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Editorial

"Healthy citizens are the greatest asset any country can have."

Dear readers of International Journal of Sanitary Engineering Research (IJSER). In front of you is 2017 issue. The author of the sentence above (in the title) is Winston S. Churchill. Although he was not public health or environmental health professional he made a good point. And his sentence is a ground basis which combines topics published in the current issue of IJSER.

First of all I am glad and honoured to welcome new members on board of our Journal. During this year Bryan W. BROOKS, from Baylor University (Texas, USA), Graeme MITCHELL from Liverpool John Moores University (United Kingdom) and Helen UDRAS from Tartu Health Care College (Estonia) have joined editorial board of IJSER.

The current issue contains six papers covering different fields of public and environmental health field. Indoor environmental quality in Slovenian children day-care centres is elaborated by Pajek et al. It is worrying that poorer situation was identified in renovated and newly constructed low-energy buildings if compared two older ones. The results of both papers submitted by Pajek et al. represent an important contribution to the assessment of indoor environmental quality in the context of building construction and renovation.

Use of a nudge tool for improving hand hygiene in a nursing team was studied in another type of institutional setting – in home for elderly people. Results demonstrate that after a specific change in the environment, hand hygiene improved among observed group of health workers. This is showing that nudging may help us prevent and control healthcare-associated infections.

Maestro et al. evaluated positive and negative impacts of boiling on the safety of the raw milk. They determined that the boiling process improves the safety of raw milk, and is responsible for significant increase of its microbiological safety. The study also revealed that the safety of raw milk in the Sarajevo Canton derogates from provisions in force for the raw milk.

Three different cleaning procedures routinely applied in hygienic sensitive working processes were systematically evaluated in the context of their cleaning effectiveness by Jevšnik et al. Based on the results authors conclude that for optimal cleaning outcomes, visual, non-microbiological, and microbiological methods should be combined as an integrated cleaning monitoring strategy.

At last but not at least you can enjoy reading this year Roy Emerson winning essay on the theme "International Travel & Health" prepared and submitted by Zarja Zrinski, student from Faculty of Health Sciences at University of Ljubljana. The essay was presented at the 2nd IFEH World Academic Congress in Jamaica.

With healthy citizens of all ages in mind I wish you will find topics in current issue interesting and informative.

Sincerely,

Andrej Ovca, Editor-in-Chief

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Original scientific article

Indoor environmental quality (IEQ) in Slovenian children daycare centres. Part I: Results of in-situ measurements

Luka **PAJEK**[1], Mitja **KOŠIR**[1], Živa **KRISTL**[2], Katarina **KACJAN ŽGAJNAR**[3], Mateja **DOVJAK**[1*]

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ABSTRACT

The number of children enrolled in daycare centres is increasing, while indoor environmental quality of Slovenian children daycare centres remains insufficiently investigated. The purpose of this paper, as Part I of the larger study "Indoor environmental quality (IEQ) in Slovenian children daycare centres", was to holistically assess indoor environmental quality of 24 playrooms in 17 publicly funded children daycare centres in Slovenia. The performed holistic assessment included simultaneous in-situ measurements of the selected comfort parameters (i.e. indoor air quality, thermal, visual and acoustic comfort), which were compared with legal requirements and recommendations. The results of in-situ measurements showed that the most critical field was the indoor air quality (in 63% of playrooms $cCO_{2i,avg}$ >1667 ppm) and that the indoor environmental quality conditions met all of the legal requirements and recommendations only in 8% of the investigated playrooms. In general, if compared to other EU countries, the conditions in Slovenian facilities were slightly worse. Therefore, a holistic approach to the assessment of indoor environmental quality is vital to achieve a universally comfortable and healthy indoor environment. Part II of this study presents further investigation of interrelationship between different building characteristics and IEQ.

Key words: indoor environmental quality, in-situ measurements, comfort, public buildings, daycare centres

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INTRODUCTION

The statistical data of EU over the last decade show that the amount of enrolled children in children daycare centres (DCCs) has increased [1], while in Slovenia almost 77% (84750) of children aged one to five were enrolled in DCCs in September 2014 [2]. As the number of children enrolled in Early Childhood Education and Care (ECEC) is high and seems to be increasing, it is essential that child's stay in an educational institution is comfortable and without adverse health effects [3–12], especially due to the fact that children are more susceptible to environmental influences, thus being a vulnerable population with particularly higher risk of adverse health effects.

Children are more susceptible to environmental influences, thus being a vulnerable population with particularly higher risk of adverse health effects.

Therefore, besides executing field measurements of IEQ parameters in the selected DCCs, one of the goals of our study was also to get a bigger picture in the field of IEQ in DCCs. We were particularly interested in existing studies in the field of IEQ all across the Europe and wider. In order to analyse the state-of-the-art in the field of IEQ in educational building facilities, a comprehensive literature review was carried out. Table 1 represents study summary of 24 selected research papers dealing with indoor environment quality in buildings intended for education (e.g. DCCs, schools).

Among the referenced studies (Table 1), the most investigated indoor comfort field is IAQ, while the least investigated is visual comfort. Thermal comfort [12–15], indoor air quality (IAQ) [4, 7, 10, 16–23, 30–32], visual comfort [5, 6, 8] or acoustic comfort [3, 25–27] and/or their impact on human health is relatively well investigated either in DCCs or in schools. In many cases studies identified the conditions as inadequate and hazardous for children. Cano et al., Teli et al. [11] and De Giuli et al. [29] presented a wider aspect as they investigated two IEQ fields, for example, by taking into account thermal comfort and indoor air quality at the same time. Very few studies of IEQ were made in Slovenian DCCs, mostly focusing only on acoustic comfort, for example a study made by Kacjan Žgajnar et al. [25]. In addition, the literature review showed that there is no such study, which would simultaneously consider all of the four comfort fields (i.e. thermal, visual, acoustic comfort and IAQ).

Table 1: An overview of the selected reviewed research papers

Comfort field	Author (year)	Location	Study area	Study population	Study parameters
Thermal comfort	Fabbri (2013) [13]	Italy, Reggio Emilia, N = 1 DCC	Thermal comfort (PMV, PPD)	Playrooms with 4–5 year old children	T_{ai}, RH_{ai}, v_{ai}, T_{mr}, ***PMV***, ***PPD***
	Hwang et al. (2009) [14]	Taiwan, N = 14 schools	Thermal comfort (TSV)	Children 12–17 years old	***TSV***
	Mors et al. (2011) [15]	Netherlands, Eindhoven, N = 3 schools	Thermal comfort (PMV, TSV)	Classrooms with 9–11 years old children	T_{ai}, RH_{ai}, v_{ai}, T_{mr}, ***PMV***, ***TSV***
	Yun et al. (2014) [12]	S. Korea, Seoul, N = 10 DCCs	Thermal comfort (PMV)	Naturally ventilated playrooms with children 4–6 years old	T_{ai}, RH_{ai}, v_{ai}, T_{mr}, ***PMV***

Comfort field	Author (year)	Location	Study area	Study population	Study parameters
Indoor air quality	Araújo-Martins et al. (2014) [16]	Portugal, Lisbon and Porto, N = 45 DCCs	IAQ and health	Playrooms with 3 months to 6 year old children	**cCO_{2i}, biological and chemical hazards, T_{ai}, RH_{ai}**
	Cars et al. (1992) [17]	Sweden, Teleborg (Växjö), N = 7 DCCs	Infectious diseases and IAQ	Playrooms in DCCs and in renovated dwellings	**cCO_{2i}, absence due to an infectious disease**
	Daneault et al. (1992) [18]	Canada, Montreal, N = 91 DCCs	IAQ	Randomly selected playrooms	**cCO_{2i}, T_{ai}, RH_{ai}**
	Gładyszewska-Fiedoruk (2013) [19]	Poland, Białystok, N = 3 DCCs	Correlation between IAQ and RH	Playrooms with 3–6 year old children	**cCO_{2i}, T_{ai}, RH_{ai}**
	Roda et al. (2011) [20]	France, Paris, N = 28 DCCs	IAQ	Playrooms with toddlers	**cCO_{2i}, biological and chemical hazards, T_{ai}, RH_{ai}**
	Ruotsalainen and Jaakkola (1993) [21]	Finland, Espoo, N = 30 DCCs	IAQ	Old and new playrooms	**cCO_{2i}, ventilation rate, chemical hazards, odours, T_{ai}, RH_{ai},**
	St-Jean et al. (2012) [10]	Canada, Montreal, N = 21 DCCs	IAQ	Playrooms with a capacity of at least 40 children	**cCO_{2i}, chemical hazards, T_{ai}, RH_{ai}**
	Stankeviča and Lešinskis (2012) [22]	Latvia, Riga, N = 6 DCCs	IAQ	Playrooms in old, new and renovated DCCs	**cCO_{2i}, T_{ai}, RH_{ai}**
	Zuraimi et al. (2008) [23]	Singapore, N = 104 DCCs	IAQ of DCCs in tropical climate	Randomly selected playrooms	**cCO_{2i}, cCO_i, T_{ai}, RH_{ai}, v_{ai}, biological hazards**
Visual comfort	Hathaway et al. (1992) [5]	Canada, schools	Impact of artificial and natural light on children	Children in classrooms with artificial or natural daylight	**Performance and health analysis of children**
	Heschong Mahone Group (1999) [6]	USA, California, N = 3 schools	Impact of daylight on children	Children in well and under-lit classrooms	**Performance analysis of children**
	Nicklas and Bailey (1997) [8]	USA, N. Carolina, N = 5 schools	Impact of daylight on children	Children in well and under-lit classrooms	**Performance analysis of children**
Acoustic comfort	Chatzakis et al. (2014) [3]	Greece, Crete, Heraklion, N = 10 DCCs	Noise level	18 playrooms	**L_{eqi}, impact of noise on health**
	Kacjan Žgajnar et al. (2009) [24]	Slovenia, Ljubljana, N = 3 DCCs	Noise level in the workplace	Educators in playrooms intended for children between 3 and 6 years old	**L_{eqi}, impact of noise on health of educators**
	Kacjan Žgajnar et al. (2009) [25]	Slovenia, Ljubljana, N = 3 DCCs	Noise level in playrooms	Playrooms intended for children between 3 and 6 years old	**L_{eqi}, impact of noise on health**
	McAllister et al. (2009) [26]	Sweden, Linköping, N = 3 DCCs	Noise level in playrooms	10 children without reported hearing problems	**L_{eqi}, impact of noise on health**
	Sjödin et al. (2012) [27]	Sweden, Umeå, N = 17 DCCs	Noise level in the workplace	Educators	**impact of noise on health**
Multiple comfort analysis	Cano et al. (2012) [28]	Portugal, Lisbon, N = 19 DCCs	IAQ and thermal comfort	125 playrooms intended for children old between 3 months and 6 years	**T_{ai}, RH_{ai}, v_{ai}, T_{mr}, cCO_{2i}, cCO_i, biological and chemical hazards**
	De Giuli et al. (2014) [29]	Italy, Padua, N = 3 schools	IAQ, thermal comfort and visual comfort	8 classrooms in primary schools	**T_{ai}, RH_{ai}, v_{ai}, T_o, PMV, PPD, cCO_{2i}, E_i**
	Teli et al. (2012) [11]	England, Hampshire, N = 1 school	IAQ and thermal comfort	Classrooms with children between 7 and 11 years old	**T_{ai}, RH_{ai}, v_{ai}, T_{mr}, *PMV*, *PPD*, *TSV*, cCO_{2i}**

T_{ai} – indoor air temperature; RH_{ai} – indoor air relative humidity; v_{ai} – indoor air velocity; T_{mr} – mean radiant temperature; T_o – operative temperature; *PMV* – predicted mean vote index; *PPD* – predicted percentage of dissatisfied; *TSV* – thermal sensation vote; cCO_{2i} – indoor concentration of carbon dioxide; cCO_i – indoor concentration of carbon oxide; L_{eqi} – indoor equivalent noise level; E_i – daylight illuminance of work plane

Therefore, it can be concluded that these four areas of comfort in DCCs are not treated equally, as some are represented in the research less often than others. In this respect, in recent years the importance of high quality ECEC is reflected in a high volume of joint reflection on policies and programmes between the European Commission and the Member States [33]. As can be seen, the IEQ of children daycare centres as well as other educational institutions was relatively well investigated throughout the facilities across the EU and wider, which was found out through the review of the published papers. Surprisingly, the quality of indoor environment in Slovenian DCCs has not been sufficiently investigated. Consequently, the objective of our study was to examine the situation in Slovenian DCCs from the IEQ perspective. Therefore, measurements of selected parameters of visual, thermal and acoustic comfort, as well as indoor air quality were carried out. Several playrooms were sampled from the selected DCCs in Slovenia in order to execute in-situ measurements of the selected comfort parameters. Hence, the above mentioned factors affecting human comfort in buildings were investigated in 24 playrooms in 17 DCCs. The study took place from March to June 2013. The indoor environment was investigated in order to improve IEQ conditions in DCCs. The latter was done by examining minimal criteria according to national and EU legal requirements, applicable recommendations or standards.

METHODS

Area and time of observation

The research was carried out in 17 randomly selected children daycare centres (anonymised and denominated by letters A–R) located in Slovenia, which included 24 playrooms intended for children aged 3 to 5. The research took place at targeted DCCs from March to June 2013. The conducted research protocol is presented in Figure 1.

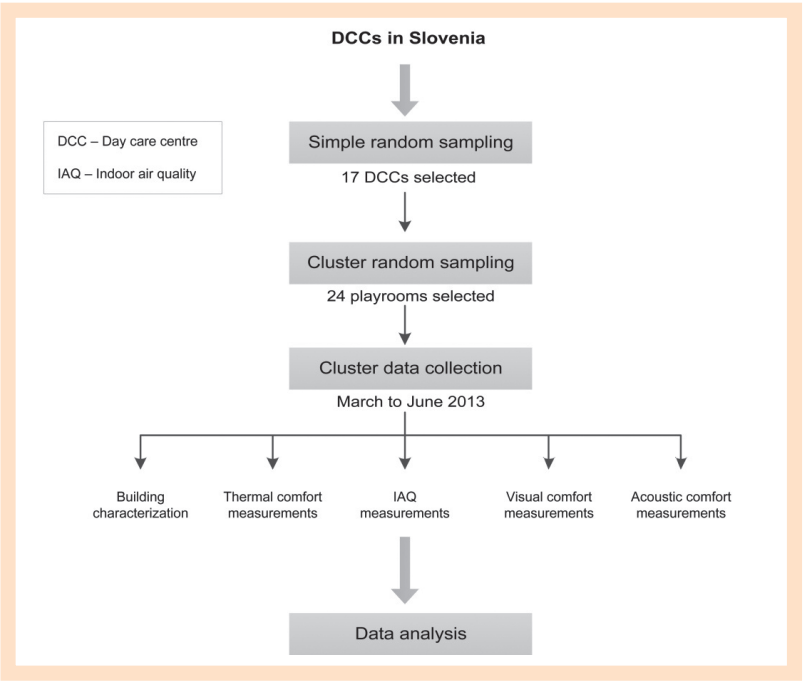

Figure 1:
Research protocol

Measurements

The required data were collected in-situ in the selected DCCs by researchers conducting measurements of the studied parameters. Measurements took place in forenoon, particularly between 9 and 12 am (i.e. after breakfast and before lunch) in occupied playrooms. Holistic evaluation of IEQ included the following measurements. Indoor air temperature (T_{ai}), indoor air relative humidity (RH_{ai}), indoor air velocity (v_{ai}) and surface temperature (T_{surf}) were measured to evaluate thermal comfort of the investigated playrooms. Field technicians measured daylight illuminance of work plane (E_i) and window glass light transmittance (LT) as the selected visual comfort parameters. To evaluate the IAQ, indoor concentration of carbon dioxide (cCO_{2i}) was measured. Indoor equivalent noise level (L_{eqi}) was the selected and measured parameter of acoustic comfort. In addition, two selected outdoor parameters were measured: outdoor noise level (L_{eqe}) and outdoor concentration of carbon dioxide (cCO_{2e}). For the purpose of the study the following measurement equipment was used: Testo 445 (T_{ai}, RH_{ai}, v_{ai}), Testo 535 (cCO_{2i}, cCO_{2e}), Raytek Raynger MX (T_{surf}) and Voltcraft DT 8820 (L_{eqi}, L_{eqe}, E_i). Outdoor air temperature (T_{ae}), relative humidity of outdoor air (RH_{ae}) and air velocity (v_{ae}) were provided by Slovenian Environment Agency [34].

All the selected indoor parameters were recorded every 20 minutes, with the exception of carbon dioxide concentration, which was recorded every 5 minutes. Measuring instruments were placed out of children's reach. A typical selection and position of measuring points is presented on a floor plan of playroom A1 (Figure 2).

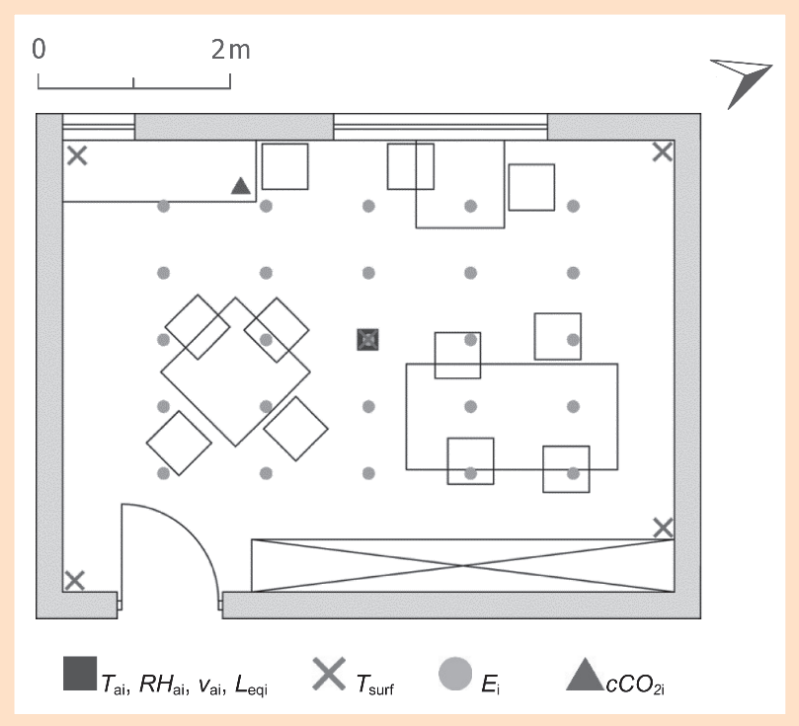

Figure 2:
Measurement points in playroom A1

All of the measurements were taken at a height of 0.70 m above the floor, with the exception of surface temperature measurements, which were taken on all the circumferential surfaces. Although the work plane for horizontal illuminance measurements in DCCs should be positioned lower than at 0.70 m above the floor, this distance was nevertheless used in order to prevent inquisitive children interfering with the measurements. However, presuming that the illuminance at lower work planes is higher than at 0.70 m, the measurements are on the safe side. Measurements of daylight illuminance were performed for the actual state of playrooms – positions of furniture and shading systems were preserved. All the sources of artificial light were turned off. Indoor environment conditions were evaluated and compared to legal requirements and recommendations for DCCs, defined in the following documents:

- Slovenian national legislation: O.J. RS, No. 42/02, 105/02 [35]; O.J. RS, No. 73/00, 75/05, 33/08, 126/08, 47/10, 47/13 [36]; O.J.RS, No.17/06, 18/06 – ed., 43/11 – ZVZD-1[37];
- Slovenian national guidelines: TSG-1-005:2012 [38];
- International standards and recommendations: ANSI/ASHRAE Standard 62.1-2007 [39]; CEN CR 1752:2001[40]; EN 12464-1:2011[41]; EN 15251:2010[42]; ISO 7730:2005 [43].

Preparation of data

All the required data were collected and prepared for further investigation. The dimensions (i.e. floor space, height, window openings) and orientation of the DCC playrooms were recorded by the field technicians. DCC managers provided information regarding lists of children present in the analysed playrooms and the age of buildings. For the purpose of evaluating indoor environmental quality, additional calculations of playroom floor area per occupant, playroom volume, mean radiant temperature (T_{mr}), predicted mean vote index (PMV), predicted percentage of dissatisfied (PPD), window to floor ratio (WFR), illuminance uniformity (i.e. $E_{i,min}$/ $E_{i,avg}$ and $E_{i,avg}$/ $E_{i,max}$) and percentage of dissatisfied with the air quality (PPD_{IAQ}) were made. Thermal comfort parameters were calculated according to ISO 7730:2005. The calculation of PPD_{IAQ} parameters was performed with the use of Equation 1 based on CEN CR 1752:2001.

$$PPD_{IAQ} = 395^{(-15.15(cCO_{2i,avg} - cCO_{2e})^{-0.25})} \quad (1)$$

RESULTS

Sample building characteristics

For the purpose of further analysis, in initial step sample building characteristics were investigated, as one of the potential factors that could affect IEQ. All of the investigated DCCs were publicly funded; none of them was privately run. In 2013 the average age of the selected buildings was 43 years, with the average year of construction 1970. The oldest building in the entire sample was constructed in 1899, as a residential villa; the

newest was constructed in 2013 as a low-energy children daycare centre. Eight out of seventeen buildings were recently renovated with the aim to lower their energy demand. All of the DCCs were renovated only by replacing windows. Playrooms in every DCC were naturally ventilated, with the exception of DCCs P and R, which were ventilated mechanically. The latter DCCs were also classified as low-energy buildings and were at the same time the youngest buildings (Table 2) included in the study. The average floor area of the selected playrooms was 41.3 m^2 and the average volume 132.2 m^3. The average floor area per occupant was 2.2 m^2. Only minority of playrooms (17%) had the average floor space equal to or higher than what is required by the Slovenian legislation (i.e., at least 3 m^2/child) [36]. None of the investigated playrooms had north orientation, with most of them (i.e. 9) oriented south. Basic information and building characteristics of each selected DCC facility are presented in Table 2.

