sanitary Engineering Research 2024;17(1): 63-78. DOI: 10.2478/ijser-2024-0004

Food safety perceptions, knowledge, and behavior of hospitality workers on food safety: A small case study from Ljubljana, Slovenia

Mojca Šetina and Mojca Jevšnik Podlesnik

ABSTRACT

Foodborne diseases are prevalent in the hospitality industry, highlighting the need for food handlers to be well-trained in food safety, with adequate knowledge, attitudes, and practices. This study aims to assess these factors among hospitality employees globally, with a specific focus on restaurant food handlers in Ljubljana. A systematic literature review was conducted, along with semi-structured interviews with eight food handlers in restaurants, to explore their knowledge, attitudes and practices regarding food safety. The results reveal that interpersonal relationships, communication, working conditions, and salary are key motivators. However, food safety knowledge gaps persist, particularly concerning microbiological risks and temperature control in food handling. Despite existing training, the transfer of knowledge to practice remains limited, primarily due to motivational and organizational barriers. Improved food safety training, enhanced communication, and a stronger commitment from management are needed to address these challenges and support good practices.

Keywords: food safety, catering, behavior, attitude, food handlers

sciendo

Case Study / Original Research Article

Received: 19. 11. 2024
Accepted: 2. 12. 2024
Published: 16. 12. 2024

University of Ljubljana
Faculty of Health Sciences
Zdravstvena pot 5
1000 Ljubljana, Slovenia

**Corresponding author*:
Assoc. Prof. Mojca Jevšnik Podlesnik, PhD
University of Ljubljana
Faculty of Health Sciences
Zdravstvena pot 5
1000 Ljubljana, Slovenia
Email: mojca.jevsnik@zf.uni-lj.si

INTRODUCTION

Factors such as changing food consumption, consumer awareness and preferences, the increase in international travel, climate change, adaptations and changes in microbial behaviour contribute to the spread of foodborne disease outbreaks (FBOs) [1, 2]. Foodborne diseases have a major impact on the economy and public health as they can cause infections and intoxications that can affect thousands to millions of people at the same time. Therefore, billions of people around the world are at risk from potentially unsafe food [3, 4, 5]. Food contamination can occur at all stages of food production, including slaughter, harvesting, processing, transport, preparation, distribution, storage, handling and consumption [6].

Food contamination can occur at all stages of food production, including slaughter, harvesting, processing, transport, preparation, distribution, storage, handling and consumption.

Key elements in ensuring food safety are the development and integration of prevention, safety and quality programmes such as good practices (GP) in food supply chain, the Hazard Analysis and Critical Control Point (HACCP) system, educational and training programmes (for food handlers and food business operators), public and private food standards, with some systems being mandatory by law and others voluntary. All stakeholders in the food supply chain are responsible for food safety: food business operators are obliged to establish and maintain a HACCP system that ensures food safety; the government is obliged to provide food safety laws/regulations and a system of official inspection; and consumers, who are the last link in the food supply chain, must handle food according to the principles of good household practice [4, 7, 8, 9].

Despite a high level of awareness, established prevention programmes and safety systems, FBOs continue to occur. Food safety issues have not decreased. According to the European Food Safety Authority (EFSA) report in 2022, for the first time since the collection of FBO data began, the number of strong-evidence FBOs in restaurants, pubs, street vendors, takeaway etc. exceeded that of FBOs in a domestic setting [10]. The number of strong-evidence FBOs occurring in restaurant or cafe or pub or bar or hotel or catering service was higher than in 2021.

Many studies highlights the most common food handling mistakes among food handlers: insufficient heat treatment, insufficient temperature/time during heat treatment, insufficient storage of food, contaminated equipment/utensils, contaminated food, cross-contamination and insufficient/poor personal hygiene.

Regarding EFSA FBOs report from 2023 significant share of FBOs occur in restaurants due to unprocessed contaminated ingredient, inadequate chilling and inadequate heat treatment, time storage/temperature abuse, cross-contamination, water treatment failure and untreated drinking water [10]. Many studies [11 - 27] highlights the most common food handling mistakes among food handlers: insufficient heat treatment, insufficient temperature/time during heat treatment, insufficient storage of food, contaminated equipment/utensils, contaminated food, cross-contamination and insufficient/poor personal hygiene. Visiting restaurants and eating out has become a new normal for most people living a fast-paced lifestyle as it is a convenient way of eating. Therefore, food handlers must be properly food safety educated and trained. They have to develop a positive attitude and correct behaviour to ensure food safety in order to reduce the possibility of food contamination [20 - 23].

The aim of this study is to analyse the knowledge and attitudes of hospitality workers towards ensuring food safety, both at a global level through a systematic literature review and in practise through a semi-structured interview with a sample of Slovenian hospitality workers.

MATERIALS AND METHODS

Systematic literature search

A literature search was carried out to gain an insight into the topic of previously published research. The literature review was also used to develop and compile the list of interview questions. Scientific literature published in English language between 2008 and 2021 was included in the review. The literature was searched in the following databases: ScienceDirect, Scopus and Web of Science as well as on the relevant websites: EFSA, FDA and WHO. We performed an advanced search for titles, abstracts and keywords to retrieve the results. The following search terms were used: 'food safety', 'catering', 'food handler', 'food worker', 'employee', 'practise', 'behaviour', 'attitude' and 'knowledge'.

The inclusion criteria on the basis of which the relevant studies were included in the analysis were as follows: In all databases, we selected those scientific journals that were thematically relevant, accessible in full text and published in English. We excluded hits that were not thematically relevant and not written in English. The inclusion and exclusion criteria are listed below in Table 1.

Table 1: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Papers published in English Papers published between 2008–2021 Full Text Available Thematic relevance	All papers published before 2008 Papers published in other languages Thematic inadequacy

Semi-structed interviews

On the basis of a systematic review of the literature, we first formulated questions for a semi-structured interview. The questions in this study were taken from previous surveys [12, 14, 15] and were designed to assess employees' attitudes and knowledge about ensuring food safety. Some questions were designed independently and related to topics such as: employee demographics (education level, gender, age, length of employment), food safety training, knowledge of microbiological risks, cross-contamination (e.g. use of colour- coded chopping boards and knives, separation of raw and cooked food, storage of different foods), cold/hot chain, defrosting of food, hand hygiene, and health status during work.

Before the interviews took place, the purpose and objectives of the study were presented to the interviewees. The interviews were conducted in a quiet room (e. g. break rooms). Each interview lasted 15-30 minutes. All respondents were asked the same questions, but we added questions and sub-questions to gain a deeper insight into the respondents ' knowledge and thinking. The order of the questions remained the same, the course of the interview changed depending on the information and knowledge of the respondents. The interviews were recorded using a mobile phone and then transcribed verbatim. Respondents took part in the interview voluntarily, and any information that could reveal the participant identity during the interview was deleted from the interview transcripts or made unrecognizable accordingly.

The questions in this study were taken from previous surveys and were designed to assess employees' attitudes and knowledge about ensuring food safety.

We ensured full data protection for the respondents. In addition, their written consent to participate was obtained in order to record the interviews and present the results in this paper.

Sample

The study was conducted in May and June 2022. As this is a pilot study, we used a purposive sample of participants. Interviewees were sought from a list of restaurants in Ljubljana and on the recommendation of a participant in the study. Respondents were also selected according to age groups (young, middle-aged and older). The data was collected in personal (face-to-face) interviews using a list of questions. A total of 8 employees (seven men and one woman) took part in the semi-structured interviews.

A total of 8 employees (seven men and one woman) took part in the semi-structured interviews.

The willingness of the food workers to participate in the study was satisfactory, but there were also workers who refused to participate. The unwillingness to participate was mainly due to a lack of time.

Data analysis

After we conducted the interviews, transcribed them and checked the transcripts. Following Vogrinec [28], we divided the data analysis into six steps: 1] processing the material, 2] determining the coding units, 3] coding, 4] selecting and defining relevant concepts and forming categories, 5] defining the categories and 6] forming the final theoretical formulation – theme design.

RESULTS

Systematic literature search

A total of 1591 papers were found. By applying time criteria, the number of hits was reduced to 475. After reviewing the titles, abstracts and other information about the literature, we then eliminated a further 220 hits. After a further review of the remaining hits, we excluded another 136 of them due to inadequate content. In the final analysis, we therefore included 20 hits that met the purpose of the study.

In the final analysis, we therefore included 20 hits that met the purpose of the study.

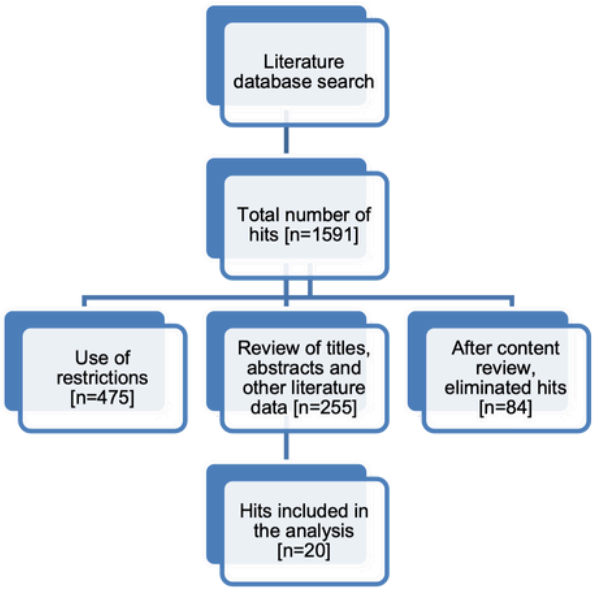


Figure 1: Diagram of the literature search and selection process

After systematically reviewing each transcript, six main themes emerged: personal food safety, employee satisfaction, cross-contamination, food storage, cold and hot chain and knowledge of microbiological hazards.

Demographic data

Table 2 contains a summarised profile of the respondents who took part in the study. All restaurants that participated in the study were privately owned. Eight selected individuals (seven men - M and one woman – F) took part in the interviews. According to their basic education and qualification structure, seven of the respondents came from the hospitality industry and one from the non-restaurant industry. All respondents had a high school education. Their mother tongue was Slovenian. In terms of work experience, three respondents had more than 30 years of work experience and five respondents had between 10 and 20 years. Due to the small size of the sample, the results cannot be generalised to the entire population of main and assistant chefs in Slovenia.

Due to the small size of the sample, the results cannot be generalised to the entire population of main and assistant chefs in Slovenia.

Table 2: Demographic characteristics of the study respondents

Identification	Gender	Mother tongue	Length of employment [years]	The function of employees
I1	M	Slovenian	50	Assistant cook and facility owner
I2	M	Slovenian	20	Kitchen manager
I3	M	Slovenian	3 [as a full-time employee] 8 [as a student]	Assistant cook
I4	M	Slovenian	34	Assistant cook
I5	F	Slovenian	36	Assistant cook
I6	M	Slovenian	14	Head chef
I7	M	Slovenian	6	Head chef and facility owner
I8	M	Slovenian	29	Assistant cook

Qualitative analysis

In this section, the results are presented in more detail according to the most important themes developed.