Table 2: Basic information and building characteristics of the selected DCCs

Daycare centre	Year of construction	Recent renovation[b]	Playroom No.	Playroom occupation (children + staff)	Floor area [m^2]	Floor area per occupant [m^2/occ]	Volume [m^3]	Area of windows [m^2]	Orientation of majority of windows, azimuth [°]
A	1952	Yes	A1	14 + 2	35.7	2.2	102.2	7.3	W, 290
			A2	20 + 2	35.8	1.6	112.2	10.3	W, 290
B	1979	Yes	B1	19 + 2	52.7	2.5	155.5	16.8	W, 292
C	1899	Yes	C1	14 + 2	35.2	2.2	131.5	11.5	E, 100
D	1963	No	D1	18 + 2	44.6	2.2	161.1	20.8	NW, 310
			D2	16 + 3	37.2	2.0	116.8	15.5	S, 178
			D3	16 + 1	46.9	2.8	142.6	13.8	SE, 130
E	1906	No	E1	14 + 2	36.3	2.3	127.4	3.3	W, 275
F	1979	No	F1	19 + 3	39.0	1.8	116.5	14.8	E, 100
G	1979	Yes	G1	14 + 2	41.9	2.6	151.7	10.0	S, 160
			G2	14 + 2	36.0	2.3	164.2	13.1	SE, 150
H	1976	Yes	H1	16 + 2	44.6	2.5	133.8	16.7	SW, 210
I	1973	Yes	I1	18 + 2	43.7	2.2	128.6	15.0	SE, 142
J	1982	No	J1	20 + 2	33.8	1.5	113.3	11.5	SE, 128
			J2	15 + 2	32.9	1.9	111.0	11.8	S, 149
K	1976	Yes	K1	18 + 2	38.2	1.9	99.4	10.7	E, 80
			K2	21 + 2	46.8	2.0	145.9	13.4	SE, 128
L	1976	No	L1	20 + 2	41.0	1.9	132.8	18.4	S, 172
M	1979	No	M1	14 + 3	42.4	2.5	122.1	9.9	SW, 220
N	1971	No	N1	17 + 2	50.3	2.6	174.5	21.5	S, 180
O	1972	Yes	O1	13 + 2	44.7	3.0	134.1	11.6	S, 200
			O2	17 + 2	49.1	2.6	146.3	13.2	S, 158
P[a]	2013	No	P1	21 + 2	39.2	1.7	118.0	17.3	S, 178
R[a]	2012	No	R1	17 + 2	43.6	2.3	132.2	15.4	S, 164

[a] Low-energy DCCs; [b] Energy retrofit: replacement of windows

Measurement and calculation of the selected IEQ parameters

The highest measured outdoor air temperature during the measurement time interval (9–12 am) was 32.4 °C, and the lowest –1.4 °C [34]. In the same way, the average value of measured outdoor CO_2 concentration was 387 ppm (330–445 ppm), the average outdoor equivalent noise level 50 dB (30–75 dB). Table 3 represents general characteristic values of measurements and calculations of the selected IEQ parameters in all the playrooms among the analysed DCCs. The measured val-

ues of thermal and visual comfort parameters were largely dispersed. Thus, in Table 3 the median values were used instead of arithmetic mean, to represent general conditions in playrooms. The main results of IEQ measurements compared with legal requirements and recommendations are presented in the subsections below.

Table 3: Measured and calculated values of indoor environmental quality parameters among all the 17 DCCs (24 playrooms)

Parameters					
Symbol	**Description**	**Unit**	**Min**	**Max**	**Median**
T_{ai}	indoor air temperature	°C	19.3	27.4	23.7
$\mathbf{T_{surf}}$	surface temperature	°C	13.5	34.2	22.3
$\mathbf{RH_{ai}}$	indoor air relative humidity	%	29.1	68.5	47.2
$\mathbf{v_{ai}}$	indoor air velocity	m/s	0.00	0.50	0.04
PMV	predicted mean vote	-	–0.33	1.10	0.19
PPD	predicted percentage of dissatisfied	%	5	29	6
LT	light transmittance of windows	-	0.52	0.89	0.69
WFR	window to floor ratio	%	9.1	45.0	30.0
$\mathbf{E_i}$	average indoor daylight illuminance	lx	44	2655	352
-	uniformity of illumination[a]	-	0.01	0.38	0.17
$\mathbf{cCO_{2i}}$	indoor CO_2 concentration	ppm	389	3613	1400
$\mathbf{PPD_{IAQ}}$	predicted percentage of dissatisfied with IAQ	%	9	43	27
$\mathbf{L_{eqi}}$	indoor equivalent noise level	dB	30	95	70

[a] Ratio between minimal and average illuminance.

Thermal comfort

During the conducted measurements indoor air temperature did not meet the required values (i.e., 19–24 °C) according to Slovenian legal requirements [35] in 37% of playrooms. In those playrooms the air temperature was too high, with the highest values reached in playroom R1 (25.5–27.4 °C). However, in relation to the recommendations [42]) (i.e., 17.5–22.5 °C), the recommended indoor air temperature was ensured only in 8% of the playrooms, with too high air temperatures in the majority of the playrooms. Radiant temperature asymmetry was not detected in any of the analysed playrooms. Nevertheless, the lowest surface temperature of 13.5 °C was measured on the external wall surface in playroom G1, as a consequence of present thermal bridge. Indoor air relative humidity was within the acceptable limits of 40 to 60% [36, 42] in 54% of the playrooms, while in other playrooms the air was mostly too dry (i.e. $RH_{ai} < 40\%$). The measured indoor air velocity exceeded the permitted value (i.e., $v_{ai} < 0.19$ m/s) [35] in 17% of the playrooms and the recommended value (i.e., < 0.15 m/s) in 29% of the playrooms. However, according to the recommendations [35, 42], appropriate PMV and PPD (i.e.,± 0.7 PMV, PPD < 15%) values were still achieved in 83% of the playrooms.

During the conducted measurements indoor air temperature did not meet the required values according to Slovenian legal requirements in 37% of playrooms.

Indoor air quality (IAQ)

In 63% of the playrooms the measured concentrations of CO_2 exceeded the value permitted by Slovenian legislation (i.e., < 1667 ppm) [35]. Overall, nearly 80% of the playrooms had mean CO_2 concentrations exceeding 1000 ppm, which is recommended as the highest value in the

In 63% of the playrooms the measured concentrations of CO_2 exceeded the value permitted by Slovenian legislation.

ANSI/ASHRAE Standard 62.1-2007 [39]. The highest achieved mean CO_2 concentration measured in playroom B1 was 2584 ppm, while the highest measured value of 3613 ppm was reported in playroom R1. According to standard EN 15251:2010 [42] and Equation 1, 8% of the investigated playrooms were classified as indoor air quality class I (PPD_{IAQ} < 15%), 17% of playrooms were classified as class II (PPD_{IAQ} < 20%), 33% as class III (PPD_{IAQ} < 30%) and the rest as class IV (PPD_{IAQ} > 30%). In more than half of the playrooms, the PPD_{IAQ} value was higher than 25%.

Visual comfort

One playroom (E1) did not meet the requirement of Slovenian legislation for the WFR in DCCs (i.e., > 20% of the floor plan) [36, 42]. Playroom L1 had the highest percentage of lighting openings in relation to the floor area (45%) due to its supplementary clerestory windows. The maximum ratio between the height and the depth of the playrooms is limited by Slovenian legislation to 2.5 [36, 42]. In contradiction to the legal requirements, in 18% of playrooms the room depth was more than 2.5 times greater than the room height. According to standard [42], in 54% of the playrooms the recommended average work plane illuminance of at least 300 lx was ensured by daylighting during the time of conducted measurements.

Maximum noise levels in some playrooms exceeded 90 dB due to high children activity (e.g. playing, singing).

Acoustic comfort

In general, high noise levels in the selected playrooms were a consequence of children activity in the playrooms. In most cases the internally generated noise was dominant over the external ambient noise sources. According to Slovenian legislation [38], indoor noise level was in general too high during the measurements. Only 58% of the playrooms met the Slovenian legal requirements for noise exposure at work (i.e., < 70 dB) [37]. However, it has to be noted that noise level measurements were performed only for the period of three hours, while the legal requirements consider the noise exposure during the entire time span of operating hours. The highest and the lowest mean indoor noise levels were 83 dB (playroom A2) and 51 dB (playroom F1). Although indoor equivalent noise level was adequate in the majority (67%) of playrooms, it has to be noted that also the impulse noise should be taken into consideration. Maximum noise levels in some playrooms exceeded 90 dB due to high children activity (e.g. playing, singing).

Holistic assessment

In order to holistically assess the IEQ in the analysed DCCs, all of the four aspects of comfort must be simultaneously evaluated. For each aspect one parameter was selected for a holistic assessment. Thus, PMV was selected to evaluate thermal comfort; average work plane illuminance with daylight was selected to evaluate visual comfort, indoor CO_2 concentration for IAQ and equivalent noise level for acoustic comfort. Table 4 represents the selected parameters of observation and general measurement results in all the 24 investigated playrooms.

Table 4: Measurement results of the selected basic parameters in each playroom

	Thermal comfort	Visual Comfort	IAQ	Acoustic comfort
Playroom No.	PMV [-]	$E_{i,avg}$ [lx]	$cCO_{2i,avg}$ [ppm]	$Leq_{,i,avg}$ [dB]
A1	0.01	139	1643	64
A2	–0.05	449	1805	83
B1	–0.30	492	2584	71
C1	0.09	136	1400	70
D1	0.33	697	1389	67
D2	0.25	918	2094	80
D3	0.69	356	1176	61
E1	0.09	74	1000	67
F1	0.43	1285	1449	51
G1	0.03	126	1433	65
G2	0.29	183	1657	60
H1	–0.33	347	1812	74
I1	0.13	690	2020	75
J1	0.66	682	1910	69
J2	0.31	162	761	65
K1	0.72	294	905	75
K2	0.31	97	628	71
L1	0.12	521	1012	64
M1	–0.02	121	1967	74
N1	–0.02	463	867	69
O1	0.42	44	1125	70
O2	0.13	163	1192	75
P1	0.75	915	1181	76
R1	1.10	2655	2023	67

Furthermore, the measured values were compared to the recommended ones. Such comparison is presented in Figure 3. The measured values of thermal and visual comfort parameters were largely dispersed. Thus, in Figure 3 the median values were used for all of the comfort types.

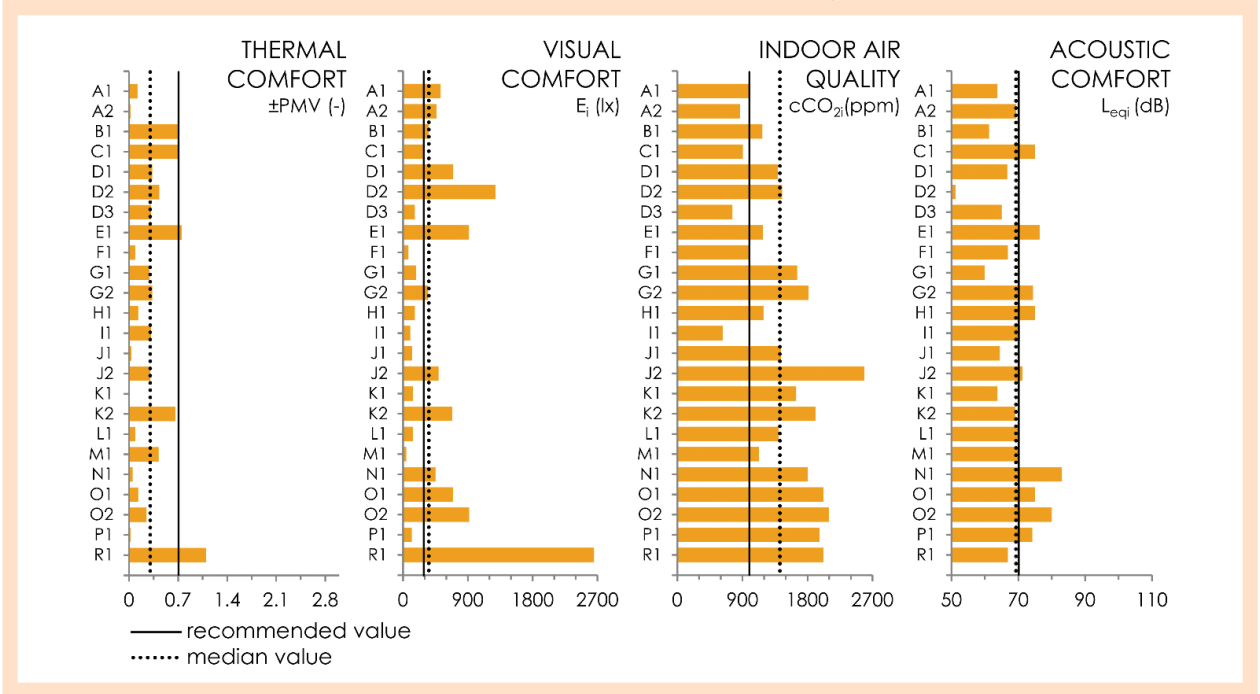

Figure 3:
Comparison of the selected IEQ fields and their parameters for playrooms A1–R1, considering parameters of thermal, visual, acoustic comfort and indoor air quality. Solid line represents the recommended value and dotted line represents the median value of the playrooms. The PMV values are shown as absolute numbers.

If the results are holistically observed, in playrooms A1 and A2 (8% of playrooms) all of the IEQ fields were within the recommended values. In 10 playrooms (42%), only one IEQ field did not meet the recommended values. In the rest of playrooms (50%), two or three uncomfortable IEQ parameters were identified simultaneously. None of the investigated playrooms had all the selected IEQ parameters inappropriate.

DISCUSSION

Poor thermal conditions of indoor environment can have negative impact on comfort and learning skills or may even cause adverse health effects, since children are more sensitive to high air temperatures than adults [12]. The measured air temperatures in the playrooms, which were considered within this paper, were similar to those in the studies conducted in Canada [18], Portugal [16] and Latvia [22], but higher than those in Portugal [44] and lower than those measured in South Korean [12] or Singaporean [23] facilities.

Inadequate control over air humidity of living environment can result in suitable conditions for the growth of mould, which has adverse effects on occupants' health [45–47]. The RH values, which were measured in DCCs during the presented study, were found to be less appropriate (i.e. lower) than those measured in Canada [18], Portugal [28], Italy [13], France [20] or South Korea [12]. At the same time, they were more suitable than in Singapore DCCs [23]. However, the latter is climate consequence of Singapore's high humidity climate.

The measured mean air velocity in the selected DDCs was similar to the values identified by Mors et al. [15] in Netherlands and Yun et al. [12] in South Korea. On the other hand, they were lower than those measured in Singapore by Zuraimi and Tham [23]. In contrast to previously conducted studies [16, 22, 28], where occupants were satisfied with thermal comfort or the reasons for discomfort were too cold thermal conditions, the PPD values identified by measurements of this study were more affected by too warm indoor environment.

The identified CO_2 concentrations (an indicator of ventilation rates) in the investigated Slovenian DCCs were similar to those measured in Portugal [16], Canada [10, 18], Latvia [22] and Poland [19], where in most cases the measured CO_2 concentrations exceeded 1000 or 2000 ppm. However, in comparison to studies conducted in Scandinavian countries [17, 21, 31], France [20] and in Singapore [23], where the average CO_2 concentrations rarely exceeded 1000 ppm, the measured CO_2 concentrations in Slovenian DCCs were higher and, thus, less appropriate.

The results of the conducted measurements of horizontal daylight illuminance show that in 37% of the analysed playrooms the average illuminance values were below the recommended value of 300 lx defined in EN 12464.

The results of the conducted measurements of horizontal daylight illuminance (Figure 3) show that in 37% of the analysed playrooms the average illuminance values were below the recommended value of 300 lx defined in EN 12464. However, it has to be emphasized that only daylighting was investigated (i.e. measured), although the recommendations of the EN 12464 standard relate to lighting in general (i.e. daylighting and artificial lighting). Among the studied playrooms in Slovenian DCCs, the most common reasons for poor daylighting were the window

properties (i.e. area, shape, type of glazing, etc.). In addition, the penetration of daylight was often obstructed by various items attached to the glazing (e.g. shaped paper, drawings). One of the reasons for visual discomfort was also the inappropriate use of shading devices. In other words, in some playrooms shades were in shading position when shading was not needed (e.g. overcast sky, shading of western windows in forenoon). In several playrooms the shading system was even damaged and therefore inoperable for the users. This is a common problem in public buildings, as identified also by De Giuli et al. [29] in their study.

Excessive noise levels in DCCs represent health risk and discomfort for children and staff, which has been considered by numerous studies [25–27]. The measured noise levels in the investigated playrooms were comparable to the findings of some other studies [25, 26] and were relatively high. The problem of excessive noise levels in Slovenian DCCs might be additionally amplified by inappropriate reverberation times, which were highlighted by the findings of Kacjan Žgajnar et al. [48].

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CONCLUSIONS

Holistic approach to the assessment of indoor environmental quality with all the IEQ fields taken into consideration is vital to achieve a universally comfortable and healthy indoor environment. All the parameters of IEQ are by some means directly or indirectly interconnected. Thus, they cannot be assessed separately one at a time. Although some authors (see references [29, 49]) do not advise ranking of buildings with a combined assessment index, a holistic approach is still necessary, where as many comfort parameters as possible should be investigated simultaneously, but not necessarily combined into a single rating. Therefore, a multi-discipline approach and cooperation of experts from different professional fields is encouraged. There are very few studies that would comprehensively and simultaneously investigate thermal comfort, indoor air quality, visual and acoustic comfort. Within the presented paper such approach was used to assess playrooms in the selected DCCs. The IEQ conditions in some of the investigated playrooms did not meet the recommended criteria. However, it must be noted that there was no playroom where all of the four considered comfort types would be inadequate. Moreover, it has to be stressed that the measurement results showed that in 42% of the investigated playrooms only one comfort field deviated from the minimal required and the recommended values (Figure 3). The one uncomfortable condition could stay unidentified if not all the comfort fields were analysed. Contrasting other studies, which deal predominantly with IEQ, the presented results show the importance of holistic approach.

An in-depth analysis of the collected data showed that among the 24 studied playrooms the most critical field of indoor environmental quality was IAQ with 75% of playrooms above the recommended value (1000 ppm). The percentage of playrooms that exceeded the recommendations in the fields of visual and acoustic comfort was also relatively high, with 46% and 38%, respectively. Comparatively, thermal comfort recommendations were exceeded only in 8% of considered playrooms, thus defining

Contrasting other studies, which deal predominantly with IEQ, the presented results show the importance of holistic approach.

This study or similar ones can be used to provide a useful evidence base for the formulation and targeting of policies for improving IEQ in school or daycare buildings.

thermal comfort as the most controlled. According to previously conducted studies (see references [11, 12, 15]), the IEQ recommendations and legal requirements for buildings intended for children should be reconsidered, since children response to the indoor environment differently than adults. In addition, the results of this paper indicate that the legislation regarding IEQ in Slovenian DCCs might be insufficient, since the identified IEQ was better in some other EU countries with generally stricter legal requirements for indoor environment, e.g. Denmark, France and Sweden [50]. This study or similar ones (see reference [30]) can be used to provide a useful evidence base for the formulation and targeting of policies for improving IEQ in school or daycare buildings. Part II of this study further examines the interrelationship between various building characteristics, occupants' behaviour and several parameters of IEQ.

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Original scientific article

Indoor environmental quality (IEQ) in Slovenian children daycare centres. Part II: The interrelationship between building characteristics and IEQ

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ABSTRACT

In the process of building design it is important to consider the interconnected impact of occupants' behaviour and building characteristics on the quality of indoor environment. Moreover, it is necessary to identify how potential energy renovation measures may influence the indoor environmental quality. For this reason, this paper, as Part II of the larger study "Indoor environmental quality (IEQ) in Slovenian children daycare centres", further investigates the results of in-situ measurements, presented in Part I. Additionally, comparative study of the potential impacts of building renovations on IEQ was performed. The IEQ was identified as poorer in renovated (i.e. where windows were replaced) and newly constructed low-energy buildings. Furthermore, the most significant connection was identified between indoor air quality and outdoor temperature, which is most likely the consequence of occupant's behaviour (opening of windows). The results of the study should raise the awareness regarding possible adverse health effects of indoor environment on occupants' health, as well as to serve as recommendations for building designers.

Key words: indoor environmental quality, holistic approach, comfort, public buildings, daycare centres

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INTRODUCTION

The presented paper further extends the analysis of the results to the study of interrelationships between IEQ parameters, environmental conditions and building characteristics of the analysed DCCs.

This is the second part of the larger study "Indoor environmental quality (IEQ) in Slovenian children daycare centres". The first part (Part I: Results of in-situ measurements) of this study presented the data, acquired by in-situ measurements of the selected comfort parameters in randomly selected 17 Slovenian children daycare centres (DCCs). The study compared the collected measured data and thus the conditions in DCC facilities with the policy requirements and recommendations. Furthermore, the IEQ conditions of Slovenian DCCs were compared to the conditions of DCC facilities in other countries, where similar studies had been made. However, the presented paper further extends the analysis of the results to the study of interrelationships between IEQ parameters, environmental conditions and building characteristics of the analysed DCCs. In other words, it was of further interest if building (e.g. age of buildings) or environmental (e.g. outdoor air temperature) characteristics influence any of the considered IEQ parameters. The authors kindly suggest the readers to firstly consider the first part of this study (i.e. Indoor environmental quality (IEQ) in Slovenian children daycare centres. Part I: Results of in-situ measurements) in order to better understand the background of the research presented in this paper.