Table 3: Developed themes

Personal food safety assurance		
Code	**Category**	**Theme 1**
Training frequency	Training	Personal food safety assurance
Training topics		
HACCP system		
Own evaluation of the usefulness of the trainings		
Disposable paper towel	Personal hygiene and hand hygiene	
Hand dryer		
Wiping hands on apron		
Usage of dedicated work clothes		
Presence in or absence from the workplace	Health status of employees	
Checking the expiration date	Food suitability	
Food that is not suitable for consumption; always changes in color, taste and/or smell		

Employee satisfaction		
Code	**Category**	**Theme 2**
Money	Motivation	Employee satisfaction
Working conditions		
Relations with colleagues		
Guest satisfaction		
Employees violate food safety rules	Demotivation	
Workplace tension		
Low salary		

Cross-contamination

Code	Category	Theme 3
Color system	Changing cutting boards	Cross-contamination
Spatial separation		
Color system	Changing knives	
Spatial separation		
Wearing gloves as an alternative to hand washing	Changing disposable gloves	
Changing gloves when switching to another task		

Food storage

Code	Category	Theme 4
Compliance with expiration dates, time and temperature	FIFO principle	Food storage
Time and temperature considerations	Raw foods [meat]	
Separation by food type		
Time and temperature considerations	Heat-treated foods	
Separation by food type		
Time and temperature considerations	Vegetables	
Separation by food type		

Cold and hot chain

Code	Category	Theme 5
Time and temperature considerations	Food defrosting	Cold and hot chain
Special room [e.g. refrigerator], containers, sink		

Time and temperature considerations	Heat treatment	Cold and hot chain
Steam convection oven		
Temperature check [stick thermometer]		
Time and temperature considerations	Cooling	
Rapid cooling		
Time and temperature considerations	Reheating	

Knowledge of microbiological hazards

Code	Category	Theme 6
Covid-19	Viruses	Knowledge of microbiological hazards
Salmonella spp.	Bacteria	
Campylobacter		

Respondents were aware that wiping hands on aprons was not an example of good practise and that bacteria and dirt accumulated on the aprons.

Personal food safety assurance

This topic consists of four categories in which 12 codes were identified. When discussing food safety training, respondents mostly mentioned the HACCP system. They had mixed opinions on whether the training was useful and whether it helped respondents to improve their food safety behaviour. Some of the interviewees felt that participating in training had greatly helped to improve their behaviour and attitude towards food safety and that it was useful to renew and expand their knowledge. However, they were not entirely sure about the frequency of training, as some attended every year, while others attended training every five years. Some did not attend at all as they felt it was no longer mandatory or employers did not provide training. Respondents rated the usefulness of the training as positive, as they felt that their school knowledge was insufficient, so the training was welcome, especially when it came to innovation.

On this topic, respondents also mentioned the importance of personal and hand hygiene, the state of health in the workplace and the suitability or safety of the food itself. All respondents were provided with disposable paper towels at their workplace to wipe their hands. Three respondents stated that they never wiped their hands with an apron, as aprons were only used as an aid when handling hot food and pans. Five respondents very rarely dried their hands with an apron and only did so out of bad habit, due to the increased workload and the fast pace of work. Respondents were aware that wiping hands on aprons was not an example of good practise and that bacteria and dirt accumulated on the aprons.

The respondents were unanimous with regard to personal hygiene [mainly hand washing] in the workplace. All agreed that ensuring and maintaining an appropriate level of personal hygiene is essential to protect food and consumer health. Restaurant owners required and expected their chefs and other food handlers to adhere to the prescribed instructions for personal hygiene in the workplace, including appropriate workwear. Appropriate work clothes were provided by employers, but beyond that it depended on the employer whether he or she was also responsible for washing and cleaning. For some respondents, employers took care of the work clothes, while for others, employers only provided the clothes and employees were responsible for cleaning and care.

The respondents were not unanimous when it came to their state of health at work. Some never came to work sick, others did, mainly to please their superiors, and some still came to work sick because of a lack of staff.

When it came to checking the usability of food, the respondents were unanimous. They regularly checked the expiration dates and paid particular attention to the appearance, smell and colour of the food. They also mentioned bacteria such as Clostridium botulinum and Salmonella. Food that they considered inedible and spoilt was disposed of as waste. Sometimes they did not always check the expiration dates, because it was mostly routine work.

All agreed that ensuring and maintaining an appropriate level of personal hygiene is essential to protect food and consumer health.

Employee satisfaction

This theme consists of two categories in which 7 codes were identified. The respondents were mostly satisfied and enjoyed coming to work. Most of them felt that money, working conditions, relationships with colleagues and guest satisfaction as well as restaurant utilisation were important factors that contributed to their motivation. The superiors also took care of motivation by organising some kind of celebration or gathering several times a year [depending on circumstances and possibilities] [e.g. New Year's party for employees, etc.]. At work, the employees were most demotivated by unruly, demanding customers and colleagues who did not follow the rules to ensure food safety. Such employees were admonished by their colleagues for their behaviour, only rarely were their superiors involved.

Respondents were consistent in their work so that knives and chopping boards for meat and vegetables were not changed as they were aware of the significant risk of cross contamination.

Cross-contamination

This theme consists of three categories in which 6 codes were identified. Respondents were consistent in their work so that knives and chopping boards for meat and vegetables were not changed as they were aware of the significant risk of cross contamination. They were fairly consistent. To avoid cross-contamination, they used a system of spatial separation and a colour system for knives and chopping boards [yellow boards were used for chicken, red for beef and pork, blue boards for the preparation of fish and other aquatic - seafood dishes].

They were also consistent in their use of gloves. They reported to use disposable gloves, which they changed regularly. When moving from one workplace to another, the respondents reported to wash their hands thoroughly with soap and water and then used a fresh pair of gloves. They also felt that replacing them was a cost to the restaurant and a burden on the environment.