According to statistical data [1, 2], the number of children enrolled in Early Childhood Education and Care (ECEC) is growing every year. Because the number of children registered in ECEC is increasing, even greater attention must be paid to comfortable conditions in indoor environment of DCCs. The latter must be provided at all times, including the elimination of adverse health effects [3–9]. Increasing number of children enrolled in DCCs results in the shortage of building stock designed specifically for educational purpose. In Europe, only Denmark, Finland, Sweden and Norway do not report any significant imbalances between the demand and supply for the entire ECEC age range [10]. The problem of overcrowded DCCs is usually solved by altering the existing norms for class sizes, or with repurposing of alternative facilities (e.g. remodelling of residential buildings). In Slovenia the government authorities amended the main ECEC legislation in 2010 to allow buildings originally constructed for purposes other than ECEC (e.g. residential, administrative or office buildings) to be used as ECEC settings. During the same year, 118 buildings of this type were brought into use. Several buildings were repurposed and renovated due to their age and increasingly stringent energy saving demands (e.g. modifications of building envelope or Heating, Ventilation and Air Conditioning – HVAC systems, replacement of windows, etc.). Although the executed renovations are ideal opportunities to improve energy performance and at the same time also indoor comfort, this is mostly not the case, as in general only the energy efficiency aspects of the building renovation are addressed [11]. Even more, the aspects of healthy and comfortable living environment are often disregarded, as they represent a "collateral" damage on the path to higher energy efficiency [12]. Thus, some fundamental decisions in building construction design, for example the choice of glazing characteristics, are essential for later behaviour of a building,

Although the executed renovations are ideal opportunities to improve energy performance and at the same time also indoor comfort.

which affects indoor environmental quality [11, 13, 14].The above described situation can in the end unintentionally result in poor indoor environmental conditions and may cause sick building syndrome and/or building related illnesses [15, 16]. Wargocki and Wyon [17] warned that impulsive and oblivious attempts to reduce energy use in buildings could lower a child's learning abilities by 30%. In the last three decades, an increasing number of studies have reported uncomfortable and unhealthy conditions in educational institutions. All the indoor environmental quality (IEQ) fields were more or less investigated with a similar proportion, with most studied definitely being indoor air quality (IAQ). Although IEQ has become a growing concern over time, very few holistic studies have been carried out in DCCs, as most of them considered each field of living or working environmental quality separately, i.e. noise, thermal comfort and indoor air quality, one or two at a time. Nevertheless, De Giuli et al. [18] investigated several indoor environmental quality fields in Italian schools simultaneously. The focus was on measuring indoor environment conditions, which included thermal comfort, IAQ and illuminance measurements.

In the last three decades, an increasing number of studies have reported uncomfortable and unhealthy conditions in educational institutions.

Throughout the process of ensuring and providing comfortable and healthy indoor environment for children, a holistic and multidisciplinary approach is essential. Consequently, the objective of our study was to holistically assess all of the IEQ fields. This was executed on the basis of in-situ measurement results, presented in the first part of this article Indoor environmental quality (IEQ) in Slovenian children daycare centres. Part I: Results of in-situ measurements. The measurement data consisted of parameters of visual, thermal and acoustic comfort, as well as indoor air quality. For a holistic and multidisciplinary study on indoor environmental issues, the objective of our research was to determine the environmental or building related characteristics that influence IEQ on a sample of 24 playrooms in 17 DCCs in Slovenia. The study took place from March to June 2013. The main goal was to get better understanding of the indoor environment conditions in DCCs, which are public facilities and where a lot of building renovations, primarily focused on energy performance, have been or will be conducted in the near future. The stated is of great importance, since DCCs represent an environment that may have a decisive influence on children's physical and mental development. In the first place, the acquired knowledge would enable designers to have better control over potentially negative effects in future building renovations. Finally, the results of the study should serve as a basis for recommendations to building designers for the minimisation and prevention of possible adverse health effects of IEQ on building occupants.

In the first place, the acquired knowledge would enable designers to have better control over potentially negative effects in future building renovations.

METHODS

The research was carried out in 17 randomly selected children daycare centres (anonymised and denominated by letters A–R) located in Slovenia, which included 24 playrooms intended for children aged 3 to 5. The research took place at the targeted DCCs from March to June 2013.

The methodology of the performed measurements and data preparation is presented in the first part of this study: Indoor environmental quality (IEQ) in Slovenian children daycare centres. Part I: Results of in-situ measurements. For the purpose of better interpretation of results, basic building characteristics of the analysed facilities are once more presented in Table 1. Buildings A, C and E were three out of 118 buildings in Slovenia originally constructed for purposes other than ECEC (residential buildings) and later adapted and used as DCCs. All other buildings included in the analysis were purposely designed and built as DCCs between 1963 and 2013. Among the analysed facilities, two were constructed in the last 10 years (i.e. P and R, 2012 and 2013, respectively) and were designed as low energy buildings. All other DCCs were constructed before the 1963.

Table 1: Basic information and building characteristics of selected DCCs

Daycare centre	Year of construction	Recent renovation[b]	Playroom No.	Playroom occupation (children + staff)	Floor area [m^2]	Floor area per occupant [m^2/occ]	Volume [m^3]	Area of windows [m^2]	Orientation of majority of windows, azimuth [°]
A	1952	Yes	A1	14 + 2	35.7	2.2	102.2	7.3	W, 290
			A2	20 + 2	35.8	1.6	112.2	10.3	W, 290
B	1979	Yes	B1	19 + 2	52.7	2.5	155.5	16.8	W, 292
C	1899	Yes	C1	14 + 2	35.2	2.2	131.5	11.5	E, 100
D	1963	No	D1	18 + 2	44.6	2.2	161.1	20.8	NW, 310
			D2	16 + 3	37.2	2.0	116.8	15.5	S, 178
			D3	16 + 1	46.9	2.8	142.6	13.8	SE, 130
E	1906	No	E1	14 + 2	36.3	2.3	127.4	3.3	W, 275
F	1979	No	F1	19 + 3	39.0	1.8	116.5	14.8	E, 100
G	1979	Yes	G1	14 + 2	41.9	2.6	151.7	10.0	S, 160
			G2	14 + 2	36.0	2.3	164.2	13.1	SE, 150
H	1976	Yes	H1	16 + 2	44.6	2.5	133.8	16.7	SW, 210
I	1973	Yes	I1	18 + 2	43.7	2.2	128.6	15.0	SE, 142
J	1982	No	J1	20 + 2	33.8	1.5	113.3	11.5	SE, 128
			J2	15 + 2	32.9	1.9	111.0	11.8	S, 149
K	1976	Yes	K1	18 + 2	38.2	1.9	99.4	10.7	E, 80
			K2	21 + 2	46.8	2.0	145.9	13.4	SE, 128
L	1976	No	L1	20 + 2	41.0	1.9	132.8	18.4	S, 172
M	1979	No	M1	14 + 3	42.4	2.5	122.1	9.9	SW, 220
N	1971	No	N1	17 + 2	50.3	2.6	174.5	21.5	S, 180
O	1972	Yes	O1	13 + 2	44.7	3.0	134.1	11.6	S, 200
			O2	17 + 2	49.1	2.6	146.3	13.2	S, 158
P[a]	2013	No	P1	21 + 2	39.2	1.7	118.0	17.3	S, 178
R[a]	2012	No	R1	17 + 2	43.6	2.3	132.2	15.4	S, 164

[a] Low-energy DCCs; [b] Energy retrofit: replacement of windows.

All the required data were then collected and prepared for further investigation. The data were directly transferred to MS Excel software environment, where a database was made and prepared for additional processing.

The main purpose of the study was to analyse the interrelationships among the selected boundary conditions and IEQ parameters. In general, the selected boundary conditions of interest can be divided into two groups, namely building characteristics and environmental characteristics.

The investigated boundary conditions of building characteristics were as following: the year of construction of building, playroom volume, playroom volume/occupant, ventilation mode (natural or mechanical), window orientation and window to flor ratio (WFR), and whether the DCC has been energy retrofitted or not. Comparatively, the investigated boundary conditions of environmental characteristics were the number of playroom occupants and outdoor air temperature. In addition, it was investigated whether the replacement of windows, as an energy renovation measure, has any impact on IAQ (i.e. concentration of CO_2) or not. Beside the studied correlations between the selected boundary conditions and IEQ parameters, the potential correlation between different IEQ parameters was investigated as well.

RESULTS AND DISCUSSION

Although many of the possible correlations between the selected boundary conditions and IEQ parameters were investigated, the following subsections represent only several selected results. In the majority of cases the selected results represent the most significant findings, where potential correlation between studied IEQ parameters and boundary conditions can be drawn. Every field of IEQ is presented separately.

Thermal comfort

Observing Figure 1, a weak correlation can be identified, showing that poorer thermal comfort conditions (higher percentage of people dissatisfied with thermal comfort, i.e. PPD) can be recognised in newer DCC facilities. In this case, high PPD values were mostly the consequence of high indoor air temperatures in comparison to prescribed values. However, this may be the result of higher outdoor air temperatures during the measurements in these facilities (Figure 2). The latter is even more apparent in the case of the two low-energy DCCs. Thus, it cannot be presumed that thermal discomfort in the investigated playrooms was necessarily a result of older building age. Similarly, in their study in Latvian DCCs Stankeviča and Lešinskis [19] reported that the temperatures were the highest in two newly-built DCCs that both had an underfloor heating system and a mechanical ventilation system, which is the same situation as for both low-energy DCCs (i.e. P and R) in the presented paper. Nevertheless, Ruotsalainen et al. [20] reported the opposite trend in Finish DCCs, where indoor air temperatures and the corresponding thermal comfort were on average significantly lower in older buildings, which were, however, mechanically ventilated.

The findings presented in Figure 2 show that PPD values grow with the increase in outdoor air temperature, which indicates a presence of correlation between PPD and outdoor air temperature. This may be the result of non-existent cooling system in the selected facilities, which operate in a free run mode during cooling season. Furthermore, thermal comfort in mechanically ventilated facilities strongly deviated from that in facilities with natural ventilation, especially in playroom R1 with PPD value of 29%. Inappropriate design or use of mechanical ventilation

The findings presented in Figure 2 show that PPD values grow with the increase in outdoor air temperature, which indicates a presence of correlation between PPD and outdoor air temperature.

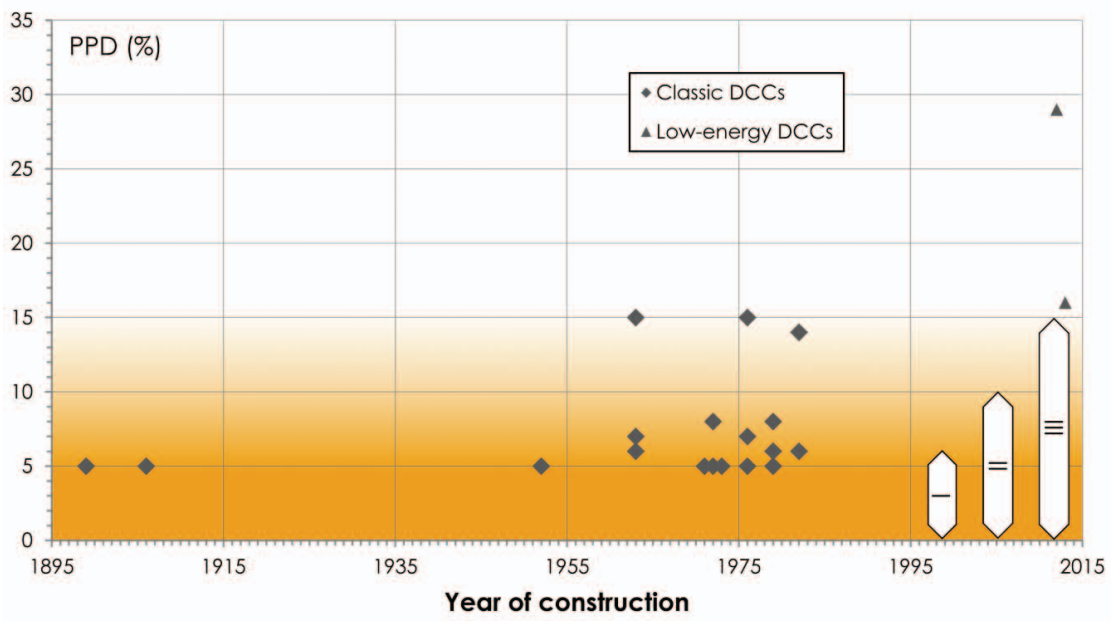

Figure 1: Percentage of people dissatisfied with thermal comfort (PPD) in all the considered playrooms compared with the building's year of construction. Roman numbers I, II and III represent classes of thermal comfort defined in EN 15251:2007.

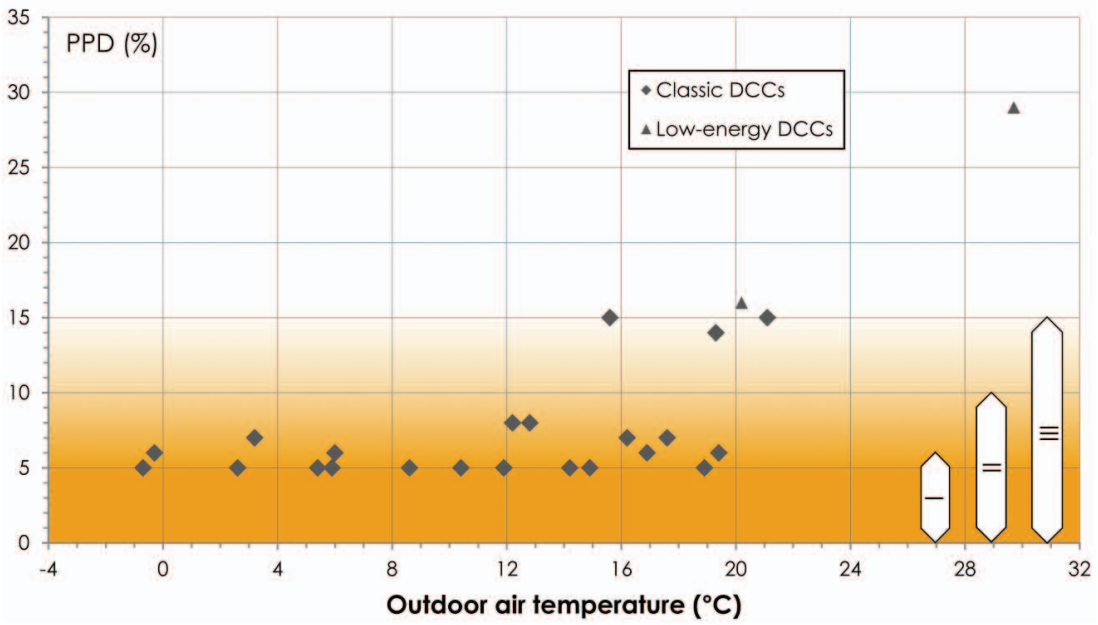

Figure 2: Percentage of people dissatisfied with thermal comfort (PPD) in all the considered playrooms compared with the average outdoor air temperature during measurements. Roman numbers I, II and III represent classes of thermal comfort defined in EN 15251:2007.

system could be one of the possible causes for thermal discomfort. As mentioned in Part I of the study, the highest CO_2 concentrations were also identified in playroom R1, which has an above average floor area per occupant ratio (Table 1). Therefore, high CO_2 concentrations are probably related to building characteristics or building use.

Indoor air quality (IAQ)

In the context of indoor air quality, the first correlation investigated was the correlation between the percentage of people dissatisfied with indoor air quality (PPD_{IAQ}) and the volume of playroom per occupant. The latter has in general a considerable impact on IAQ, since greater volume of air means that there is more breathing air available per occupant. The volume of playroom per occupant varied between 4.97 m^3/occ in playroom K1 and 10.26 m^3/occ in playroom G2, which had the greatest ratio, while the average value is 7.22 m^3/occ. However, playroom G2 was among playrooms with the worst IAQ (highest concentrations of CO_2 were measured). The results in Figure 3 show that, surprisingly, there is no obvious correlation between the volume of playroom per occupant and the predicted percentage of dissatisfied with indoor air quality. Therefore, because indoor concentration of CO_2 is also directly connected to the volume of indoor air, it can be said that other influential parameters have much greater effect on IAQ than the volume/occupant ratio. One of such parameters is definitely occupants' behaviour. In this study, the latter is investigated through a search for the correlation between PPD_{IAQ}, temperature of outdoor air and teachers' behaviour (i.e. decision to open a window or not) in Figure 4.

In the context of indoor air quality, the first correlation investigated was the correlation between the percentage of people dissatisfied with indoor air quality (PPD_{IAQ}) and the volume of playroom per occupant.

Similar to the interpretation of PPD values in Figure 2, PPD_{IAQ} values in the investigated DCCs (Figure 4) show a probable dependence on outdoor air temperature as well. The trend is evident for the playrooms with natural ventilation, since the teachers in these playrooms opened windows or doors towards the outside (i.e. they naturally ventilated the playroom) more often, when the outdoor air temperatures were higher. No evident connection can be identified in the cases with mechanical ventilation system, as such systems are usually programed to ventilate rooms at a constant rate. However, it can be concluded that naturally ventilated playrooms had better IAQ than the ones with mechanical ventilation (low-energy DCCs). This is more apparent when observing the PPD_{IAQ} value in the case with mechanical ventilation in relation to the other naturally ventilated playrooms with the same outdoor temperature (about 20°C) (Figure 4). In this instance, the PPD_{IAQ} of mechanically ventilated DCCs was approximately 10 percentage points higher than in the case of naturally ventilated ones. The trend line in Figure 4 presents the connection between PPD_{IAQ} and external air temperatures for naturally ventilated playrooms. It was generated according to the conducted measurements, but excluding the values for playrooms D1, I1 and J1 (marked with doted ellipse). The measured values for the stated playrooms greatly diverge from the trend evident in other naturally ventilated playrooms, due to external causes connected to the use of the rooms. Comparison of playrooms in the same DCC facilities (i.e. D2 to D1 and D3 as well as J1 to J2) shows

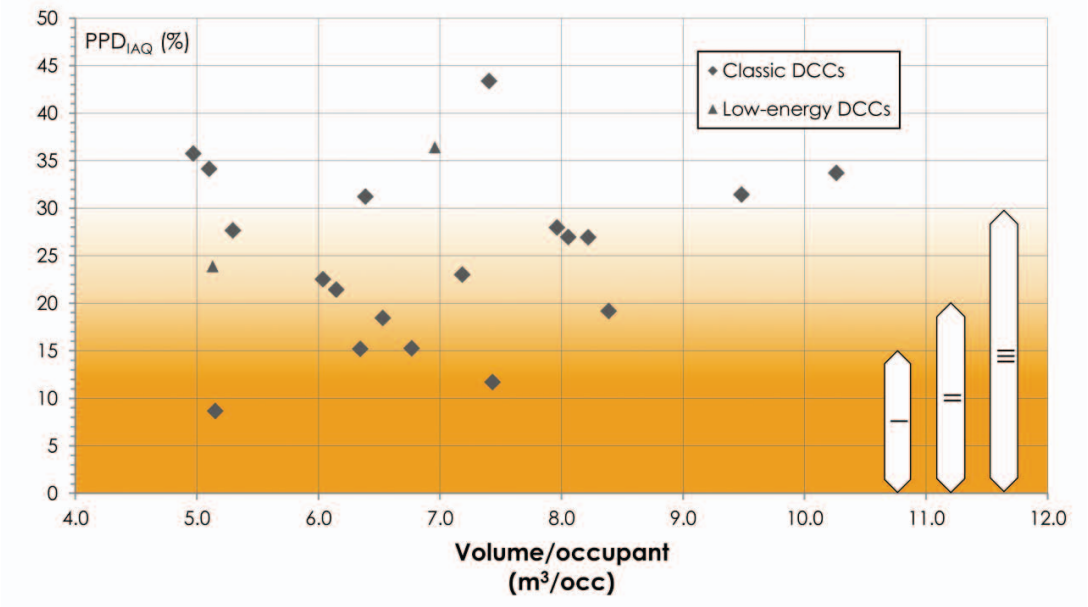

Figure 3: Percentage of people dissatisfied with indoor air quality (PPD_{IAQ}) in all the considered playrooms compared with the volume of playroom per occupant. Roman numbers I, II and III represent classes of indoor air quality defined in EN 15251:2007.

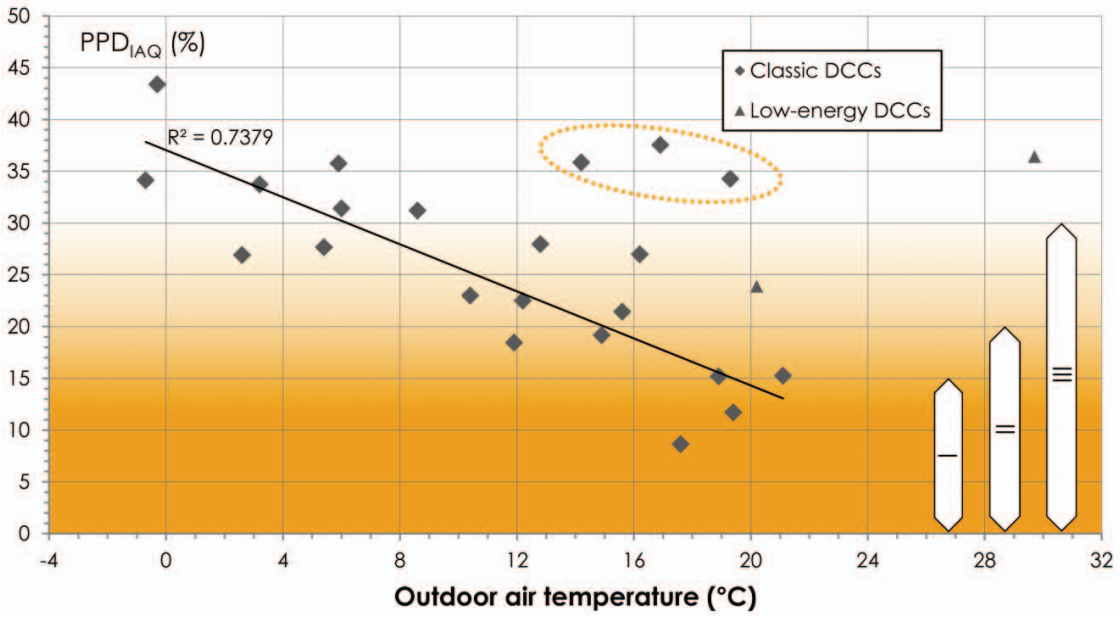

Figure 4: Percentage of people dissatisfied with indoor air quality (PPD_{IAQ}) in all the considered playrooms compared with the average outdoor air temperature during measurements. Roman numbers I, II and III represent classes of indoor air quality defined in EN 15251:2007. Trend line was calculated only for playrooms with natural ventilation, excluding playrooms D2, I1 and J1, marked with dots.

that the high values of PPD_{IAQ} are probably the cause of occupant interaction with the built environment (e.g. teachers opening windows only when the children left the playroom due to the institutional internal rules as in the case of playroom I1). In other cases the reason why the playrooms were inadequately ventilated by teachers was in the external environment, as in the case of D2 when due to the mowing of the lawn the windows were kept shut during the conducted measurements in order to block high levels of external noise (L_{eqe} = 75 dB).

Although the majority of the playrooms used natural ventilation as a ventilation mode, poor IAQ was still identified in several such cases. Teachers were reluctant to open windows or doors to naturally ventilate playrooms when outdoor temperatures were low or precipitations were present. Similarly, Cano et al. [21] noticed that teachers seldom open windows when outdoor temperatures are low, while Andersen et al. [22] and Dubrul [23] showed that occupants in general open windows more often and for longer periods during sunny weather. Correspondingly, since opening of windows in such situations cannot provide the optimal indoor conditions, Stankeviča and Lešinskis [19] recommended the use of a more efficient ventilation system (i.e. mechanical). Nevertheless, in order to ensure the highest level of hygienic conditions, regular maintenance and supervision of such systems is necessary.

However, since mechanical ventilation can have its benefits (i.e. is occupant independent), a number of parameters influence its functioning as well. The latter can again result in poor IAQ, if the ventilation regime is not properly designed or its continuous maintenance is not performed. Hence, it was of further interest, if there are any differences in the IAQ of old, renovated or mechanically ventilated facilities. On the basis of Figure 5 it can be assumed that energy renovation of DCC facilities (i.e. replacement of windows) that were naturally ventilated had a negative impact on IAQ. The higher CO_2 concentrations in renovated DCCs are probably the

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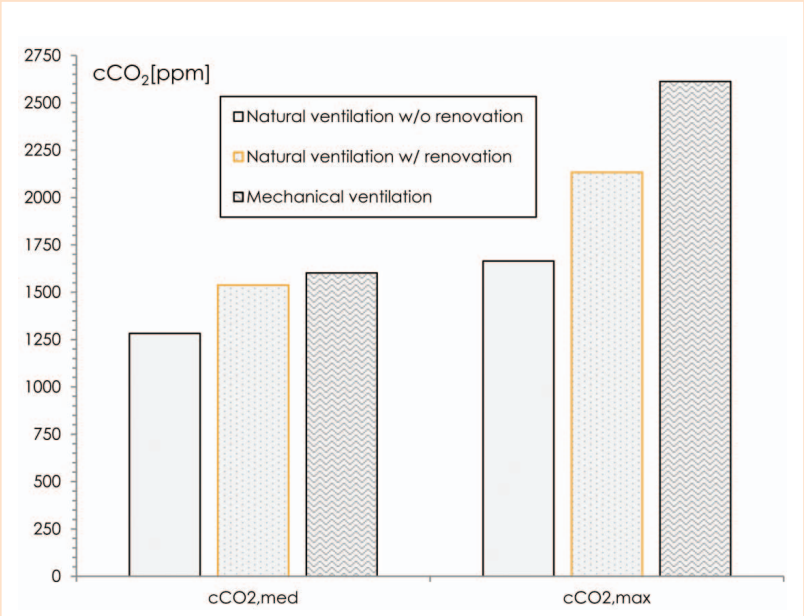

Figure 5:
Median values and mean maximal values of CO_2 concentrations, measured in the considered playrooms, divided in three different categories: playrooms with natural ventilation w/ (N=12) or w/o (N=10) recent renovation (i.e. replacement of windows) and playrooms with mechanical ventilation (N=2).

Nevertheless, the occupants' air ventilation habits remain the same as before the renovation.

result of new windows, which are better sealed and thus the uncontrolled infiltration of external air is lower. Nevertheless, the occupants' air ventilation habits remain the same as before the renovation. Therefore, it is essential to assess the potential impact of the performed energy renovation measures on indoor environmental quality in DCC facilities. Moreover, the staff (e.g. teachers, managers, janitors) should be informed and educated about the consequences of executed energy renovations in order to adjust their behaviour appropriately. Unexpectedly, the measured CO_2 concentrations in new low-energy DCCs with mechanical ventilation systems were also quite high. This is probably the result of inappropriately designed ventilation system and of thoughtless wish to achieve greater energy savings of building, ignoring IEQ at the same time. Nonetheless, in some investigated playrooms the teachers noticed poor IAQ conditions by themselves as well.

Visual comfort

The trend of the insufficiently naturally lit playrooms can be to some degree related to the external weather conditions, as insufficient illuminance of the work plane was mostly recorded during overcast sky conditions (Figure 6). Overcast sky conditions were present in 77% of measurements in the analysed playrooms where the average work plane illuminance was below the 300 lx threshold. On the other hand, as expected, the playrooms with larger areas of transparent elements (i.e. windows) exhibited higher levels of indoor illuminance. This can be seen from the trend lines generated for overcast and intermediate sky condition measurements presented in Figure 6.

However, this relationship between indoor illuminance and building envelope configuration is also dependent on the orientation of the windows, as it can be observed from the results measured during clear sky conditions (Figure 6), where larger windows do not necessarily mean

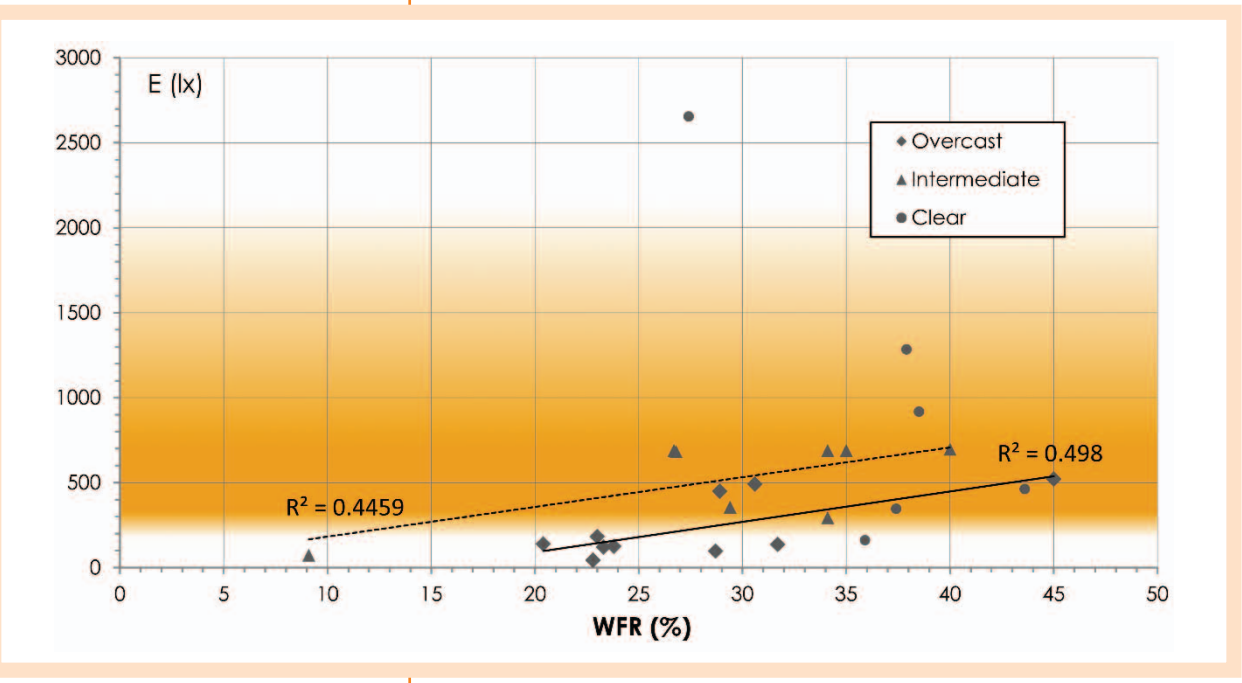

Figure 6: Mean daylight illuminance of working plane (E) in all the considered playrooms compared to the WFR. Playrooms are classified by the sky condition in three classes: overcast, intermediate and clear sky. The solid trend line is calculated for playrooms with overcast sky conditions, the dashed trend line for those with intermediate sky conditions.

better indoor visual comfort [24, 25]. High values of indoor illuminance can also cause occupant discomfort. Therefore, they represent a source of dissatisfaction with indoor visual environment, mainly due to the occurrence of glare. An upper limit of 2000 lx (Figure 6) for average indoor illuminance was set in the conducted analysis on the basis of Useful Daylight Illuminance metrics proposed by Nabil & Mardaljević [26, 27], where horizontal illuminance levels above this value indicate higher level of glare occurrence [28]. Only one case (i.e. R1) exhibited average values above 2000 lx during the time of conducted measurements. However, this does not mean that in other cases localized parts of the playrooms were not illuminated above the upper threshold.

Acoustic comfort

Although potential links between noise level and building characteristics were investigated, no specific correlations were found. Thus, the number of children in playrooms or the volume of playroom per occupant had no evident effect on the measured noise levels. Moreover, no clear association was detected between the noise level in the playrooms and other types of discomfort. Specifically, no correlation was identified between the measured equivalent noise level and PPD (Figure 7) or PPD_{IAQ}, where it was speculated that children would make more noise when dissatisfied with the thermal comfort or the quality of indoor air. Notably, Figure 7 clearly illustrates that for the selected sample of playrooms, no evident correlation between noise level and PPD can be identified, since playrooms with the worst PPD (e.g. playroom R1), were not necessarily also the noisiest. However, no correlation between the parameters of acoustic comfort and other investigated parameters was identified during the conducted analysis. Although this may be the case, the phenomenon is worth of further investigation in order to identify whether the connection exists or not.

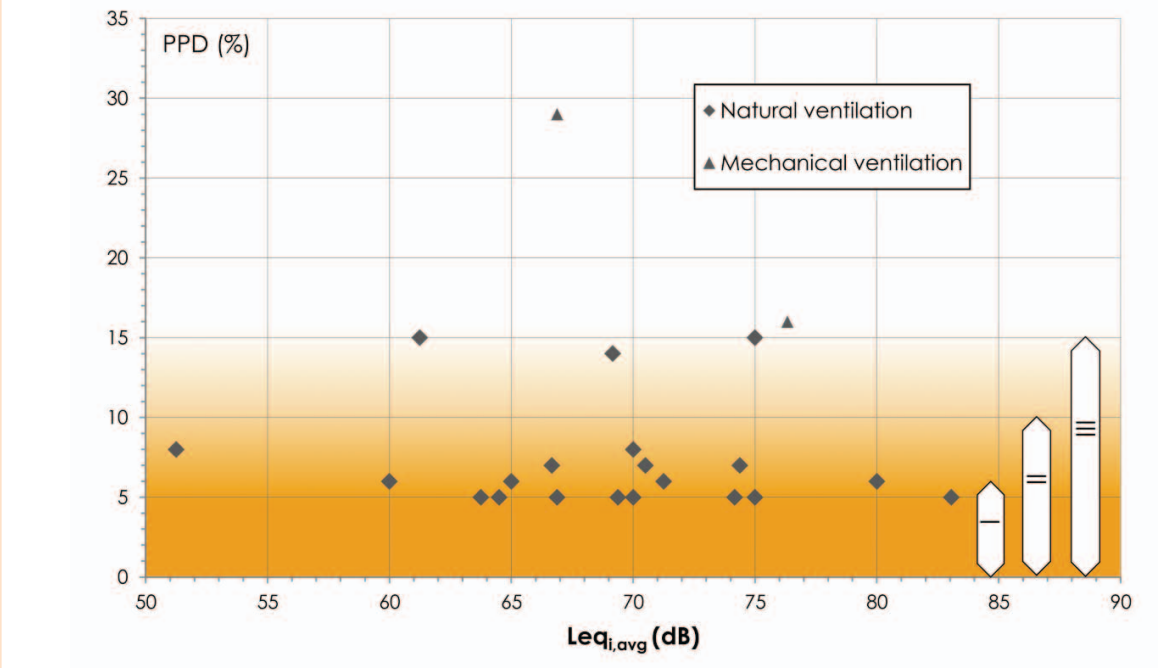

Figure 7:
Percentage of people dissatisfied with thermal comfort (PPD) in all the considered playrooms compared with the average measured noise level. Roman numbers I, II and III represent classes of indoor air quality defined in EN 15251:2007.

STUDY LIMITATIONS

Although this research was carefully prepared, we are aware of its limitations. One of the greatest limitations is the sample size of the analysed children daycare centres. Because the sample of 24 playrooms is relatively small, no certain statistical correlation can be determined. However, the identified relationship between the studied IEQ parameters and environmental boundary conditions was in some cases weak or even non-existent (e.g. acoustic comfort), while in other instances it was strong (e.g. relationship between PPD_{IAQ} and external air temperatures). Even though some of the presented results probably do point to a trend connecting certain studied parameters, they should still be used with caution due to a small sample of buildings and varied environmental conditions encountered during the conducted measurements. Furthermore, in order to get more accurate results, IEQ parameters should be monitored and measured through a longer time span. For instance, monitoring of IEQ parameters should be conducted during several months, preferably including both heating and cooling season and for the entire period of occupied hours of DCC.

Even though some of the presented results probably do point to a trend connecting certain studied parameters, they should still be used with caution due to a small sample of buildings and varied environmental conditions encountered during the conducted measurements.

Another limitation of the study is that there is not enough prior research available in the field of indoor environmental quality in Slovenian children daycare centres. Consequently, there are no or very few available data to, for example, compare IEQ in the same facility before and after the executed energy renovation. Therefore, further research in this field is highly encouraged.

CONCLUSIONS

Occupants play a key role in the design of buildings and their indoor environment, especially if they are a vulnerable population (e.g. children). However, initial design decisions on the level of building envelope largely influence further response of a building, as shown by Hudobivnik et al. [13] and Pajek et al. [29]. Therefore, thoughtful design decisions should be encouraged, because designers rarely holistically analyse the building behaviour before it is put into use. In addition, the potential negative impacts of energy renovation of buildings on IEQ have to be taken into account, where the wish for smaller energy use in buildings in most cases dominates over other design criteria [11]. Similar conclusions were shown by Perino et al. [30] for residential buildings, where energy renovations had a negative impact on IAQ. Consequentially, it can be assumed that in DCC facilities this problem could be even more pronounced (Figure 5) due to higher occupant density. Thus, it is on one hand necessary to understand how the energy renovation measures will influence the indoor environment and on the other to educate the occupants how to use the renovated building, as higher levels of building envelope's air tightness will result in lower air changes and consequentially lower IAQ. This was already identified by Langer and Bekö [31], reporting that newer buildings were characterised by lower air change rates and therefore higher levels of indoor pollutants. Nevertheless, outdoor air quality also has an evident impact on indoor envi-

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ronment and should be considered as well [32]. In the case of buildings with mechanical ventilation system applied, the design and use of the system should be occupant-requirement based and not influenced only by the energy-saving potential of lower ventilation rates. This is very important, because mechanical systems are more user independent than natural ventilation, which can be manually regulated by the occupants according to their needs and wishes.

Acknowledgements

This study was conducted in collaboration with the selected children daycare centres in Slovenia. The children daycare centres included in the research were randomly selected and were given free choice to participate or not in the research. The authors gratefully acknowledge cooperation of the managers and educators of the participating day care centres, field technicians and other project collaborators.

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Original scientific article

Use of a nudge tool for improving hand hygiene in a nursing team in home for elderly people – case study

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ABSTRACT

The prevention and control of healthcare-associated infections are one of the most important indicators of quality in healthcare institutions and their employees. For this purpose, experts in this field are attempting to find improvements; one of them is called "nudging". This study aims to present the importance of providing hand hygiene quality in nurses and to analyse the effectiveness of a selected nudging tool in practice. An observation checklist was made to evaluate nurses in a selected nursing home in Ljubljana. Based on data analysis, a picture of male eyes as hygiene promotion and how it affects the change in hygiene compliance of the nurses was tested. After a change in the environment, hand hygiene improved; the greatest improvement was seen prior to the preparation of devices for personal hygiene, before the procedure, after washing the patient's face, body, back and hands, after washing the feet, and after the whole procedure was completed. With the use of behavioural theories, better hand hygiene compliance can be achieved. It can be concluded that nudging may help us prevent and control healthcare-associated infections and provide a higher quality of life for residents and, consequentially, improve the quality of nursing care.

Key words: nursing care, hand, hygiene, elderly, behaviour, employees

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Healthcare-associated infections (HCAI) are very common and are one of the most widespread adverse events in healthcare.

INTRODUCTION

The elderly represent a large and increasing segment of the population throughout the world. According to the EUROPOP2008 population projections, people older than 79 are expected to triple in number by 2060, and since long-term care begins to rise exponentially at around 75 to 85 years of age, rapid growth in demand for such service is inevitable for the next fifty years or so [1]. Because of their age, illness, motor disability, general weakness, and dementia, more and more of the elderly live in nursing homes. Healthcare-associated infections (HCAI) are very common and are one of the most widespread adverse events in healthcare. HCAI not only bring financial costs, but extend hospitalization, make a significant contribution to patient mortality, and to permanent disability. Prevention and control of HCAI is one of the most important elements for providing patient safety and an indicator of the work quality among nurses and homes for the elderly [2, 3]. Hand hygiene is considered the most important intervention to prevent and control the spread of HCAI. Nurse's hands are the most common means of transferring microorganisms from the colonized, infected patient, and his environment to other patients. Inconsistent hand hygiene is present in all environments, in the developed and developing worlds and in all profiles of healthcare professionals. The reasons for the inconsistency are many and dependent on the environment, infrastructure, cultural differences and even religion [4]. Numerous research studies state that lack of experience, overburdened schedules, heavy workloads, lack of knowledge and insufficient washing basins are reasons for poor hand hygiene among nurses in the nursing homes. In most cases, hand hygiene is previously used to protect nurses, rather than to protect residents, because the compliance of hand hygiene is higher after contact with the patient than before. More nurses provide better hand hygiene after contact with body fluids in comparison to other forms of contact with the residents or their surroundings [5].

Prevention and control of HCAI is one of the most important elements for providing patient safety and an indicator of the work quality among nurses and homes for the elderly.

Experts for providing and controlling HCAI are striving to eliminate factors that contribute to poor hygiene of the hands. One current method of improving hand hygiene compliance is called nudging [6]. The idea originates from economics, but it can be used in many areas, including nursing care. It is about behaviour that can be influenced by subconscious cues in the environment, such as sights, smells, and sounds. Nudging acts outside of our conscious awareness and influences our behaviour and cognition. By using the elements of nudging, better results in the field of hand hygiene compliance can be achieved, which, in theory, leads to reducing the incidence of HCAI [7, 8]. The main reasons for using nudging in healthcare are to improve public health (encouraging healthy eating habits, regular physical activity, less smoking, less stressful lifestyle, reducing body weight, etc.); reducing the need for treatment, which is a great expense and, finally, an improvement in the quality of life during hospitalization or living in nursing home [9].

In this way, some hospitals in America have attempted to improve their employee's hygiene. As a nudge, a clean, fresh citrus smell, which came from an aroma dispenser, was used, accompanied by a photograph of

male eyes that was prominently displayed above the alcohol dispenser. The results have shown that people exposed to these specific cues had better hand hygiene compliance [7, 8].

There are other ways to improve hand hygiene compliance. Which alcohol dispenser in the corridor of the hospital is mostly used was observed. Above the dispensers, signs were placed that defined dispensers from the least used (5th place) to the most used (1st place). After these signs were installed, alcohol dispensers were used 250% more frequently than before [10]. A similar study was made at the Gentofte Hospital in Denmark. The nudge consisted of three parts: placement, colour, and normative message. Researchers spent five days watching the frequency of the visitor's hand disinfection. In the Medical Department, alcohol dispensers were primarily located above the sinks inside the hospital wards. The choice of using hand sanitizer is thus offered at a seemingly late point in time, competing against the choice of approaching one's hospitalized relative. For this purpose, they introduced a freestanding alcohol dispenser at the entrance the Medical Department. Disinfectants and dispensers are usually transparent, which made them blend into the surrounding environment. The researchers, therefore, introduced a red sign right above the freestanding dispenser. The last prime was the text message printed on that red sign: "Here we use hand disinfectant in order to protect your relatives". The first part of the text ("Here we use hand disinfection") informs visitors about the most acceptable behaviour in relation to hand hygiene at the hospital. The second part of the text ("in order to protect your relatives") was used to make the consequences of hand hygiene compliance more tangible to visitors by giving them a plausible reason as to why they should engage in positive hand hygiene behaviour. The results indicate that the visitor's hand hygiene compliance, after the introduction of the freestanding alcohol dispenser, increased up to 17%, and after putting the red sign above the freestanding dispenser, up to 64%. The research was not intended for nurses but for hospital visitors, but the same environmental cues could also be used among hospital employees [11].