When moving from one workplace to another, the respondents reported to wash their hands thoroughly with soap and water and then used a fresh pair of gloves.

All respondents agreed on gloves and believed that the use of gloves was not a sufficient measure to ensure hand hygiene. Gloves are used for intermediate or step cleaning of kitchen surfaces and for dirty work [e.g. cutting onions because of the smell, cutting beetroot because the colour of the beetroot is difficult to wash off hands, and preparing breadcrumbs because they are difficult to remove from hands and nails, etc.].

All respondents agreed on gloves and believed that the use of gloves was not a sufficient measure to ensure hand hygiene.

One of respondents pointed out that he dislikes the use of disinfectants as they have a harmful effect on the skin. The remaining respondents had no concerns about disinfectants and said that they had become accustomed to them during the Covid pandemic.

Food storage

This theme consists of four categories in which 7 codes were identified. The respondents were unanimous on theme 4. They were clear about the importance of separating different types of food. All of them reported to store meat separately from other foods. Vegetables also had their own place where only vegetables were stored. Food was reported to be stored separately in special refrigerators and freezers. They also reported that refrigerators and freezers were equipped with thermometers, which were regularly checked and the temperature monitored. Respondents were not very consistent in their knowledge of the temperatures in the cold rooms, giving values of 0° to 5°C and around -18°C for the freezers. Most of the respondents had never heard of the "First In, First Out" (FIFO) storage method. After the meaning of the abbreviation was explained to them, all respondents stated that they always stored their food in this way. Some (especially the younger population) had heard of FIFO in educational institutions.

Most of the respondents had never heard of the "First In, First Out" (FIFO) storage method.

Cold and hot chain

This theme consists of four categories in which 8 codes were identified. Respondents were largely in agreement about defrosting food. Respondents defrosted meat in portions, meaning that they only defrosted as much meat as they expected to be consumed that day. Most respondents did not freeze meat as they received fresh meat every day. Defrosted food was protected by foil or a cover on work surfaces in containers and in refrigerators or cold rooms. Most thawed the food in hot running water and overnight. They tried to avoid the temperature zone between 5 °C and 60 °C.

They regularly monitored the temperature and tried not to let the temperature fall below 60 °C.

Respondents were also quite unanimous when it came to the heat treatment of food. They regularly monitored the temperature and tried not to let the temperature fall below 60 °C. They checked the temperature with the help of measuring devices and displays (e.g. displays on ovens etc.), but they also relied on their experience (i.e. they knew approximately how long and at what temperature a particular food should be processed to be safe for consumption), and cuts of meat were checked using penetration thermometers.

Respondents approached food cooling in different ways, depending on the available equipment resources. Some heat-treated foods were cooled with water/a water bath or rapid cooling units (so-called cooling shockers) were used. Then the food was stored in refrigerators.

Respondents were unanimous about the time interval for cooling food – this should be as short as possible (e.g. a piece of meat cools down to 5 °C in 120 minutes, etc.).

When reheating food, they emphasised that food (with the exception of soups, which are heated to boiling) is generally not reheated and that they adhered to the portion system. They regularly checked the temperature [which they said should be between 60 °C and 85 °C), just as with the primary heat treatment. They used a probe thermometer, which all respondents reported to correctly insert into the thickest part of the meat or right next to the bone.

When it comes to knowledge of microbiological contaminants, respondents were not consistent and had insufficient knowledge of what they themselves were aware of.

Knowledge of microbiological hazards

This topic consists of two categories in which 3 codes have been identified. When it comes to knowledge of microbiological contaminants, respondents were not consistent and had insufficient knowledge of what they themselves were aware of. Most of the respondents had heard of Salmonella and it was also their first choice when listing bacteria. Fewer respondents also mentioned Staphylococcus aureus, Clostridium botulinum, coronavirus and mould.

DISCUSSION

Food safety continues to be a pressing public health issue, with thousands of people still falling ill from foodborne diseases every year. In the EU, the number of reported foodborne outbreaks and cases, hospitalisations and deaths were higher in 2022 than in 2021. The number of deaths from outbreaks was the highest ever reported in the EU in the last 10 years, mainly caused by L. monocytogenes and to a lesser degree by Salmonella. In 2022, for the first time since the collection of foodborne outbreaks (FBO) data began, the number of strong-evidence FBOs in restaurants, pubs, street vendors, takeaway etc. exceeded that of FBOs in a domestic setting [15]. Although there are many factors that can cause food contamination, improper food handling and inadequate knowledge of food workers are the main source of foodborne illness [22, 23, 29, 30].

The number of deaths from outbreaks was the highest ever reported in the EU in the last 10 years, mainly caused by L. monocytogenes and to a lesser degree by Salmonella.

A systematic literature review shows differences between the USA and the EU, particularly in the area of salary as a motivating factor. While EU countries have guaranteed funding to ensure that employees who are absent from work due to illness are paid for sick leave, the US has no such system. In a system where employees do not have paid sick leave, they will come to work sick for fear of a financial crisis and fear of losing their jobs. However, in both EU and non-EU member states and the US, workers are still pressurised by their managers to come to work without regard for their health and well-being due to staff shortages [19, 17, 20, 21, 22, 25, 16]. We came to similar conclusions in our study. Most of the interviewees stayed home when sick, but some also stated that they went to work out of a sense of responsibility to their superiors and because of the pressure they were under due to staff shortages. The employees were aware that their behaviour was not in line with good practise. They believed that they were not alone in this practise, but they did it anyway to avoid ill-will and bad relations in the workplace. Respondents were most motivated by good relationships with colleagues, followed by appropriate working conditions, job satisfaction, salary, positive superiors, deepening teamwork [team building], social events [e.g. New Year celebrations, etc.] and guest satisfaction. Respondents were most demotivated by colleagues who did not follow food safety rules, the work schedule and demanding customers.

Research has shown that many disease outbreaks are due to cross-contamination because employees do not change their work equipment, including gloves, when moving from one task to another. Personal beliefs, work overload, long working hours, salary satisfaction, motivation and an appropriate working environment are the reasons for selective abandonment of good practises [16, 31, 21, 20, 24, 25, 30]. In the interviews, we concluded that respondents used gloves less frequently, that they were aware that using gloves is not a substitute for hand washing, and that they washed their hands thoroughly before each task. Regarding the importance of cross-contamination, all [n=8] agreed and consistently changed disposable gloves and utensils [chopping boards, knives] when switching between tasks.

In the interviews, we concluded that respondents used gloves less frequently, that they were aware that using gloves is not a substitute for hand washing, and that they washed their hands thoroughly before each task.

The results of scientific publications [18, 24, 32] indicate that employees lack knowledge about defrosting food and the temperature ranges for heat treatment of food. In our research, we also came to similar conclusions regarding the "cold and hot chain". Respondents indicated the approximate temperature and time values that they must adhere to when heat treating, cooling food and reheating. Due to inadequate knowledge and equipment (e.g. equipment for rapid cooling of food), half of the respondents (n=4) thawed frozen food incorrectly by covering it with a lid and thawing it overnight on work surfaces. Based on the results, it is essential to educate employees about the temperature conditions to ensure the cold and hot chain. The focus is therefore on the need for staff training and education.

Based on the results, it is essential to educate employees about the temperature conditions to ensure the cold and hot chain.

In conclusion, we advocate that in order to avoid and prevent undesirable employee behaviour, management must create appropriate working conditions and relationships that have a positive influence, encourage desirable behaviour and discourage employees from violating good practises. It is also necessary to change management's attitude towards training, as they see it merely as a duty that means more administrative work.

CONCLUSION

A review of scientific publications on barriers to food safety shows that there is room for improvement, particularly in the areas of ensuring adequate personal hygiene, training employees in food safety, motivating workers and controlling temperatures during heat treatment of food.

The lack of knowledge about food safety was mainly reflected in the knowledge of microbiological risk factors, temperature parameters (they did not know the exact temperature values) for heat treatment, cooling, reheating and the correct way to defrost food.

In semi-structured interviews, we found that the employees carried out their work conscientiously. They adhered to the rules of personal and hand hygiene, did not wear jewelry on their hands, kept their nails short and unpainted, kept their work clothes and aprons clean and maintained the cold and hot chain as far as their premises allowed (e.g. some did not have shock devices for cooling food, etc.). They adhered to a portioning system to avoid excessive food waste and chilling and reheating of food. Employees were aware that they had to come to work healthy. However, they stated that they sometimes came to work sick due to staff shortages and pressure from superiors.

For respondents, the good relationships and good communication between employees were the greatest motivating factors. Despite training, employees' knowledge was insufficient. The lack of knowledge about food safety was mainly reflected in the knowledge of microbiological risk factors, temperature parameters (they did not know the exact temperature values) for heat treatment, cooling, reheating and the correct way to defrost food.

In view of the lack of knowledge, we conclude that the methods and frequency of training are unsatisfactory. Employees are trained by external contractors who usually only come with a PowerPoint presentation and do not provide job-specific training with practical examples. Food business operators do not have a proper food safety training plan or any training plan at all. Most employees also do not know if they are trained everyone, three, five or ten years as they have not received any training for some time.

Employees who are a risk factor because they do not follow the rules of food hygiene must understand why it is important to carry out certain activities. It is the responsibility of supervisors and external trainers to explain in an understandable and interesting way how certain behaviours (e.g. hand washing, maintaining temperature and time in hot and cold chains, etc.) can contribute to or prevent potential risks and thus the outbreak of foodborne diseases.

To avoid and prevent undesirable food safety behaviour by employees, managers must first and foremost create the right work environment and attitude to positively influence, encourage and discourage employees from improper food handling practices. Managers' attitudes towards training also need to change, as they see it as a mere obligation with more paperwork and administrative burden, which is not in line with the principles of a food safety culture.

Employees are trained by external contractors who usually only come with a PowerPoint presentation and do not provide job-specific training with practical examples.

RESEARCH LIMITATION

Due to the small and homogeneous sample located in Ljubljana, the results are not representative and cannot be generalized to the entire population of food handlers in hospitality sector in Slovenia. In the future, it would be useful to include a larger sample covering different regions and demographic groups, which would allow more representative and general conclusions on food safety practices in the hospitality sector in Slovenia. Further research with mixed methodology is needed, with a broader and more graphical presentation of the problems concerned that influence the food safety aspect in hospitality sector.

In the future, it would be useful to include a larger sample covering different regions and demographic groups, which would allow more representative and general conclusions on food safety practices in the hospitality sector in Slovenia.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to all food handlers who participated in the study.

FUNDING

This research was supported by the Slovenian Research Agency (research core funding No. P3-0388).

REFERENCES

[1] Schirone M, Visciano P, Tofalo R, et al. Editorial: Foodborne pathogens: hygiene and safety. Frontiers in Microbiology. 2019; [10]: 1974. DOI: https://doi.org/10.3389/fmicb.2019.01974.

[2] Smith JL, Fratamico PM. Emerging and re-emerging foodborne pathogens. Foodborne Pathogens and Disease. 2018; 15[12]: 737–757. doi: https://doi.org/10.1089/fpd.2018.2493.