Researchers spent five days watching the frequency of the visitor's hand disinfection.

Hand hygiene compliance can also be influenced by technological promoters. One example is an LCD TV screen which shows what percentage of people washed their hands after using the toilet [12]. The next example is the BIOVIGIL device, which aims to exploit emotional embarrassment. The BIOVIGIL system uses traffic-light colours: green, yellow and red. It works in conjunction with a badge clipped to workers' shirts, which communicates with infrared sensors put in patient's rooms. When the physician or nurse washes his/her hands, they hold them up to the badge's sensors, which will determine whether they are germ-free. If they are, the badge turns green, but if they are not, it turns red. This reminds the patient that a physician or a nurse with dirty hands will touch him. This encourages hospital employees to take care of hand hygiene, as nobody wants to walk around wearing a red badge [13, 14].

Hand hygiene compliance can also be influenced by the visibility and accessibility of alcohol dispensers. Most studies recommend the installation of alcohol dispensers at the entrances and exits to the patient's room and

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They took 10 samples from the medical staff's hands and then showed them pictures of cultures similar to the contamination on their hands.

its surroundings, and near the toilets [15]. The next visual cues were images of bacterial growth designed to motivate hospital staff to comply with hand hygiene regimes. They took 10 samples from the medical staff's hands and then showed them pictures of cultures similar to the contamination on their hands. In a very short time, their hand hygiene compliance increased, which proves that visual triggers are an effective way to motivate nurses and other healthcare providers to clean their hands more often [16]. Automatic dispensers for paper towels in public toilets have been installed to stimulate hand washing, which present a towel with or without user activation. The use of towels was 22.6% higher and the use of soap 13.3% higher [17]. Visual cues also include signs at the door before entering the room. On a piece of paper, the following was written in red: "Warning, this room is under constant supervision of hand hygiene. An error will trigger an alarm, and the violation will be reported." This nudge has been the most successful of all [18].

This research aims to present the importance of ensuring the quality of hand hygiene (with emphasis on hand disinfection) of employees in nursing care and analyses the effectiveness of a selected nudging tool in daily practice among selected nurses.

METHODS

Between October 2016 and February 2017, a literature review on the COBIB.SI, Medline (PubMed), CINAHL, Cochraine and Web of Science databases over a ten-year period (2007–2017) was performed. An intervention study has been made. For the data collection regarding the hand disinfection of eight nurses, an observation checklist was made. Criteria for observing the hand disinfection were determined on the basis of standards of nursing activity [19]. The process of hand hygiene was observed, with an emphasis on hand disinfection. In the measuring instrument (observation checklist), the first column listed the opportunities for hand disinfection (i.e. procedures from the beginning of the personal hygiene procedure to the end, in sequence). Afterwards, whether the nurse performed the hand disinfection properly and in accordance with the standards or not was marked. Does she or he use a sufficient amount of disinfectant (3 ml or two pushes on the dispenser), does hand disinfection last at least 20 s, or disinfect all areas of the arm in the prescribed order (palms, fingers, middle areas and back of the hand) and disable transmission of microorganisms from one part to another [20]? In the observation checklist, there was also a space for observer comments on the conditions during the observation. The last column in the observation checklist was intended to indicate the disturbing and warning factors that remind or deter the observed nurse from acting correctly (e.g. observer presence, full hands, dry and damaged skin of the observed, too much work, forgetfulness, less probability of transmission of infection, disagreement with recommendations, lack of information, thinking that after using gloves, it is not necessary to disinfect the hands, jewellery and long nails, which does not provide correct hand hygiene compliance, call of patient / colleague / physician and personal beliefs).

Afterwards, whether the nurse performed the hand disinfection properly and in accordance with the standards or not was marked.

The observation process took place in a nursing home in Ljubljana from 30 January to 1 March 2017. For the purpose of the observation process, we selected eight nurses, at the nursing care workplace, based on previously obtained consent, from the director of the observed Home for Elderly People. Data processing and names of the selected nurses were anonymous. Three observations per day were carried out, from 7 am to 9 am in the morning shift, in the implementation of personal hygiene of two or three residents. Each nurse was observed throughout the entire work process, but not all the eight observed were observed for equal amounts of time, due to the different working schedules. At the time of observation, notes were made in the observation checklist. The first phase of observation process was carried out without the selected nudge tool, and the second phase was performed with the selected nudge tool (picture of male eyes above the alcohol dispensers). All images were coloured, with dimensions of 6 × 17 cm. Both phases last 14 days. This was followed by a re-analysis of data and a comparison of the results of the first and second observations. The acquired data were processed using MS Excel software. Frequencies and ratios were calculated according to the equation (E1) [21]. A summary presentation of the results was presented in a diagram, and the most common reasons for abandonment or improper hand disinfection were represented.

$$\text{Consideration of hand hygiene} = \frac{\text{number of actual}}{\text{number of occasions}} \times 100$$

RESULTS AND DISCUSSION

There were 75 observations of hand disinfection of 8 nurses in the nursing team without nudging, and then another 75 observations of hand disinfection with nudging. Eight observers represent 16% of all employees in the nursing team. Table 1 shows the results of observing hand disinfection without nudging, with it, and the causes of noncompliance in hygiene behavior. Since all of the eight observed were not observed at the same time and since each of the observed was observed several times a day and several days in a row, the object of the observation is not the number of people who have properly disinfected their hands, but the number of hand disinfection observations. The most correct hand disinfections were performed at the seventh criterion (putting the new gloves on and performing anogenital care; after this is done, gloves are taken off, and hands are disinfected). In 71 observations, the observed nurse disinfected his/her hands correctly. Hand hygiene compliance was also good at the third criterion (i.e. use of gloves immediately before washing areas that are dirty with blood, secretions, saliva, washing the anogenital area and legs; after use of gloves, hands are disinfected). At 67 observations, the nurse observed disinfected his/her hands correctly. At the sixth criterion (i.e. changing the water, disposable washbasin and clothing, following which hands are disinfected) disinfection was done the least or almost never, because this procedure, followed by hand disinfection, was not executed. At a nursing home, nurses do not put the lotion on residents' skin after personal hygiene is made, they do not change the water

The first phase of observation process was carried out without the selected nudge tool, and the second phase was performed with the selected nudge tool.

At a nursing home, nurses do not put the lotion on residents' skin after personal hygiene is made, they do not change the water for each resident, and gloves are rarely changed.

for each resident, and gloves are rarely changed. In addition, hand disinfection was worse at the fourth criterion (i.e. washing the patient's face, body, back and hands, followed by hand disinfection). The observed nurses disinfected their hands in 37 observations at the fourth criterion. After completing the first part of the observation, a tool to promote hand hygiene compliance (picture of male eyes above the alcohol dispensers), was introduced, and then the entire procedure of hand disinfection was observed again. The most compliant observed nurse disinfected his/her hands in accordance with the seventh criterion (i.e. putting the new gloves on and performing anogenital care, following which, gloves are taken off, and hands are disinfected). At the seventh criterion, there were 71 observations. It was established that the observed nurse disinfected his/her hands correctly. The eighth criterion (i.e. gloves are put on again, the lotion is put on the residents and hands are disinfected) was observed the least or almost never. The results are shown in Table 1, in which 100% means that the observed nurse correctly disinfected his/her hands 75 times out of 75 opportunities.

Table 1: Results of hand disinfection observation at the observed nursing team, during the personal hygiene procedure and reasons for non-accomplishment of hygiene requirements

Criterion of observation	A (*n*)	A Ratio (%)	B (*n*)	B Ratio (%)	Reasons for non-accomplishment of hand disinfection
1. Hand disinfection and preparation of the items for personal hygiene.	30	40	45	60	Forgetfulness, conversation with an employee rush, dry skin, observed nurse did not disinfect all areas of his/her hands, insufficient amount of disinfectant and too fast disinfection.
2. Hand disinfection before the personal hygiene procedure.	56	75	61	81	Less possible infection transmission dry skin, rush, too fast disinfection, conversation with an employee, insufficient amount of disinfectant, forgetfulness, the observed nurse did not disinfect all areas of his/her hands.
3. Use of gloves before washing the areas that are dirty with blood, secretions, salvia; at washing anogenital area and legs. After their use, hands are disinfected.	67	89	67	89	Rush, conversation with the resident, the observed nurse did not disinfect all parts of his/her hands, too quick disinfection and insufficient amount of disinfectant.
4. Washing the patient's face, body, back and hands, followed by hand disinfection.	37	49	39	52	Conversation with resident, forgetfulness, rush, too quick disinfection, dry skin, insufficient amount of used disinfectant and the observed nurse did not disinfect all areas of his/her hands.
5. Clean gloves are put on. The legs are washed. Gloves are taken off, and hands are disinfected.	52	69	55	73	Forgetfulness, full hands, conversation with an employee, too quick disinfection not enough of disinfectant, rush, the observed nurse did not disinfect all areas of his/her hands.
6. Water, washbasin and the clothes are replaced and, after this, hands are disinfected.	0	0	0	0	The procedure was not accomplished because of the rush.
7. New gloves are put on, and anogenital area is washed. Gloves are taken off, and hands are disinfected.	71	95	71	95	Rush, the observed nurse, did not disinfect all areas of his/her hand, full hands and conversation with the resident.
8. Gloves are put on. Lotion is spread on the resident and hands are disinfected.	6	8	0	0	The procedure was not accomplished because of the rush.
9. After the whole procedure is done, the hands are disinfected.	61	81	63	85	Less disinfectant used, the observed nurse did not disinfect all areas of his/her hand, forgetfulness and full hands.

Legend: A – correct hand hygiene observation without nudging; B– correct hand hygiene observation with nudging; (*n* – number of observation; % – ratio

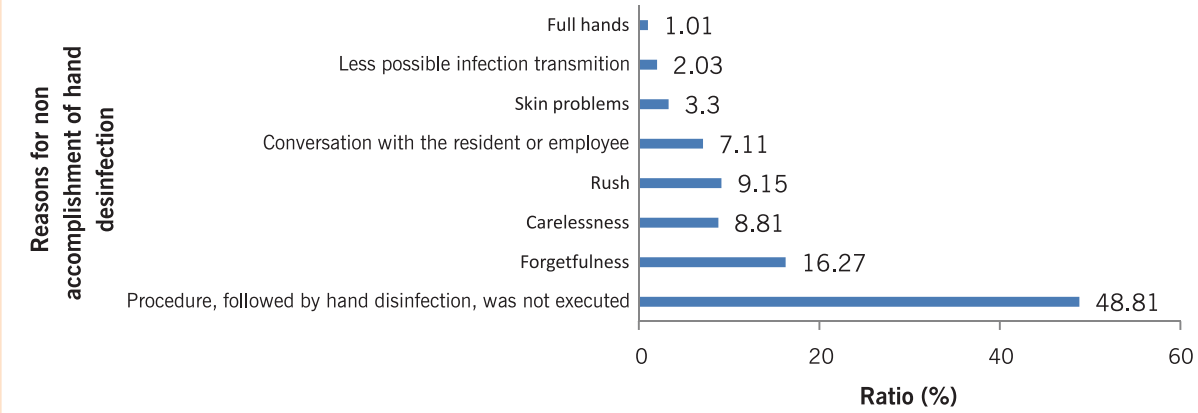


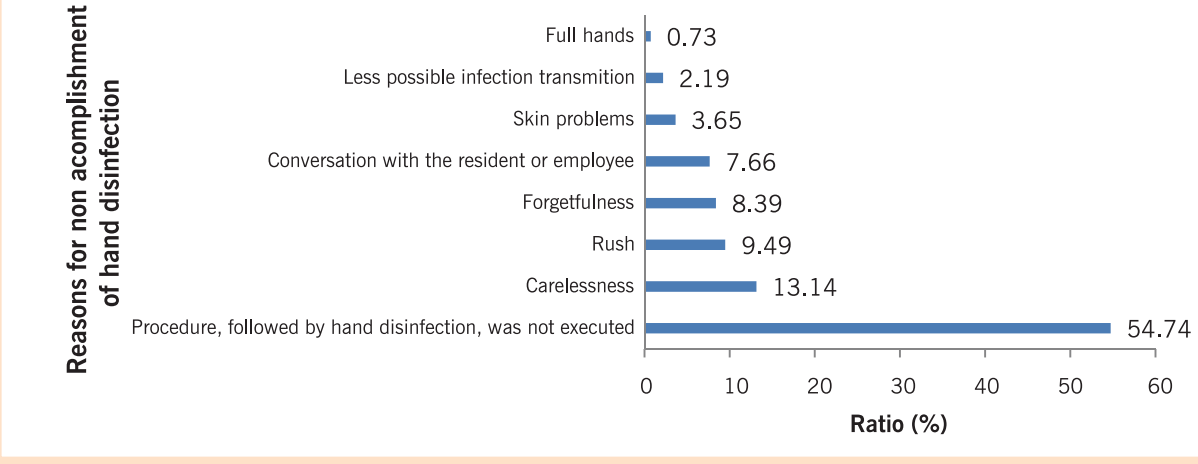
Figure 1:
Reasons for non-accomplishment of hand disinfection without the nudge

At the observation process without the use of the selected nudging tool, there were 675 opportunities for hand disinfection. Correct hand hygiene of the observed nurses was conducted 380 times, of which 295 times were done incorrectly. Figure 1 shows the reasons why the observed nurse did not correctly disinfect his/her hands. The most common reason for this was that the procedure followed by the hand disinfection was not made. The least common reason was when the hands of the observed nurse were full of resident's laundry and hygiene supplies. During the observation process with the selected nudge tool, there were 675 opportunities for hand disinfection.

Correct hand hygiene of the observed nurses was conducted 401 times, and 274 times it was not done so. Figure 2 shows the reasons that the observed nurse did not disinfect his/her hands. The most common reason for this was that the procedure followed by hand disinfection was not made. The least common reason was when the observed nurse's hands were full of personal hygiene products and residents' laundry.

In the nursing home, because of the more frequent contact between the staff and residents, HCAI are more common. They contribute to the poorer quality of living in the institution. In the nursing home, the nurs-

Figure 2:
Reasons for non-accomplishment of hand disinfection with the nudge



ing team plays a very important role in preventing the transmission of infections to residents, from the resident to the staff and from resident to resident via nursing care supplies and hand contact. With proper hand hygiene, transfer can be effectively prevented [22]. In the considered nursing home in Ljubljana, they decided to record the data of the HCAI occurrence among the residents, in order to determine the quality of hand hygiene and on this basis plan further improvements [23]. They record the infections with MRSA and ESBL. In 2011 they had one HCAI, 2012 three, 2013 six, 2014 thirteen, 2015 nine, and 2016 seven (Table 2). The quality of nursing care is also assessed through the recorded occurrence of HCAI. Therefore, it is crucial that graduate nurses, as carriers of nursing care, determine the needs for the prevention of HCAI, plan and implement interventions for prevention, identify performers and, ultimately, evaluate the performed work and achieved nursing-care goals [2, 23].

Table 2: Number of residents colonized with MRSA and ESBL from 2011 to 2016 in nursing home where research was done

Year	2011	2012	2013	2014	2015	2016
MRSA	1	3	2	5	2	4
ESBL	0	0	4	8	7	3

One of the newer methods of preventing HCAI, and thus ensuring quality in nursing care, is nudging, which, by applying behavioral theory, affects the behavior of employees. According to the literature review, the most effective promoters of hand hygiene behavior were: the citrus smell from air fresheners (hand disinfecting was improved by 32%), the image of male eyes above the disinfectant dispensers (hand disinfection improved by 18%), numbers 1 to 5 defining alcohol dispensers as the most or the least used (hand disinfection improved by 250%), a red sign above the alcohol dispenser (disinfection improved by 64%) and an automatic paper towel dispenser (disinfection improved by 22%). In this study, a visual cue was used to improve the hand hygiene of the observed nurses. The nudge tool was the image of male eyes that were placed above the disinfectants in the living room, in the corridor, in the bathroom and on the nursing cart (Figures 3, 4, 5). All images were in color, with dimensions of 6×17 cm [6, 7].

Among the residents, only two older women noticed them and asked the researcher about their meaning. On the first day of installation, the images caused a lot of attention and interest among the employees in and out of the department. All the employees said that the pictures were awful, frightening, and they felt that they had constantly been observed.

In the beginning, several days were spent observing the nurses without recording the results on the observation checklist, so that the nurses became accustomed to the presence of the researcher. Data recording then started. It was discovered that the observed nurses did not consider the prescribed hygiene standards of hand disinfection in the accomplishment

Figure 3:
Picture of male eyes above automatic alcohol dispenser (Photo: Mlakar, 2017)

Figure 4:
Picture of male eyes next to the alcohol dispenser and the soap dispenser (Photo: Mlakar, 2017)

Figure 5:
Picture of male eyes at the alcohol dispenser on the wagon for personal hygiene items (Photo: Mlakar, 2017)

of the entire personal hygiene process. They almost never disinfected their hands after changing the water and clothing and after putting the lotion on the resident, because the procedure followed by hand disinfection was not executed. Furthermore, disinfection of the hands was slightly worse after washing the face, body, back and hands, as the observed were in a hurry during the procedure and often forgot to replace the gloves and dis-

infect their hands. Disinfection immediately before preparing personal hygiene products was also a bit worse. Often the reason was forgetfulness and conversation with colleagues or students on practical training. Thinking that hands are clean at the beginning of the day and disinfecting damaged hands can be painful, which deters the employees from disinfecting their hands again when they come to work.The most correct and precise hand disinfection was after the glove use, immediately after the contact with areas that were dirty with blood, secretions, and saliva, and washing the anogenital area. Hand disinfection was also good after the whole procedure was finished. The results showed that the observed employees' hand hygiene was the most precise after contact with the patient. More observed nurses attend proper hand hygiene after body fluid contact, compared to other contacts with the resident or his/her surroundings. At other recorded incomplete hand disinfection, employees in most cases used sufficient amounts of soap, but their hand disinfection was too short, or they did not disinfect all hand areas. Observer's hands were without jewellery; nails were short and without nail polish. This is very important in preventing HCAI, as most microorganisms accumulate under long nails and under jewellery, with which good disinfection is very hard to provide.

The reasons that the observed nurses did not disinfect their hands correctly or did not disinfect them at all are tiredness, early morning hours, rush, distracted thinking and the observed simply forgot about the proper hand hygiene.

The reasons that the observed nurses did not disinfect their hands correctly or did not disinfect them at all are tiredness, early morning hours, rush, distracted thinking and the observed simply forgot about the proper hand hygiene. This happened mostly during the hygiene product preparation and then during the process. Conversation with an employee or a resident during the process often distracts the observed from the correct hand disinfection technique, because his/her attention is focused on the conversation. For this reason, hand disinfection was superficial. The observed nurses spend less than 20 seconds for disinfection, with not enough disinfectant (less than 3 ml or two pushes on the alcohol dispenser), or she/he does not disinfect all hand parts. Each health institution prescribes a regime of hand disinfection and hand washing techniques, which must be followed in the correct order so that all hand areas are disinfected (palms, fingers, middle spaces and back of the arms) [20]. One very common reason for the hand hygiene inconsistency was being rushed. In the observed nursing home ward, 20 immobile residents live. On a shift, only three nurses and two students of the health faculty in Ljubljana work there. Given the number of nursing procedures that the staff had to do, they had to hurry, so they could finish the work by breakfast, and then continued with bathing the patients and other procedures. This is a department with mostly residents with dementia; consequently, performing personal hygiene lasts even longer because of the specific factors of movement, understanding, and communication. In addition, the employees need a lot of time to explain to the residents what they are going to do, and to obtain their cooperation and permission to carry out the procedure. The number of employees and overcrowded departments are two of the biggest problems in the observed nursing home. The HCAI occurrence is inversely proportional to the number of health care providers [2].

Because the observation was executed in winter, many nurses had problems with dry and cracked skin, which made hand disinfection very

painful. Many had skin problems, not only because of the weather and season but also because of the daily multiple hand washing with soap and water. Therefore, the employees avoided hand disinfection, especially when they thought that there was a minor possibility of infection transmission (during the preparation of the hand hygiene nudge tool). They did not change their gloves so they would not need to disinfect their hands [23]. Changing the water and putting the lotion on the resident are two procedures that were almost never performed because of the rush and way of working in the nursing home. Therefore, there was no hand disinfection. During personal hygiene performance, it was also necessary to carry away the dirty laundry from the resident's room (pyjamas, other clothes, and other items), because of which the observed nurse had full hands and, therefore, did not disinfect them.

The reasons, from the most frequent to the least, that the observed nurse did not why he/she did not properly disinfect hands (or at all) during observation without the nudge are: forgetfulness, carelessness regarding disinfection, rush, conversation with an employee or resident, damaged skin of the observed nurse, less likely infection transmission, and full hands. These are also the most common reasons that nurses have bad hygiene compliance.

During personal hygiene performance, it was also necessary to carry away the dirty laundry from the resident's room.