[3] WHO. Food safety. World Health Organization. 2022. https://www.who.int/news-room/fact-sheets/detail/food-safety (3. 10. 2022).

[4] Fung F, Wang HS, Menon S. Food safety in the 21st century. BioMed Research International. 2018; 41[2]: 88–95. DOI: https://doi.org/10.1016/j.bj.2018.03.003.

[5] Webb M, Morancie A. Food safety knowledge of foodservice workers at a university campus by education level, experience, and food safety training. Food Control. 2015; 50: 259–264. DOI: 10.1016/j.foodcont.2014.09.002.

[6] FAO. National food safety policy [2017 – 2026]. 2017. https://leap.unep.org/countries/mv/national-legislation/national-food-safety-policy-2017-2026 (3. 10. 2022).

[7] Faour-Klingbeil D, Todd CDE. Prevention and control of foodborne diseases in Middle-East North African countries: review of national control systems. International Journal of Environmental Research and Public Health. 2019; 17[1]: 70. DOI: https://doi.org/10.3390/ijerph17010070.

[8] GOV. Obveznosti nosilcev živilske dejavnosti. [Obligations of food business operators]. 2020. https://www.gov.si/teme/obveznosti-nosilcev-zivilske-dejavnosti/ (2. 10. 2022).

[9] Eudace. Kaj je varna hrana in ali je hrana danes bolj varna kot nekoč?. [What is safe food and is food safer today than it used to be?]. 2020. https://eudace.eu/kaj-je-varna-hrana-in-ali-je-hrana-danes-bolj-varna-kot-nekoc/ (2. 10. 2022).

[10] EFSA Journal. 2023; 21: e8442. DOI: 10.2903/j.efsa.2023.8442 https://doi.org/10.2903/j.efsa.2023.8442.

[11] Panchal P, Bonhôte P, Dworkin MS. Food safety knowledge among restaurant food handlers in Neuchâtel, Switzerland. Food Protection Trends. 2013; 33: 133-144. https://www.researchgate.net/publication/287613110_Food_safety_knowledge_among_restaurant_food_handlers_in_Neuchatel_Switzerland.

[12] Carpenter LR, Green A, Norton DM, et al. Food worker experiences with and beliefs about working while ill. Journal of Food Protection. 2013; 76[12]: 2146-2154. DOI: https://doi.org/10.4315/0362-028X.JFP-13-128.

[13] Pichler J, Ziegler J, Aldrian U, et al. Evaluating levels of knowledge on food safety among food handlers from restaurants and various catering businesses in Vienna, Austria 2011/2012. Food Control. 2014; 35[33]: 40. DOI: https://ur.booksc.me/book/23047203/38cf3a.

[14] Clayton ML, Clegg Smith K, Neff R, et al. Listening to food workers: Factors that impact proper health and hygiene practice in food service. International Journal of Occupational and Environmental Health. 2015; 21[4]: 1-14. DOI: https://doi.org/10.1179/2049396715Y.0000000011.

[15] EFSA and ECDC (European Food Safety Authority and European Centre for Disease Prevention and Control). The European Union One Health 2022 Zoonoses Report. EFSA Journal. 2023; 21(12): e8442. DOI: https://doi.org/10.2903/j.efsa.2023.8442.

[16] Arendt A, Strohbehn C, Jun J. Motivators and barriers to safe food practices: Observation and interview. Food Protection Trends. 2015; 35[5]: 365–376. https://www.researchgate.net/publication/283774748_Motivators_and_barriers_to_safe_food_practices_Observation_and_interview.

[17] Rebouças LT, Santiago LB, Martins LS. Food safety knowledge and practices of food handlers, head chefs and managers in hotels' restaurants of Salvador, Brazil. Food Control. 2016. DOI: 10.1016/j.foodcont.2016.08.026.

[18] Angelo KM, Nisler AL, Hall AJ, et al. Epidemiology of restaurant-associated foodborne disease outbreaks, United States, 1998–2013. Epidemiology and Infection. 2017; 145[3]: 523–534. DOI: https://doi.org/10.1017/S0950268816002314.

[19] Freitas de R, da Cunha, DT, Stedefeldt E. Food safety knowledge as gateway to cognitive illusions of food handlers and the different degrees of risk perception. The International Food Research Journal. 2019; 116: 126–134. DOI: https://doi.org/10.1016/j.foodres.2018.12.058.

[20] Garayoa R, Abundancia C, Díez-Leturia M, et al. Essential tools for food safety surveillance in catering services: On-site inspections and control of high risk cross-contamination surfaces. Food Control. 2017; 75: 48 – 54. DOI: https://doi.org/10.1016/j.foodcont.2016.12.032.

[21] Asim HS, Elnemr I, Goktepe I, et al. Assessing safe food handling knowledge and practices of food service managers in Doha, Qatar. Food Science and Technology International. 2019; 25[5]: 1–9. DOI: https://doi.org/10.1177/1082013219830843.

[22] Disanto C, Celano G, Dambrosio A, et al. Food safety in collective catering: knowledge, attitudes and correct application of GHP/GMP knowledge among foodservice workers. Italian Journal of Food Safety. 2021; 9[4]: 8453. DOI: https://doi.org/10.4081/ijfs.2020.8453.

[23] Okpala C, Korzeniowska M. Understanding the relevance of quality management in agro-food product industry: from ethical considerations to assuring food hygiene quality safety standards and its associated processes. Food Reviews International. 2021; 37. DOI: 10.1080/87559129.2021.1938600.

[24] Putri MS, Susanna D. Food safety knowledge, attitudes, and practices of food handlers at kitchen premises in the Port 'X' area, North Jakarta, Indonesia 2018. Italian Journal of Food Safety. 2021; 10[4]: 9215. DOI: https://doi.org/10.4081/ijfs.2021.9215.