After the first part of the observation was finished, the nudge was introduced. It was determined that the hand disinfection before the preparation of personal hygiene products was improved by 20%, before starting the procedure by 6%; after the glove use after washing the dirty areas with blood, secretions, saliva, washing the anogenital area and feet, the result remained the same; after washing the face, body, back and hands, hand disinfection improved by 3%, after washing the feet by 4%; after changing the water and washbasin, the result remained unchanged. Furthermore, after anogenital care, after putting on the lotion, and after the whole procedure of personal hygiene was done, hand disinfection improved by 4%. In research studies [7, 8], the results show that employees who were exposed to triggers (picture of men's eyes above the dispensers) had better hand hygiene compliance. It can be concluded that nursing staffs' actions can be improved if they are exposed to specific cues. Therefore, nudging could be used as a way of preventing HCAI and as a new and better method for changing employees' behavior, with the purpose of improving the living quality of residents in a nursing home [24, 25].

The main reason for incorrect hand hygiene compliance at the observation with the nudge is in the first place the same as in the previous observation: the procedure followed by hand disinfection was not executed. The second reason is carelessness, followed by rush, forgetfulness, conversation with the resident or employee, skin damage of the observed nurse, less possible infection transmission, and full hands. As a reason for incorrect hand disinfection, forgetfulness moved from the second place to the fourth. It can be concluded that the visual cue had the strongest effect on this reason.

More proper hand disinfection because of observer presence was not observed.

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There are students from a health faculty in Ljubljana present

Quality is an indispensable and essential element of nursing care.

throughout the year, and the staff is accustomed to their presence. Those who are consistent with personal hygiene procedures are also consistent with hand hygiene compliance.

The employees in the observed nursing home ward are aware of the importance of good hand hygiene and are convinced that HCAI is a major problem in nursing care and healthcare in general. They also say that if there were more employees, they would also have more time for residents and provide better nursing care for each one. The nudge accomplished its purpose, as the consistency of hand hygiene improved the most before the preparation of personal hygiene products, before starting the procedure, after washing the patient's face, body, back and hands, after washing the legs, and after the whole procedure was done. In those procedures (after using gloves after washing areas that are dirty with blood, secretions, saliva, washing the anogenital region and legs) for which hand disinfection was good even before the introduction of the nudge, there was no difference. After the introduction of the nudge, hand hygiene improved the most at the beginning, during the preparation of the devices, compared to other stages of the personal hygiene procedure. The reason is that the observed nurse stayed the longest with the cart supplies, disinfectants, and the picture of men's eyes above the disinfectant, while they were preparing personal hygiene items and the fact that there was the most noticeable difference in comparison to the previous poor hand disinfection.

Alcohol dispensers were always full in the observed ward. One automatic alcohol dispenser was installed in the corridor, another in the dining room next to the washbasin, a third on the cart for hygiene items and a fourth in the bathroom next to the washbasin (Figure 1). This is a novelty that attracted a lot of attention in the nursing home among employees, residents, and visitors. Depending on the amount of disinfectant in the alcohol dispenser, there was a greater consumption than with standard alcohol dispensers. Automatic disinfectants measure a sufficient or appropriate amount of disinfectant. They represent something technologically new, interesting, and are also very appealing. As with pictures above alcohol dispensers, they represent a nudge to promote hand hygiene behavior, using the latest technology. From this, it can be concluded that the observed nursing home is already using a new way of preventing the HCAI and thus provide high living quality of the residents. This is also confirmed by the data. The number of residents with HCAI during the years of data recording is low, ranging from 0 to 13 (Table 2). The recording of the numbers of HCAI (MRSA and ESBL) started in 2011.

CONCLUSION

It is vital that residents in nursing homes feel well, comfortable, and safe and that there is the highest possible quality of living and nursing care. Quality is an indispensable and essential element of nursing care. Knowledge and considering prevention and control methods of HCAI is imperative for all healthcare providers because it prevents negative con-

sequences, such as the social isolation of the resident, early death, and disability. Nurses in the observed nursing home partially consider the prescribed hygiene standards regarding hand disinfection. Observed nurses almost never disinfected their hands after changing the water, the clothes, and after putting the lotion on the resident because this procedure, followed by hand disinfection, was not executed. Moreover, hand disinfection was worse after washing the residents' faces, bodies, backs, and hands, and before preparing personal hygiene items. The most correct and accurate was hand disinfection after use of the gloves, immediately after the contact of the areas that were dirty with blood, secretions, saliva, washing the anogenital area and after the working procedure was completed. After the implementation of the nudge, hand disinfection before the preparation of personal hygiene items, before the beginning of the procedure, after washing the patient's face, body, back and hands, after washing the legs, and disinfection after the whole procedure had been done improved the most. There was no difference after nudging for the procedures for which disinfection was already performed well: after the use of gloves after washing the areas that were dirty with blood, secretions, saliva, and washing the anogenital region and legs. Based on this research, we can conclude that employees hand hygiene behavior may be subconsciously influenced by cues in the environment. Furthermore, an increased number of employees in the nursing home would contribute to this, as the staff would have more time for residents. Finally, in preventing the HCAI, motivation, clearly defined goals, high professional qualifications, and teamwork of all employees in the nursing home ward are also important.

Based on this research, we can conclude that employees hand hygiene behavior may be subconsciously influenced by cues in the environment.

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Original scientific article

Impact of boiling on raw milk – food safety aspects

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ABSTRACT

Goal: Milk is a nutrient of high biological value, consumed in larger quantities and frequencies by sensitive groups of population. This fact makes the monitoring of milk's safety particularly important for the public health. An increasing number of persons consume raw, unpasteurized milk. Superior nutritional value, quality, taste and other health benefits are advocated as reasons for increased interest in the consumption of the raw milk. However, scientifically based data to support such claims are very limited. Almost all of the international advisory and regulatory agencies dealing with food safety strongly support the principle of exclusive consumption of pasteurized milk. This research seeks to verify both the positive and negative impacts of boiling on the safety of the raw milk. **Scope:** This study was conducted on 30 samples of raw milk, selected by a method of random sampling from individual retailers in grocery stores and open markets in the city of Sarajevo. The boiling process was conducted by heating the raw milk to its boiling point during 20 seconds. Each collected sample was divided into two groups (A and B), where sample A was analysed before, and sample B after the boiling process. **Findings:** The study determined that the boiling process improves the safety of raw milk, and is responsible for an exceptional and significant increase of its microbiological safety. The study also revealed that the safety of raw milk in the Sarajevo Canton derogates from provisions in force for the raw milk.

Key words: raw milk, boiling, safety

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INTRODUCTION

Human interest in the consumption of safe food exists from ancient times, which resulted with global demand for production of food that could be used without risks upon health of humans. In addition to the macro and micro nutrients, as well as the non-nutritive natural components of food, often responsible for its organoleptic properties, biological values and admission, the food also contains numerous other substances being more or less harmful to human health. These, primarily, concern the microorganisms and their toxins, additives and residues of contamination. Examination of food's safety rests on evidencing the presence of such substances and their determination [1]. Food safety implies that a food will not cause adverse effects on human health if prepared and consumed in accordance with its intended use [2]. From the perspective of a healthy and balanced diet, milk is a unique food in many different ways. It is of natural origin, and contains all the ingredients needed for proper nutrition of an organism, either of a child or an adult [3].

Milk is a food of high biological value used in larger quantities and frequencies by sensitive population groups (children, pregnant women, elderly persons).

Milk is a food of high biological value used in larger quantities and frequencies by sensitive population groups (children, pregnant women, elderly persons). This fact makes the monitoring of milk's safety particularly important for public health [4]. Specific regulations on microbiological safety of food had set the norms for each food with respect to the type and number of microorganisms allowed for nutrition of humans [1].

Access of individual elements into the food chain can differ, yet predominantly depends on activities of humans. Contamination of food and environment with inorganic pollutants may be of primary or of secondary character. Primary contamination implies that the contamination of the plant foods was conducted through soil, water or air, whereas the contamination of animals was conducted through food or water. Secondary contamination implies that the contamination of food occurred during its processing, packaging or storage due to the migration of toxic metals from equipment, packaging, appliances, utensils or contaminated food additives. Quality of milk depends of its composition and level of hygiene applied during the milking process, i.e. the purity of milking pots, condition of its storage place, mode of transport and cleanliness of each animal's udders. Production of milk and dairy products under non-hygienic conditions and poor manufacturing practices may cause setbacks for both the public health and the economy [4].

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Raw milk can be contaminated by a wide range of bacteria, including *Staphylococcus aureus*, *Escherichia coli*, *Bacillus* spp., *Brucella* spp., *Listeria monocytogenes*, *Salmonella* spp. and *Corynebacterium* spp., as well as by a number of moulds and yeasts [5]. In some cases, the milk's infection with viable pathogenic bacteria may cause its contamination and spoilage, which makes the milk unsafe. Main life threatening diseases associated with milk include gastroenteritis, diarrhea, typhoid or tuberculosis of the cattle [6].

The toxic metabolites of aflatoxin may also be found in animal products, milk and meat, in case the cattle feed was previously contaminated with moulds [7]. Aflatoxin M1 is a relatively stable molecule, which cannot be inactivated by the heating treatments like pasteurization and sterilization [8]. Due to these characteristics, Aflatoxin M1 may have adverse effects on health of humans, particularly of children who are the main consumers of milk and dairy products [9].

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MATERIALS AND METHODS

Our analysis was conducted on 30 samples of raw milk, selected by a method of random sampling from individual retailers in grocery stores and open markets in the city of Sarajevo. Criteria for sampling was that the raw milk in question can be found in official grocery stores or at open markets of the Sarajevo Canton. The samples were collected in sterile laboratory containers and kept stored in refrigerating showcases on temperature varying from 4 to 8 °C.

The samples were transported on temperature of 4 °C, and, pending the analysis, kept in storage on temperature of -20 °C.

Collected samples were labelled in accordance with the standard laboratory procedures for receipt and labelling of samples. Each collected sample was split into two groups (A and B), where sample A was analysed before, and sample B after the boiling process. The boiling was conducted by heating the raw milk to the point of its boiling, it most frequently being between 97-102,5 °C, which depended of the milk's composition. Once the boiling point was reached, the milk was heated for additional 20 seconds, by which the boiling treatment was completed [10].

Determination of heavy metals (Lead, Arsenic)

Analysis of samples (that were firstly prepared in a microwave oven) on the presence of heavy metals (lead, arsenic) was conducted in the SHIMADZU AA-6650 atomic absorption spectrophotometer. Even though the SHIMADZU AA – 6650 atomic absorption spectrophotometer is mainly used for determination of concentration of heavy metals in a sample, it may also be used for some other tasks to depend of the software and the needs. The principle of its work is based on atomic absorption and spectrophotometry. The SHIMADZU AA-6650 atomic absorption spectrophotometer combines two correction functions, the D2 method (deuterium lamp method) and the SR method (self-reversal method), thus enabling that the samples are examined under appropriate method.

Determination of Aflatoksin M1

Quantitative analysis of Aflatoxin M1 in the milk samples was conducted through application of the ELISA testing (Enzyme-linked Immunosorbent Assay). The principle was to test the antigen – antibody reaction. The test kit contained reagents for 96 samples (including the calibration curves). Samples of the milk were initially defatted by cen-

trifugation of cold milk in conical tubes at 2000 x g of rotation for 10 minutes. The layer of fat created on the top has been removed with a spatula, and 100 μL of the defatted milk was used for the ELSA testing. The standards were concentrated and needed a dilution with standard diluents prior to the testing. The calibration curve illustrates the ratio of concentration of Aflatoxin M1 in the standard and the value of its absorption at 450 nm, displayed on the reader of the microtiter plate "DAS PLATE READER". All of the milk samples were prepared in accordance with the instructions contained in the ELISA kit.

Microbiological parameters

For evidencing, we used the following microbiological methods: the Horizontal method for detection of *Salmonella* spp (BAS EN ISO 6579:2005); the Horizontal method for detection and counting of coagulase-positive staphylococci – *Staphylococcus aureus* (BAS EN ISO 6888-1:2005); the Horizontal method for detection and counting of *Enterobacteriaceae* (BAS EN ISO 21528-2:2008); the Horizontal method for counting of *Clostridium perfringens* – the colony counting method (BAS EN ISO 7937:2005); the Horizontal method for counting of microorganisms – technique of counting the colonies at 30 degrees Celsius (BAS EN ISO 4833:2006); the Horizontal method for detection and counting of *Listeria monocytogenes* (BAS EN ISO 11290-1:2005).

Statistical data processing

The results of the analysis have been statistically processed through applicable and verified methods – the *Microsoft Excel 2010* computer program and the *IBM® SPSS® Statistics 24.0 software*.

By applying appropriate functions available within the *IBM® SPSS® Statistics 24.0 software*, there have been calculated the basic statistical parameters of: the mean (MEAN) and variability measures – standard deviation (SD) and standard error of the mean (SEM). To acquire a more detailed interpretation and a better understanding of the obtained results, we have also used the Microsoft Excel 2010 computer program to calculate percentages of the average values of certain parameters after the boiling of examined milk samples.

The statistical significance of differences between the measured values of the examined parameters in the raw and boiled milk was evaluated by a dependant (paired) two-tailed t testing, and calculated in the *IBM® SPSS® Statistics 24.0 software*.

RESULTS AND DISCUSSION

Out of 30 samples of the raw cow's milk that were tested, 16 samples (53.3%) proved unsafe. Following the method of boiling that was used, 7 samples (23.3%) remained unsafe.

Table 1: Display of safe and unsafe samples of milk, before and after boiling

Type of sample	Safe	Unsafe
Raw milk	14 (46,6%)	16 (53,3%)
Boiled milk	23 (76,6%)	7 (23,3)

Results of microbiological parameters

Average number of colonies of aerobic mesophilic bacteria in the samples of raw milk was 8.1×10^2, while the samples of boiled milk showed the value of 1×10^1. The average number of colonies of aerobic mesophilic bacteria in boiled milk decreased by 99.33% in comparison to the average number of same bacteria in the raw milk, and t-test (t=7.93) showed statistically significant difference (t=7.93; p <0.0001). The average number of colonies of Staphylococcus aureus in the raw milk samples was 1.7×10^2. Presence of such bacteria was not noted in any sample of the boiled milk, and the t-test showed statistically significant difference (t = 4.79; p <0.0001). The average number of colonies of Enterobacteriaceae bacteria in the samples of raw milk was 1.6×10^2, while their presence in the samples of boiled milk was not found at all. Application of the t-test demonstrated a statistically significant difference (t = 5.22; p <0.0001). Neither of the samples of raw milk demonstrated the presence of Salmonella spp., Clostridium perfringens or Listeria monocytogenes.

Table 2: Comparative review of the number of aerobic mesophilic bacteria (CFU/g), Staphylococcus aureus (CFU/g) bacteria and enterobacteriaceae (CFU/g) in samples of raw and boiled milk

Sample	Aerobic mesophilic bacteria (CFU/g)		*Staphylococcus aureus* (CFU/g)		*Enterobacteriaceae* (CFU/g)	
	Raw milk	Boiled milk	Raw milk	Boiled milk	Raw milk	Boiled milk
Mean	**$8,1\times10^2$**	**1×10^1**	**$1,7\times10^2$**	**0**	**$1,6\times10^2$**	**0**
SD	$5,4\times10^2$	5	$1,9\times10^2$	0	$1,7\times10^2$	0
Min	$6,4\times10^1$	0	$1,2\times10^1$	0	$5,2\times10^1$	0
Max	$1,8\times10^3$	2×10^1	$8,8\times10^2$	0	$6,2\times10^2$	0
p-value	**< 0,0001***		**< 0,0001***		**< 0,0001***	

* t-test

Results of the heavy metals testing (As, Pb)

Average level of arsenic in raw milk samples was 0.01 mg/l, while no evidence of presence of this heavy metal was noted in any sample of the boiled milk. The t-test showed a statistically significant difference (t = 3.42; p = 0.001).

The average level of lead in raw milk samples was 0.03 mg/l, and in the boiled milk samples 0.01 mg/l, thus showing a decrease in the average level of lead in tested samples of the letter category by 73.34%. Application of the t-test demonstrated a statistically significant difference between the samples of raw and boiled milk (t = 3.42, p = 0.02).

Table 3: Comparative review of arsenic (As) and lead (Pb) levels in samples of raw and boiled milk

Sample	Level of As (mg/l)		Level of Pb (mg/l)	
	Raw milk	Boiled milk	Raw milk	Boiled milk
Mean	**0,01**	**0,00**	**0,03**	**0,01**
SD	0,016	0,000	0,057	0,017
Min.	0,000	0,000	0,000	0,000
Max.	0,072	0,000	0,222	0,064
p-value	**0,0019***		**0,0214***	

*t-test

Figure 1: Comparative review of measured levels of Arsenic (mg/l) in raw and boiled milk

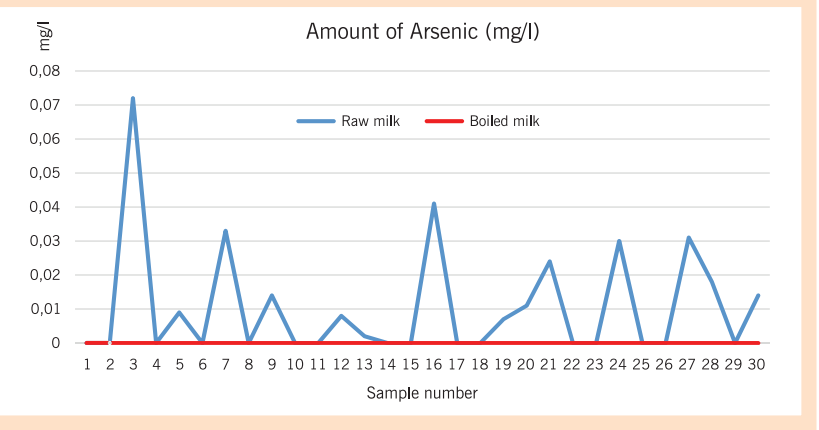
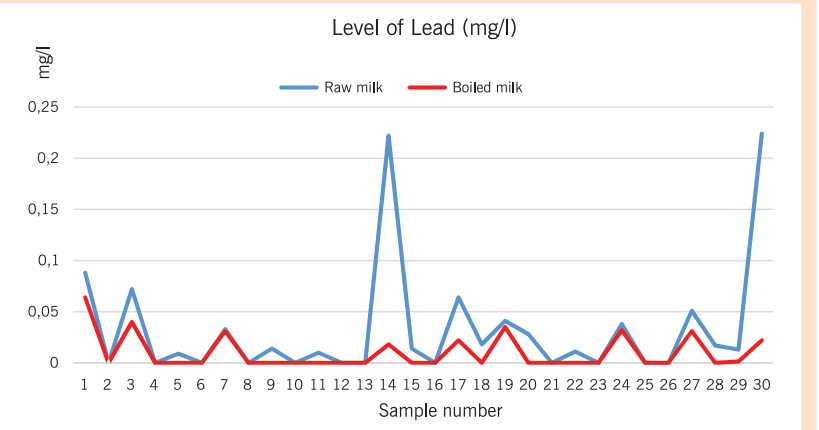


Figure 2: Comparative review of measured levels of Lead (mg/l) in raw and boiled milk



Results of the study relating to presence of Aflatoxin M1

Due to low level of detected concentrations of Aflatoxin M1, the results were displayed in pg/ml instead of μg/l, as required by the Rulebook on maximum permitted levels of certain contaminants in foodstuffs ("The Official Gazette of Bosnia and Herzegovina", No. 37/09).

No significant difference in concentration of Aflatoxin M1 was detected between the samples of raw and boiled milk. The average concentration of Aflatoxin M1 in samples of raw milk was 0.68 pg/ml, and in the samples of boiled milk 0.675 pg/ml. The statistical significance of this difference was additionally evaluated by t-testing, when no statistically significant difference was found (p> 0.05).

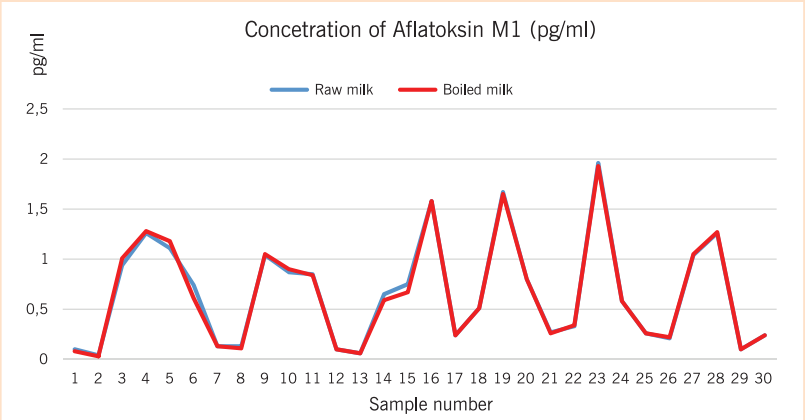


Figure 3:
Comparative review of measured concentrations of Aflatoxin M1 (pg/ml) in raw and boiled milk

The results of the analysis on the raw milk's safety clearly indicate that the raw milk available in the Canton of Sarajevo derogates from applicable regulations on the raw milk. By boiling such milk, its safety improves.

The results of the comparative microbiological analysis of samples of raw and boiled milk clearly show a very pronounced influence of the application of this treatment towards the increase of microbiological stability of the milk by reducing the microbiological contamination of the raw milk. The pronounced decrease in the number of aerobic mesophilic bacteria, as well as the complete destruction of enterobacteriaceae and staphylococci is in line with expected results resting on the data from professional literature, which finds the boiling method a very effective mean of prevention of possible risks for poisoning the raw milk by bacteria [11]. Staphylococcus aureus was found in all of the examined samples of raw milk, where 50% of the tested samples showed the value of $> 10^2$, it being higher than evidenced in a research conducted in the Czech Republic [12]. The data clearly indicate that pore hygiene conditions were applied during the milking, packing and transport of raw milk; as such, the contamination of raw milk is of secondary character.