[25] Strohbehn C. Glove use in retail foodservice establishments - what managers need to know. 2011. https://store.extension.iastate.edu/product/Glove-Use-in-Retail-Foodservice-Establishments-What-Managers-Need-to-Know.

[26] Constable K, Lam H. Gloves in the food industry – A white paper. HACCP international. 2020. https://haccp-international.com/gloves-in-the-food-industry-a-white-paper/.

[27] Rajagopal L, Strohbehn C. Observational assessment of glove use behaviors among foodservice workers in a university dining setting: Testing a visual intervention tool. Food Protection Trends. 2013; 33[5]: 315-324. https://www.researchgate.net/publication/287242396_Observational_assessment_of_glove_use_behaviors_among_foodservice_workers_in_a_university_dining_setting_Testing_a_visual_intervention_tool.

[28] Da Cunha D.T. Improving food safety practices in the foodservice industry. Current Opinion in Food Science. 2021; 42: 127-133. DOI: https://doi.org/10.1016/j.cofs.2021.05.010.

[29] Vogrinc, J. Kvalitativno raziskovanje na pedagoškem področju. Ljubljana: Univerza v Ljubljani, Pedagoška fakulteta. 2008.

Instructions for Authors

Scope

Sanitarno inženirstvo/International Journal of Sanitary Engineering Research present broad interdisciplinary information on the practice and status of research in environmental, food and occupational hygiene, epidemiology, the environmental engineering science, systems engineering, and sanitation. Papers focus on design. Development of health engineering methods, management, governmental policies, and societal impacts of drinking water, wastewater collection and treatment; the fate and transport of contaminants on watersheds, in surface waters, in groundwater, in the soil, and the atmosphere; environmental biology, microbiology, chemistry, fluid mechanics, and physical processes that control natural concentrations and dispersion of wastes in the air, water, and soil; non-point source pollution on water-sheds, in streams, in groundwater, in lakes, and in estuaries and coastal areas; treatment, management, and control of hazardous wastes; control and monitoring of air pollution and acid deposition; air-shed management; and design and management of solid waste professional obligations facilities; food technology, management of food quality and food safety. A balanced contribution from consultants, sanitary engineers, and researchers is sought on engineering solutions and responsibilities.

Submission of Articles

All manuscripts for Sanitarno Inženirstvo/International Journal of Sanitary Engineering Research should be submitted to:

Inštitut za sanitarno inženirstvo
Institute of Public and Environmental Health
Zaloška cesta 155
Ljubljana, Slovenia 1000
E-mail: info@institut-isi.si

Your article will be submitted to the review process. All correspondence, including notification of the Editor's decision and request for revision, takes place by e-mail.

Submission of a paper implies that it has not been published previously, that it is not under consideration for publication elsewhere, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, without the written permission of the publisher. Authors are solely responsible for the factual accuracy of their papers.

MANUSCRIPT PREPARATION

Cover letter:

- Title of the paper (without any abbreviations).
- Full name(s) of the author(s).
- Affiliation and addresses of the author(s).
- Mailing address of the corresponding author (address, phone, e-mail).
- A statement that the article is original, the manuscript or any part of it (except abstract) has not been sent to any other publisher or it is not in consideration for publication anywhere in any language.
- A statement that all authors read the article and agree with the content.
- Written permission of the publisher for the use of tables, figures and any other part of the material in original form used in the article.
- A statement of the ethnical principles used during the experiments with animals (if any).

A copy of the cover letter must be signed by the corresponding author and sent to the editor by regular mail.

General: Manuscript must be prepared with Word, double-spaced with wide margin 25 mm; 12 pt. Times New Roman font is recommended. Correct spelling and grammar are the sole responsibility of the author(s). Articles should be written in a concise and succinct manner.
Research papers should have the following structure:
· Title,
· authors and affiliations,
· abstract (max. 200 words),
· keywords (max. 6 words),
· introduction,
· methods,
· results and discussion,
· acknowledgements (if any),
· references,
· vitae,
· figure captions and
· tables.

Technical and review articles should have a similar structure; abstracts should not exceed 200 words. All articles should be in English, except news, reviews, and reports, which can be in Slovenian, Croatian or Serbian. Chapters should be arranged according to the ISO 2145 and ISO 690 standards. Abbreviations must be explained at their first instance in the text.

The first page of the article should contain the title of the article (max. 10 words), author(s)' name(s), institution and address. The corresponding author should be identified with an asterisk and footnote (the text in the footnote: to whom all correspondence should be addressed and added tel. and fax numbers, and e-mail). The second page should contain the abstract and keywords. An abstract of approximately 100 words should have the following structure: aims, scope, and conclusions of the article.

Symbols and Units:

Authors should follow the ISO 31 and IUPAC recommendations. Please note that all symbols should be written in italic; superscript and subscript are written in plain text.

Tables, figures and illustrations: Tables, figures, and illustrations should be numbered consecutively and given a suitable caption, and each table, figure, and illustration should be given on a separate page and file. No vertical rules for tables should be used. Images should be of sufficient quality for the printed version (300 dpi minimum). Figures should be at sufficient resolution (in EPS, JPEG, or TIFF format) to be assessed by the referees

References: References should be numbered, and ordered sequentially as they appear in the text. When numbered in the text, reference numbers should be in brackets, following the punctuation marks. If the cited reference has more than three authors, add the abbreviation et al. after the third author. References should be given in the following form:

[1] Bhatt Siddharta M. Energy audit case studies II – Air conditioning (cooling) systems. Appl Th Eng. 2000; 20: 297-307.