The results of the quantitative analysis of Aflatoxin M1 show that the boiling of milk does not affect the presence of this mycotoxin. These results are consistent with the literature on the thermostability of its molecule, which cannot be destroyed in the process of pasteurization and sterilization [8]. The obtained results indicate that the boiling does reduce the concentration of lead and arsenic, as unstable metals that could be lost with this treatment. In addition to being non-thermostable at high temperatures, these metals also tend to bind to proteins [13], so their reduced concentration in the boiled milk can also be explained by the fact that they could have been previously removed as tied to coagulated proteins in the surface layer of removed fat. However, the measured concentrations of these metals in raw milk are very low (much lower than their maximum allowed amounts), so no final conclusions can be drawn as to the effect of boiling of milk on its health safety in terms of concentration of these heavy metals. In subsequent researches, this problem could be solved through an experiment in which the raw milks would be contaminated with certified reference materials of Pb and As, and then boiled. The concentrations

The results of the quantitative analysis of Aflatoxin M1 show that the boiling of milk does not affect the presence of this mycotoxin.

The boiling of milk has no effect on the reduction of concentration of Aflatoxin M1.

of the mentioned metals would be measured after the boiling of contaminated milk by the method that was described and applied in this paper.

CONCLUSION

Boiling of raw milk improves its safety and has a very pronounced and significant influence on increase of its microbiological safety. In other words, it is a very effective method for destroying all present pathogens in the raw milk. With respect to chemical contaminants, the boiling of milk proved to be effective in reducing the concentration of arsenic, though not lead. The boiling of milk has no effect on the reduction of concentration of Aflatoxin M1. The safety of raw milk in the Canton of Sarajevo derogates from regulations in force for the raw milk. The results of this work clearly point to the need for educating and informing the population consuming the raw milk in terms of changing their habits as well as removing prejudices related to the boiling of milk.

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Original scientific article

A comparison of three different cleaning methods for reducing contaminants on contact surfaces – a preliminary study

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ABSTRACT

The aim of this study was to evaluate three different cleaning procedures routinely applied in processes to prevent microbiological product contamination. The evaluation was done in the context of their hygienic suitability and cleaning effectiveness according to defined surface hygiene standards. Furthermore, the suitability of a generic testing method to monitor cleaning effectiveness was investigated. The results of this preliminary study revealed discrepancies between the results acquired with a generic method compared to the conventional microbiological surface examination in the context of surface hygiene monitoring. The results demonstrate the higher efficiency of the semi-automatic system in comparison to the mechanical system on surfaces with the same characteristics. The results also indicate that in both of applied the semi-automatic systems, cleaning effectiveness depends on the surface accessibility and cleaning direction. Based on the results presented, we can conclude that for maximum benefit, visual, non-microbiological, and microbiological methods should be combined as an integrated cleaning monitoring strategy.

Key words: cleaning, two-bucket system, box system, mechanical cleaning, visual inspection, microbiological control, hygiene

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INTRODUCTION

The environment of the processes with high hygiene control to prevent product contamination is an important factor in determining the quality and safety of the final products. Sandle [1] noted that cleaning and disinfection are necessary in order to prevent microorganisms surviving in cleanrooms and for maintaining a level of hygiene in laboratories. Cleaning is needed to remove soil (such as protein and grease) from surfaces, and disinfection, if necessary, to inactivate or to kill microorganisms. As Moore and Griffith [2] stated, 'cleanliness' is, however, a relative concept: what is acceptable as being 'clean' in one situation may be unacceptable in another. Lelièvre et al. [3] asserted that cleaning is a complex phenomenon whose efficiency depends on production conditions and the design of equipment, and on operating conditions. Indeed, soils generated during production are often complex, containing microorganisms as well as organic material, which could modify both the microorganisms and the solid surface properties [3]. Prabu et al. [4] pointed out that pharmaceutical products and active pharmaceutical ingredients (APIs) can be contaminated by other pharmaceutical products or APIs by cleaning agents, by microorganisms, or by other materials (e.g., airborne particles, dust, lubricants, raw materials, intermediates, and auxiliaries). Adequate cleaning procedures are essential in order to avoid product contamination especially microbiological contamination. Documented standard cleaning procedures for each piece of equipment should be prepared for a comprehensive infection prevention strategy and an important step in the manufacture of pharmaceutical products [5, 6]. It is vital that the equipment design is evaluated in detail in conjunction with the product residues that are to be removed, the available cleaning agents and cleaning techniques when determining the optimum cleaning procedure for the equipment. Cleaning procedures should be sufficiently detailed to remove the possibility of any inconsistencies during the cleaning process. The following parameters are to be considered during cleaning procedures [5]. Shi and Zhu (2009) indicated that biofilms were often established by various microorganisms on the equipment surfaces of the production line. *L. monocytogenes* became one of the major causes of contamination of food products or transmission of diseases. Therefore, it is very important to develop cleaning and disinfection methods and control systems in food-processing plants and environments. Prabu et al. [4] indicated that cleaning has recently attained a position of increasing importance in the pharmaceutical industry. Virtually every aspect of manufacturing involves cleaning, from the initial stages of bulk production to the final dosage form to ensure the safety, identity, strength, quality, or purity of the drug product. Modern pharmaceutical manufacturing involves highly technically trained personnel, complex equipment, sophisticated facilities, and complex processes. Akl et al. [7] indicated that the cleaning procedures for the equipment must be validated according to good manufacturing practice (GMP) rules and guidelines. Cleaning validation is, however, a significant analytical challenge for the pharmaceutical industry [8]. The pur-

Cleaning and disinfection are necessary in order to prevent microorganisms surviving in cleanrooms and for maintaining a level of hygiene in laboratories.

pose of cleaning validation is to prevent contamination and cross-contamination in pharmaceutical dosage forms [4]. Cleaning validation is a documented process that proves the effectiveness and consistency of cleaning pharmaceutical production equipment. Cleaning validation consists of two separate activities: the first is the development and validation of the cleaning procedure used to remove drug residues from manufacturing surfaces and the second involves the development and validation of methods for quantifying residuals from the surfaces of manufacturing equipment. Furthermore, many sampling points of the manufacturing facility and the manufacturing equipment have to be tested to verify the occurrence of contamination [7]. Peles et al. [9] stated that the typical residual acceptance limits (RAL) used to verify the cleanliness of pharmaceutical manufacturing equipment are selected for residuals that are deemed to be a risk to subsequent products based on potency and toxicity. The limits are defined as residual mass/surface area ($\mu g/cm^2$) and fall well below the accepted "visibly clean" limit of 100 μg per 25 cm^2 [10, 11]. The residual mass on the manufacturing equipment surface is quantified with a validated analytical methodology from swab extracts or rinse, the products of swab or rinse sampling [9].

Griffith et al. [12] demonstrated that the effectiveness of sanitation procedures has traditionally been evaluated using different methods, such as visual inspection, swabs, dipslides and contact plates. Visual inspection is insufficient for defining cleanliness [13] or for objectively evaluating the microbial contamination of all surfaces [14], although this method is still widely used to assess the level of cleanliness [15]. ATP bioluminescence is a widely used technique for the rapid validation about cleaning effectiveness. Compared with traditional microbiological testing, ATP bioluminescence has advantages including the rapidity of its results, which can be obtained within 2 min [15].

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Among the rapid tests, Oberyszyn and Robertson [15] developed a method to examine aerosol containment using a modified, commercially available product called Glo Germ® (Glo Germ, Moab, UT). This product is used for teaching aseptic techniques in hospitals, industry, restaurants, and schools and is visualized with ultraviolet (UV) or black light. Glo Germ® is available in three forms: a white powder, an orange oil-based suspension, and a white lotion based suspension of a melamine copolymer resin. Carrascosa et al. [16] summarised the results of some studies, which considered rapid techniques to be particularly useful in large manufacturing plants where regular and frequent monitoring can provide management with data on trends. In the case of ATP, it also provides rapid results of the amount of organic remains and microbial contamination on the surfaces of establishments. Calvert et al. [17] pointed out that this method does not identify the quantity of the microorganisms or contaminant species; it can be used as a medium for monitoring hygiene and verifying cleanliness. Consequently, to monitor the efficacy of disinfection procedures, some microbiological testing (using dip slides, contact plates, or swabs) may be required [16].

The aim of this study is to analyse three different cleaning procedures, applying their specific protocols (the double bucket system, the box system, and the mechanical cleaning) in order to determine the differences between them and to examine their hygienically suitability when used in processes of high hygiene control. To perform this study holistically, we also included cleaning verification with a generic test.

MATERIALS AND METHODS

Surface cleaning techniques

The three different cleaning techniques described in Table 1 were evaluated.

Table 1: Description of cleaning techniques

Cleaning type	Cleaning procedure
Box system	The box system provides prepared cleaning wipes impregnated with 1% cleaning solution* ready to use and stored in a box fixed on the handcart. The excess cleaning solution is strained off and stored in the separate compartment under the box. Wipes are used via the telescoping stick and changed after approximately every 2 m^2 or more often if cleaning effectiveness is not sufficient. There is no wring-out step. Used wipes are collected in a separate compartment also fixed on the handcart.
Double bucket system	Two buckets fixed in the handcart are filled with 1% cleaning solution*. The first (blue) bucket contains 15L and the second (red) bucket contains 2L of prepared cleaning solutions. A cleaning wipes wringer is located above the red bucket. The wipe is first soaked in the red bucket, wring out and used for cleaning. After that, approximately every 2m^2 the wipe is soaked again into the red bucket, rinsed and wrung out, followed by soaking it in the blue bucket and wringing it out. After the cleaning procedure in one room is finished, the cleaning solution in both buckets is replaced with a new one.
Mechanical cleaning	The cleaning machine is composed of a reservoir for clean water (filled in before the cleaning procedure) and the dosage compartment containing a 1% cleaning solution*. The cleaning procedure is executed with the round horizontal wheel in the bottom of the cleaning machine. After the cleaning procedure is finished, the wastewater is removed from the reservoir, followed by rinsing and drying the equipment. Also, the cleaning wheel coming into contact with the surface is rinsed under running water and dried.

Legend: *Alcohol-based cleaner suitable for use on all water-resistant surfaces, objects, and floor coverings as well as on coated floors. Ingredients according to 648/2004/EC [18] Non-ionic surfactants < 5%, water-soluble solvents, fragrances (linalool), preservatives (methyl-/methylchloroisothiazolinone). pH value (concentrate): approx. 7 pH value (ready-to-use solution): approx. 7.5

The box and double bucket system were evaluated in two separate but comparable areas. Mechanical cleaning was evaluated in the area typical for that type cleaning. The surface material evaluated was the same in all three areas.

Sampling points

Sampling points (20 cm^2 each) were systematically selected regardless of the area and cleaning type investigated (Table 2). When selecting the sampling points, accessibility and workload in the area as criteria were considered. Sampling points 1 to 6 were equally distant from each other (50 cm) and, in the case of sampling points 1 to 4, equally distant from the walls and corners (15 cm). To assure that a sampling point was always on the same spot, the centre of the sampling point was marked with a small black dot resistant to the cleaning procedures evaluated.

Table 2: Description of sampling points

Sampling point	Sampling point criteria
1	Right corner area close to the room entrance.
2	Right corner area opposite to the room entrance.
3	Left corner area opposite the room entrance.
4	Left corner area close to the room entrance.
5	Area in the middle of the room opposite to the room entrance.
6	Area in the middle of the room close to the room entrance.

Surface visual control with Glo Germ®

On each sampling point from 1 to 6 (Table 2), different kits (lotion-based, oil-based, and powder) were deposited before the cleaning procedure. Each kit was first deposited on the sampling point in the size of a pea and then distributed with a cotton swab on a surface of 20 cm^2. There was no cleaning of the surface for at least 20 minutes after deposition. After the cleaning procedure had been completed, each sampling point was checked in detail under the UV light. If there were no kit residual left on the surface, the sampling point was evaluated with a mark of 1 during evaluation. If there were any remains left on the surface the sampling point was evaluated with a mark of 0.

Surface sampling and microbiological analysis

Systematic unannounced surface sampling was executed in three sequences in the case of each type of cleaning. During each sequence, two sampling intervals were done. Before the first surface sample (BC) was taken, the surface cleaning was not done for at least 24 h. The second sample (AC) was taken 25 minutes after the cleaning procedure to assure that the sampling point was completely dry. To exclude cleaning accessories as a possible cause of contamination cleaning solutions and wipes were also sampled before the cleaning procedure and analysed in each sampling sequence.

Surface samples and samples from cleaning wipes (Box and double bucket system) were taken with sterile swabs (cotton swab in 9 mL sterile physiological solution). The surface sampling technique was applied according to the ISO18593 standard [19]. The cleaning solution was collected in sterile 100 mL containers prior to the cleaning procedure starting.

Surface samples and samples from cleaning wipes were taken with sterile swabs.

Microbiological analysis was performed in an internal microbiological laboratory of a company with processes of high hygiene control. According to the internal company standards of environmental microbiological quality, Gram+ bacteria were determined. Surface samples were incubated on Soybean Casein Digest Agar Medium for 5 days at 30 ± 2 °C. Before incubation on agar media, samples of cleaning solutions were treated with aseptic membrane filtration (0,46 μ) in a laminar flow cabin. Because internally determined warning and action limits for Gram+ bacteria were not exceeded in AC samples, no further specific

Microbiological analysis was performed in an internal microbiological laboratory of a company with processes of high hygiene control.

analysis were done. Standards of environmental microbiological quality (warning limit and action limit) are internal in their nature and therefore not published in this paper.

RESULTS

Simple visual inspection of the sampling points after cleaning was in all cases evaluated as visually clean because there were no kit residues on the surfaces that would be visible to the naked eye. However, based on the results presented in Table 3, we can determine that based on the GloGerm® method there are differences visible under UV light. The results in Table 3 demonstrate that the most effective way of cleaning is mechanical cleaning, which successfully removed all three kit types from the surface in all sampling points except 1st and 6th. Monitoring of cleaning effectiveness after applying the system and the two-bucket system has revealed that the test kit applied on the surface was often smudged (especially when sampling points are more difficult to reach) and, therefore, evaluated as not being sufficiently clean. Comparison of the box system and the two-bucket system also reveals that the oil-based kit is more successfully removed from the surface with the box system, while efficiency in case of other two kits applied is comparable and related more to the sampling point. We can see that situation at sampling point 1 and 6 is generally, at least, satisfying (Table 3).

Table 3: Evaluation of surface cleanliness after cleaning according to cleaning type and the sampling point using Glo Germ® method

Cleaning type	Kit type	Sampling point					
		1	2	3	4	5	6
Box system	Lotion-based	0	1	1	0	1	0
	Oil-based	1	1	1	1	1	1
	Powder	0	1	0	0	1	0
Double bucket system	Lotion-based	0	1	1	1	1	0
	Oil-based	0	1	0	0	0	0
	Powder	1	0	1	1	0	0
Mechanical cleaning	Lotion-based	0	1	1	1	1	0
	Oil-based	0	1	1	1	1	0
	Powder	0	1	1	1	1	1

Legend: 1 – Complete absence of the kit under UV light; 0 – remains of the kit visible under UV light

A microbiological investigation was also conducted. In most of the cases presented in Table 4, the number of CFU is already low before cleaning. The internally defined surface hygiene standard defined as action limit of 200 CFU is not crossed, indicating good hygiene practice about the surfaces investigated. After cleaning, the degree of purity significantly improves in all cases, demonstrated as lower microbiological counts. Only in one case of mechanical cleaning is the internally defined surface hygiene standard, with the minimal limit of 50 CFU, not reached after the cleaning (Table 4).

Table 4: Microbiological situation (CFU/mL) before and after cleaning at the surface after microbiological examination of surface sampling in three sequences of (two samples in one sequence) according to the cleaning type and the sampling point

Cleaning type	Sampling sequence	Sampling interval	CFU/mL at each sampling point					
			1	2	3	4	5	6
Box system	1st	BC	41	4	13	15	22	97
		AC	0	0	0	3	0	2
	2nd	BC	13	4	11	13	2	8
		AC	0	2	0	0	0	0
	3rd	BC	16	6	2	3	3	10
		AC	0	2	0	0	0	1
Double bucket system	1st	BC	9	12	18	9	1	2
		AC	2	0	0	0	0	0
	2nd	BC	6	3	5	72	15	5
		AC	0	0	0	2	0	0
	3rd	BC	21	30	7	3	19	4
		AC	0	1	2	1	0	0
Mechanical cleaning	1st	BC	53	67	91	107	59	44
		AC	7	23	1	3	2	0
	2nd	BC	45	47	68	58	23	6
		AC	6	46	7	39	13	1
	3rd	BC	93	31	120	55	31	29
		AC	3	1	69	21	10	2

Legend: BC – Before cleaning; AC – After cleaning

The microbiological investigation of cleaning solutions was on average between 8 and 11 CFU/mL, which is lower than the internally defined action limit (100 CFU/mL). The microbiological investigation of swabs taken from cleaning wipes yielded no microbiological counts (CFU).

Calculating the results from Table 4 into an average cleaning effectiveness according to the cleaning type, we can observe the higher efficiency of box system and two-bucket system at all sampling points when compared to the mechanical cleaning (Figure 1), which is contrary to the results obtained with the GloGerm® method. However, we have to consider that the microbiological counts before cleaning were higher in the case of mechanical cleaning (Table 4). This could be related to the greater frequency of workload in comparison to the other two areas evaluated. Another reason for the lower efficiency of mechanical cleaning could be related to the fact that after the mechanical cleaning procedure is accomplished more water is still present on the surface in comparison to the box system and two-bucket system.

Closer examination of the cleaning performance according to the sampling point indicates that effectiveness is also related to the accessibility of the cleaning area during the cleaning procedure. Sampling point 6, located in the middle of the room, has the lowest discrepancy in the cleaning efficiency when all three cleaning methods are compared (Figure 1). In addition, the cleaning efficiency in the case of sampling point 1 (not considering the cleaning type) is generally better compared to

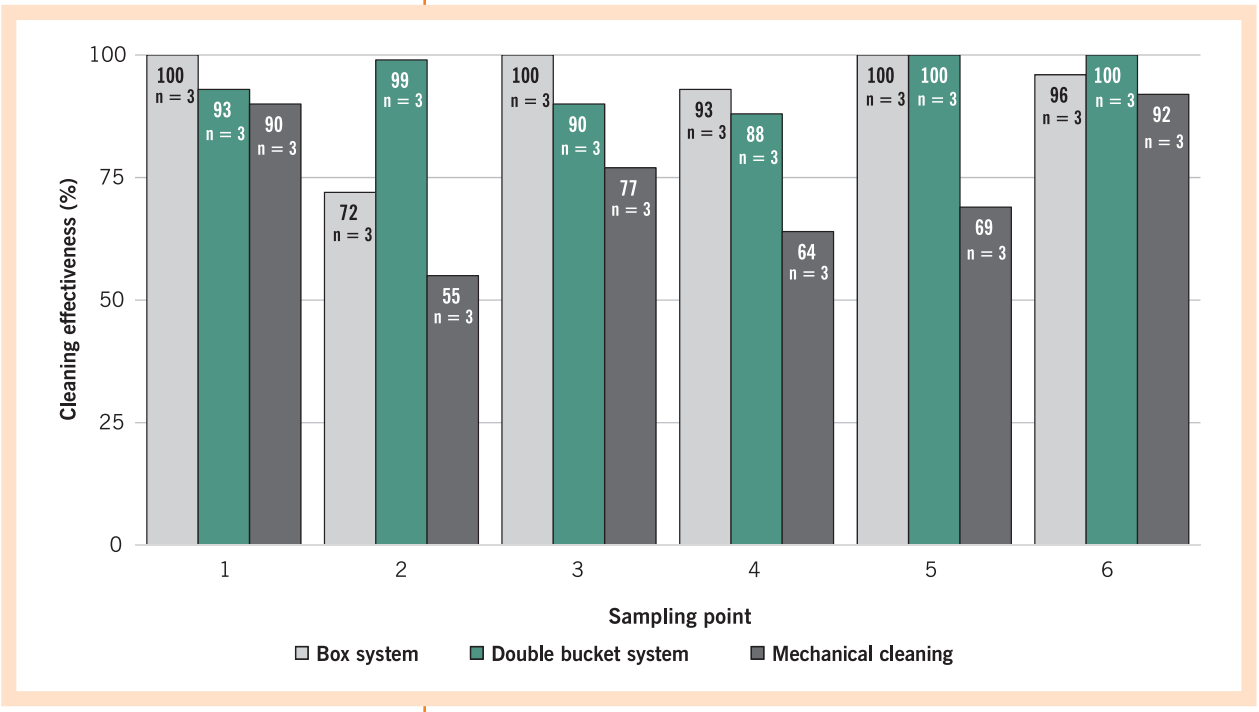

Figure 1:
Average cleaning effectiveness (%) according to the cleaning type expressed as a reduction in the number of CFU/mL after cleaning; n – number of sampling sequences

sampling points 2–4 in spite of their locations, which are quite similar. This also indicates that the cleaning direction is important. The area of sampling point 1 was cleaned first in the case of all three cleaning types, which is again contrary to the results gained with GloGerm® method (Table 3) where sampling point 1 was (other than sampling point 6) evaluated as at the least effectively cleaned.