[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.

[4] Mansfieid LW. How the nurse learns which imbalance is present. V: Moidel HC, Sorensen GE, Giblin EC, Kaufman MA, eds. Nursing care of the patient with medical-surgical disorders. New York: Mc Grow-Hill, 1971: 153-60.

[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).

Publication ethics

The publication of an article in a peer-reviewed journal is an essential model for "International Journal of Sanitary Engineering Research". It is necessary to agree upon standards of expected ethical behaviour for all parties involved in the act of publishing: the author, the journal editor, the peer reviewer and the publisher. Our ethic statements are based on COPE's Best Practice Guidelines for Journal Editors.

Publication decisions
The editor is responsible for deciding which of the articles submitted to the journal should be published. The editor may be guided by the policies of the journal's editorial board and constrained by such legal requirements as shall then be in force regarding libel, copyright infringement, and plagiarism. The editor may confer with other editors or reviewers in making this decision.

Fair play
An editor always evaluates manuscripts for their intellectual content without regard to race, gender, sexual orientation, religious belief, ethnic origin, citizenship, or political philosophy of the authors.

Confidentiality
The editor and any editorial staff must not disclose any information about a submitted manuscript to anyone other than the corresponding author, reviewers, potential reviewers, other editorial advisers, and the publisher, as appropriate.

Disclosure and conflicts of interest
Unpublished materials disclosed in a submitted manuscript must not be used in an editor's own research work without the express written consent of the author.

DUTIES OF REVIEWERS

Contribution to Editorial Decisions
Peer review assists the editor in making editorial decisions and, through the editorial communications with author, may also assist the author in improving the paper.

Promptness
Any selected referee who feels unqualified to review the research reported in a manuscript or knows that its prompt review will be impossible should notify the editor and excuse himself from the review process.

Confidentiality
Any manuscripts received for review must be treated as confidential documents. They must not be shown to or discussed with others except as authorized by the editor.

Standards of Objectivity
Reviews should be conducted objectively. Personal criticism of the author is inappropriate. Referees should express their views clearly with supporting arguments.

Acknowledgement of Sources
Reviewers should identify relevant published work that has not been cited by the authors. Any statement that an observation, derivation, or argument had been previously reported should be accompanied by the relevant citation. A reviewer should also call to the editor's attention any substantial similarity or overlap between the manuscript under consideration and any other published paper of which they have personal knowledge.

Disclosure and Conflict of Interest
Privileged information or ideas obtained through peer review must be kept confidential and not used for personal advantage. Reviewers should not consider manuscripts in which they have conflicts of interest resulting from competitive, collaborative, or other relationships or connections with any of the authors, companies, or institutions connected to the papers.

DUTIES OF AUTHORS

Reporting standards
The authors of reports of original research should present an accurate account of the work performed as well as an objective discussion of its significance. The underlying data should be represented accurately in the paper. A paper should contain sufficient detail and references to permit others to replicate the work. Fraudulent or knowingly inaccurate statements constitute unethical behaviour and are unacceptable.

Data Access and Retention
Authors are asked to provide the raw data in connection with a paper for editorial review, and should be prepared to provide public access to such data (consistent with the ALPSP-STM Statement on Data and Databases), if practicable, and should in any event be prepared to retain such data for a reasonable time after publication.

Originality and Plagiarism
The authors should ensure that they have written entirely original works, and if the authors have used the work and/or words of others that this has been appropriately cited or quoted.

Multiple, Redundant or Concurrent Publication
An author should not, in general, publish manuscripts describing essentially the same research in more than one journal or primary publication. Submitting the same manuscript to more than one journal concurrently constitutes unethical publishing behaviour and is unacceptable.

Acknowledgement of Sources
Proper acknowledgment of the work of others must always be given. Authors should cite publications that have been influential in determining the nature of the reported work.

Authorship of the Paper

Authorship should be limited to those who have made a significant contribution to the conception, design, execution, or interpretation of the reported study. All those who have made significant contributions should be listed as co-authors. When there are others who have participated in certain substantive aspects of the research project, they should be acknowledged or listed as contributors. The corresponding author should ensure that all appropriate co-authors and no inappropriate co-authors are included in the paper and that all co-authors have seen and approved the final version of the paper and have agreed to its submission for publication.

Hazards and Human or Animal Subjects

If the work involves chemicals, procedures or equipment that have any unusual hazards inherent in their use, the author must clearly identify these in the manuscript.

Disclosure and Conflicts of Interest

All authors should disclose in their manuscript any financial or other substantive conflicts of interest that might be construed to influence the results or interpretation of their manuscript. All sources of financial support for the project should be disclosed.

Fundamental errors in published works

When an author discovers a significant error or inaccuracy in his/ her own published work, it is the author's obligation to promptly notify the journal editor or publisher and cooperate with the editor to retract or correct the paper.

Journal SANITARNO INŽENIRSTVO / International Journal of Sanitary Engineering Research – IJSER is an open-access journal, meaning that all of its contents are freely accessible without any charge to the user or their institution. All articles are available on the internet to all users immediately upon publication.

IJSER do not take any responsibility for the contents of articles published in the journal and all such responsibility lies with the author/s. The opinions expressed in the articles are solely of the author/s and IJSER may not agree with such opinions in part or in full.

All the articles submitted for publication in IJSER are peer reviewed for authenticity, ethical issues and usefulness. The Similarity Check System is used in order to ensure that the content published is original and trustworthy. Similarity Check is a medium that allows for comprehensive manuscripts screening, aimed to eliminate plagiarism and provide a high standard and quality peer-review process. Authors are solely responsible for orginality of the published work.

Annual subscription for print version is 160 EUR + VAT (9,5%).