DISCUSSION

The scarcity of advanced and recent publications in the area of general hygiene management is obvious in scientific literature. If the publications exist, they are focused on particular types of interests, which are frequently about pathogens. Consequently, we lack data that would enable a comparison of the state of the art in general, and we cannot determine the microbial population dynamic in this area of activity. The main focus of each cleaning procedure is to ensure the required levels of cleanliness of different places, the workspace, equipment and other accessories, which all influence the safety, quality, and effectiveness of the final products. This is not only the elimination of particular pathogenic species. Cleaning does not entail the end of a productive procedure but the beginning of the procedure of a new product. Therefore, if cleaning is not also taking into account general hygiene, it easily brings the system into a situation in which certain spoilage microflora or even potentially pathogenic flora are accumulating resistance and slowly begin to predominate. Therefore, it is of crucial importance to screen this aspect of cleaning efficiency as well. For that reason, we performed this study.

Al-Hamad and Maxwell [20] determined that the risk of acquiring infection from environmental surfaces, such as floors, walls, or the surfaces

of medical equipment or furniture, is probably small. However, there is a large body of clinical evidence, derived from case reports and outbreak investigations, which does identify links between poor environmental hygiene and the transmission of micro-organisms causing hospital-acquired infection. Srey et al. [21] emphasized that pathogenic microorganisms in biofilms formed in different food industries settings are a source of food contamination. As the demand for fresh, ready-to-eat and processed foods increases, many studies are needed to address biofilm removal and disinfectant efficacy in food industries. Sinsheimer et al. [22] showed that professional wet cleaning has been determined as an energy efficient, nontoxic, zero-emission technology, and it can be used to process previously dry cleaned garments. In our study, the monitoring of cleaning effectiveness after applying the box system and the two-bucket system has revealed that test kits applied on the surface were often smudged and therefore evaluated as not being sufficiently clean. This demonstrates that the cleaning effect is largely dependent on the cleaning type applied and cleaning technique applied by the cleaning staff. Sinsheimer et al. [22] also concluded that the cleaners they studied in California who switched to professional wet cleaning were able to maintain their level of service and customer base while lowering operating costs. They also found that the cleaners were able to transition to professional wet cleaning without a great degree of difficulty and were highly satisfied with the new technology [22, 23].

Cleaning effect is largely dependent on the cleaning type applied and cleaning technique applied by the cleaning staff.

In this preliminary study, according to the GloGerm® method the results indicate that the most effective way of cleaning is mechanical cleaning (Table 3), which is not the case when the microbiological evaluation is done (Table 4) revealing the discrepancy between the results gained with the generic method compared to conventional microbiological examination. The results of average cleaning effectiveness according to the cleaning type demonstrated the box system to be the most efficient followed by the two-bucket system and the mechanical method (Figure 1). In the case of mechanical cleaning, it should be noted that workload was higher compared to other two areas when this cleaning method was used as intended (Table 4). Another reason for the lower efficiency of mechanical cleaning could be related to the fact that, in comparison to the box and two-bucket systems, after the cleaning procedure is accomplished more water remains present on the surface. Although both methods applied for surface hygiene monitoring cannot be directly compared, the contrast between the results of the GloGerm® method and microbiological analysis indicates the need for the validation of generic methods before being applied as a standard way of monitoring of surface cleanliness. The absence of a test kit does not necessarily also mean a better microbiological situation and vice versa. Moreover, one can observe that the tests applied might be linked to the cleaning process (Table 3). It seems that mechanical cleaning can be handled well with all three test kits, which was not the case with the other two cleaning protocols. Closer examination in other industrial circumstances would also be beneficial to clarify this inconsistency in test reliability. The results of our preliminary study support the conclusions of Griffith et al. [24], who demonstrated that for maximum benefit, vis-

It was ascertained that the accessibility of sampling points is correlated with the effectiveness of the cleaning procedure.

ual, non-microbiological and microbiological methods should be combined, resulting in the production of an integrated cleaning monitoring strategy. Moore and Griffith [2] indicated that conventional microbiological techniques would detect only the microbial component of any residual surface contamination. Furthermore, despite the use of hygiene swabs enabling the detection of relatively low levels of bacteria on a wet surface, previous studies have indicated that the recovery of microorganisms is severely compromised when the sampled surface is dry.

It was ascertained that the accessibility of sampling points is correlated with the effectiveness of the cleaning procedure. An important step in the manufacture of pharmaceutical products, demonstrated by Akl et al. [7], is the cleaning of equipment and surfaces. The cleaning procedures for the equipment must be validated according to GMP rules and guidelines. The main objective of cleaning validation is to avoid contamination between different productions or cross-contamination [7]. Resto et al. [25] indicated the main requirements for the validation of cleaning processes in the pharmaceutical industry, specifying that no detergent should remain after the cleaning process, what is similar for processes for high hygiene control. The accessibility of sampling points during the cleaning procedure and cleaning direction defined the effectiveness of cleaning performance (Table 4, Figure 1) according to the sampling point (e.g. sampling points 5 and 6 located in the middle of the room in case of the double bucket system have higher cleaning efficiency in comparison to other sampling points). We estimated good hygiene practise considering the surfaces investigated before cleaning (e.g. in most cases the number of CFU is low under the internally defined action limit (200 CFU)) and after cleaning (e.g. the degree of purity in all cases except one improves, demonstrated as lower microbiological counts) (Table 4). For validation of the cleaning process and for continuously educating cleaning staff, quick and objective feedback on the surface cleanliness is of paramount importance [26].

Luick et al. [27] found that subjective and objective measures of cleanliness based on visual inspection, ATP assay, or aerobic culture were all able to demonstrate significant increases in the proportion of surfaces considered clean if analysed before and after the routine terminal cleaning protocol described in this paper. However, if visual inspection were used alone, a significantly higher proportion of surfaces would be considered clean before terminal cleaning.

CONCLUSION

The evaluation of three different cleaning procedures revealed that cleaning effectiveness depends on the surface accessibility and cleaning direction. Discrepancies between results acquired with a generic method compared to conventional microbiological surface examination in the context of surface hygiene monitoring were discovered. The semi-automatic system has shown higher efficiency in comparison to the mechanical system on surfaces with the same characteristics. We can conclude that an integrated cleaning monitoring strategy should be

The evaluation of three different cleaning procedures revealed that cleaning effectiveness depends on the surface accessibility and cleaning direction.

based on a combination of visual, non-microbiological and microbiological methods for optimal cleaning results.

This preliminary study provides vital information in the context of the very small number of publications in the field of general basic hygiene management. Assessing all interactions within cleaning procedures in different hygiene processes, it seems that many issues do not have the attention they deserve. However these kinds of research are internal in its nature and have often a confidential status. Despite of lack of published studies in this field, this kind of research is constantly underway in processes of high hygiene control including the one participating in current study, as this is one way of ensuring adequate product quality. This is of particular importance, as results of our preliminary study might serve as a basis for further professional and scientific research. This preliminary study's findings suggest that future research should explore these themes in greater depth.

Assessing all interactions within cleaning procedures in different hygiene processes, it seems that many issues do not have the attention they deserve.

LIMITATIONS OF THE STUDY

The reader of this paper should take into consideration a few limitations of the current study, which is of a preliminary nature. The study was conducted in a single institution for the processes of high hygiene control with a modest sample size and minimal sampling sequences. There was no intention to validate a generic method for surface hygiene evaluation. Smaller surfaces were evaluated under semi-controlled circumcentres with regards to the cleaning solution, surface characteristics and location of sampling points. The possible effect of the cleaning staff was not considered.

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Professional paper

Is the knowledge of international travel health a legal obligation or a social and personal responsibility?

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ABSTRACT

The preservation of health is a crucial aspect in the development of international travel. The aim of this literature review was to analyse the issues of travel- related helath risks and the possibilities of prevention. As the destination changes, hazards differ. Health hazards depend on the cultural, infrastructural, technological, enviromental aspects of tourists locations. The process of health promotion helps travellers to gather necessary information about the destination and to accomplish a safe travel. By taking precautions and complying with safety requirements, travellers avoid the spread of diseases. The knowledge of international travel health is a legal obligation and an important responsibility for every traveller.

Key words: international travel, hazards, health promotion, travellers

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INTRODUCTION

The objectives of the pre-travel consultation are to assess the traveler's trip plans and determine potential health hazards.

Travel medicine is concerned with the prevention and treatment of travel-related disease [1]. The objectives of the pre-travel consultation are to assess the traveler's trip plans and determine potential health hazards [2]. The consultation includes information about the most important health risks, including traffic accidents [3]. This speciality is increasingly comprehensive and encompasses the epidemiology of travel-related infection, the pre-travel consultation with advice on prevention, vaccination, chemoprophylaxis and self-treatment during travel. In Europe, pre-travel preventive advice follows national guidelines or WHO recommendations [1].

The likelihood of disease and injury connected with the trip depends on traveller and itinerary specific factors [4]. The consultation should take place at least 4–8 weeks before the journey and preferably earlier if long-term travel or overseas work is envisaged. Travellers with underlying medical problems are strongly advised to consult a travel medicine clinic or medical practitioner to ensure that their potentially complex travel health needs are met [3].

METHODS

Literature review and an analysis of the issue based on the current publications and agreed International Travel Health Controls to manage public health risks. Considering disease information, vaccination, travel health risks including: environmental risks, infectious disease & potential risks, accidental injury and speed of pan continental transmission including controls to minimise the global public health risks.

Sistematic literature research including implications of international travel health and basic health hazard prevention. Evaluating the theory of corelation between legal obligations and the viewpoint on social and personal responsibility. The literature review includes articles with the publication year between 1994 and 2017. Articles are available at the online scientific service Web of Science.

LITERARY ANALYSIS AND DISCUSSION

Vaccination

Vaccinations are a principal measure of pre-travel preparation and they most probably constitute the most frequent reason for which an international traveller requests consultation prior to depart.

Vaccinations are a principal measure of pre-travel preparation and they most probably constitute the most frequent reason for which an international traveller requests consultation prior to depart [5]. Travel vaccines include routine vaccines already incorporated in the national immunization program, required vaccines necessary for entry into certain countries and recommended vaccines whose recommendation depends on the risks of exposure at travel destination [3]. Risk assessment should be individualized on the basis of the epidemiological situation at destination, travel characteristics and traveller's characteristics. In addition, pre-travel consultation provides a timely opportunity for updating routine vaccinations [6]. The vaccines that may be recommended or considered for travellers are summarized in Table 1.

Table 1: Vaccines that may be recommended or considered for travellers [3]

CATEGORY	VACCINE
1. Routine vaccination	Diphtheria, tetanus, and pertussis Hepatitis B *Haemophilus influenzae* type b Human papillomavirus[a] Influenza[b] Measles, mumps and rubella Pneumococcal disease Poliomyelitis Rotavirus[a] Tuberculosis[c] Varicella
2. Selective use for travellers to destinations of particular risks[d]	Cholera Hepatitis A[e] Japanese encephalitis[e] Meningococcal disease[e] Rabies Tick-borne encephalitis[e] Typhoid fever Yellow fever[e]
3. Required vaccination	Yellow fever Meningococcal disease against serogroups A, C, Y and W135 (Saudi Arabia demands proof of recent meningococcal vaccination (tetravalent vaccine) as a visa requirement for pilgrims and guest workers) and polio (required by Saudi Arabia for pilgrims)

a To date, introduced into the routine immunization programme of a limited number of countries.

b Routine vaccination for certain age groups and also for individuals belonging to certain high-risk groups.

c No longer routine in most industrialized countries.

d For diseases in this category a summary of vaccine recommendations and other precautions is provided.

e These vaccines are also included in the routine immunization programme in several high-risk countries.

ENVIRONMENTAL RISKS

Travellers often experience abrupt and dramatic changes in environmental conditions, which may have detrimental effects on health and well-being. Travel may involve major changes in altitude, heat and humidity, and exposure to microbes, animals and insects. The negative impact of sudden changes in the environment can be minimized by taking simple precautions [3].

Altitude

Altitude illness commonly affects unacclimatized individuals traveling to altitudes over 2500 m. The term refers to a number of diagnoses including acute mountain sickness, which is most common, as well as the more severe high altitude cerebral edema and high altitude pulmonary edema [7]. Acute mountain sickness symptoms are nonspecific, with the diagnosis being defined as the presence of headache plus one or more of the following: gastrointestinal upset (anorexia, nausea, or vomiting), sleep disturbance, dizziness, and fatigueinan individual recently arrived at altitude [8].

Altitude illness commonly affects unacclimatized individuals traveling to altitudes over 2500 m.

Travellers should avoid one-day travel to sleeping altitudes over 2750 m if possible and break the journey for at least one night at 2000–2500 m to help prevent acute mountain sickness.

Only a few conditions are contraindications for travel to altitude; they include unstable angina, pulmonary hypertension, severe chronic obstructive pulmonary disease and sickle-cell anaemia [3].

Travellers should avoid one-day travel to sleeping altitudes over 2750 m if possible and break the journey for at least one night at 2000–2500 m to help prevent acute mountain sickness. They must avoid overexertion and alcohol for the first 24 h at altitude and drink extra water. If direct travel to sleeping altitude over 2750 m is unavoidable, they should consider prophylaxis with acetazolamide. Travellers with pre-existing cardiovascular or pulmonary disease should seek medical advice before travelling to high altitudes [3].

Heat and humidity

The mechanism by which heat impacts humans is complex, and although it is often treated as a sole product of temperature, in reality it is a result of the interactions between temperature, radiation, wind, and humidity. Despite its physiological importance, humidity is rarely the explicit focus in health impact studies [9]. Heat-related illnesses can manifest in occupations that demand a high amount of physical work in high ambient temperatures [10].

Consumption of salt-containing food and drink helps to replenish the electrolytes in case of heat exhaustion and after excessive sweating. Travellers should drink enough fluid to be able to maintain usual urine production. A daily shower using soap, wearing loose cotton clothing and applying talcum powder to sensitive skin areas help to reduce the development or spread of fungal skin infections. Travellers should avoid contact lenses in order to reduce the risk of eye problems [3].

Foodborne diseases

The food chain has undergone considerable and rapid changes over the last 50 years, becoming highly sophisticated and international. Although the safety of food has dramatically improved overall, progress is uneven and food-borne outbreaks remain common in many countries [11].

Examples of diseases acquired through food and water consumption are travellers' diarrhoea, hepatitis A, typhoid fever and cholera [3]. Many infectious diseases, including a variety of gastrointestinal disorders, are contracted by individuals while travelling outside their country of residence [12]. As a result, someone can be exposed to a foodborne illness in one country and expose others to the infection in a location thousand of miles away from the original source of infection [12, 13].

Heat-related illnesses can manifest in occupations that demand a high amount of physical work in high ambient temperatures.

In order to reduce the number of foodborne outbreaks, a regulatory international framework for food production and food safety has been developed over the last few years. European Union legislation on food hygiene focuses on the controls needed for public health protection and clarifies the responsibility of food business operators to produce food safely [14].

Measures to prevent foodborne diseases include diet (foods and beverages to be avoided) and hygiene (boiling water or treating it with chlorine or iodine preparations, washing hands before eating) [15].

Measures to prevent foodborne diseases include diet (foods and beverages to be avoided) and hygiene (boiling water or treating it with chlorine or iodine preparations, washing hands before eating).

Waterborne diseases

Waterborne diseases refer to any disease that can be transmitted through water, which is mainly via pathogen ingestion. However, many other potential transmission routes, such as eating food touched by an individual with soiled hands, drinking sewagecontaminated water, or contacting an infected individual during treatment in a hospital, may account for the spread of waterborne diseases [16].

Access to safe drinking water is essential to health, a basic human right and a component of effective policy for health protection. Travellers should avoid consumption or use of unsafe water, avoid unpasteurized juices, ice made from untreated water, salads or other uncooked melas. They should drink water that has been bolied, filtered or treated with chlorine or iodine and sotred in clean containers, bottled water and beverages from sealed and tamper-proof containers, pasteurized juices and pasteurized milk [17].

Animals

Animal bites have serious medical consequences including trauma, wound infection, exposure to rabies virus and social costs for the bitten individuals, and lead to thousands of deaths and injuries [18]. Taking care of animal bite-related injuries can provide useful information for planning and evaluation of public health interventions [19].

Rabies is the most important infectious health hazard from animal bites. In many developing countries, rabies is transmitted mainly by dogs, but many other mammalian species can be infected by the rabies virus [3].

Travellers should avoid direct contact with domestic animals in areas where rabies occurs, and with all wild and captive animals, behaviour that may startle, frighten or threaten an animal. A number of rabies-free countries have additional requirements. Before taking an animal abroad, the traveller should ascertain the regulatory requirements of the countries of destination and transit [3].

Snake bites

Snake bite prevention suggests avoiding all contact with snakes, even if believed to beharmless or dead, wearing protective clothing (boots not open sandals, socks, long trousers) in undergrowth or deep sand, using a light at night. Travellers should sleep off the ground, under a well-tucked-in mosquito net or on a sewn-in groundsheet to prevent nocturnal bites [20].

Travellers should avoid consumption or use of unsafe water, avoid unpasteurized juices, ice made from untreated water, salads or other uncooked melas.

Scorpion stings and spider bites

Dangerously venomous scorpions inhabit deserts or hot dusty terrains. Dangerous spiders occur in the Americas, the Mediterranean, southern

The safety of swimming in pools is susceptible by a large variety of risks, including microbiological agents, chemical agents and technological and work related hazards.

Africa and Australia. Travellers should use a permethrin-impregnated bed net, sleep off the ground, treat living quarters with insecticides and not walk bare-footed [21].

Aquatic bites and stings

Many freshwater and marine venomous fish, including stingrays, catfish, weevers, scorpion fish and stonefish, have venomous stinging spines on their gills, fins or tail [20].

Prevention of aquatic bites and stings includes the observation of local advice and warning notices before entering the water. Wetsuits and footwear prevent sea snake bites and jellyfish stings.

Swimming pools

The safety of swimming in pools is susceptible by a large variety of risks, including microbiological agents, chemical agents and technological and work related hazards [22]. The risk of illness or infection associated with swimming pools and similar recreational water environments is primarily associated with faecal contamination of the water. There are over 50 types of adenoviruses that have been linked to swimming pool outbreaks.

In some countries, it is common to shower before a swim. Showering will help to remove traces of sweat, urine, faecal matter, cosmetics, suntan oil and other potential water contaminants. Where pool users normally shower before swimming, pool water is cleaner, easier to disinfect with smaller amounts of chemicals and thus more pleasant to swim in [23].

Coastal and fresh waters

In coastal waters, infection may result from ingestion or inhalation of, or contact with, pathogenic microorganisms, which may be naturally present, carried by people or animals using the water, or present as a result of faecal contamination [3].

Travellers should use life jackets where appropriate, pay attention to, and seek information from local residents regarding, tides and currents, and avoid outlets in spas and swimming pools. They should ensure constant adult supervision of children in or near recreational waters, including small volumes of water and avoid consumption of alcohol before any activity in or near water [3].

Parasites

A parasite is an organism that lives on or in a host organism and gets its food from or at the expense of its host. There are three main classes of parasites that can cause disease in humans: protozoa, helminths, and ectoparasites.

Travellers should avoid walking barefoot, as parasites can enter intact or damaged skin [24].

INFECTIOUS DISEASES AND POTENTIAL RISKS

Infectious diseases constitute one important aspect of travel associated risks. Despite possibilities of prevention by means of vaccinations and other preventive measures, vaccine preventable diseases remain an important contributor to morbidity in travellers [25].

Travellers as tourists or occupational travellers will encounter a range of infectious agents at the destination that differ greatly from those of home especially when visiting low income, tropical countries [1].

Zoonotic diseases

Zoonotic diseases are described as those diseases transmitted from animals to humans. While the transmissive stages of zoonoses can be transmitted directly (e.g. by animal human contact or through contact with contaminated faeces, soil and herbage), they can also be transmitted through contaminated water and food [26].

The risk of infection can be reduced by avoiding close contact with any animals – including wild, captive and domestic animals in places where infection is likely to be present. Particular care should be taken to prevent children from approaching or touching animals [3].

Sexually transmitted infections

Sexually Transmitted Diseases (STDs) are diseases that are passed on from one person to another through sexual contact, and sometimes by genital contact – the infection can be passed on via vaginal intercourse, oral sex, and anal sex [27].

The risk of infection can be reduced by avoiding casual and unprotected sexual intercourse and by use of condoms [3].

Bloodborne diseases and diseases transmitted via soil

Bloodborne diseases are transmitted by direct contact with infected blood or other body fluids. The risk of infection can be reduced by avoiding direct contact with blood and body fluids. Soil-transmitted diseases include those caused by dormant forms (spores) of infectious agents, which can cause infection by contact with broken skin. The risk of infection can be reduced by protecting the skin from direct contact with soil in places where soil-transmitted infections are likely to be present [3]. The risk of contracting a soil-transmitted disease can be high when getting a tattoo abroad. Travellers should make sure that all tattoo equipment is fully sealed, within date, sterilised and opened in front of them.

Airborne diseases

People encounter and have contacts with others in conducting activities or traveling; thus, they may become infected with air- borne viruses when epidemics are prevalent [28]. Airborne transmission occurs when droplet nuclei <5 μm in size are disseminated in the air and breathed in. Droplets are usually generated by the infected individual during coughing, sneezing or talking [3].

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Today's highly mobile, interdependent and interconnected world provides myriad opportunities for the rapid spread of diseases.

The probability that a susceptible person becomes infected during a visit to a sublocation depends on: how many infectious persons co-occupy the room, how long each contact lasts, the type of activity, and the infectiousness category of the infectious person [28].

ACCIDENTAL INJURY

Unintentional injury is a global public health problem. Reasons for the increasing public health importance of injury include the decline of infectious disease, the processes of urbanization, industrialization, motorization, and increased opportunities to travel [29].

Motor vehicle crashes, drownings, aircraft crashes, homicides, and burns can cause fatal injury deaths to travelers. Injuries to travelers are not random events. As with other health problems such as infectious diseases, injuries are preventable. Injury prevention and control is a science with fundamental principles and a growing knowledge base [30].

Traffic injury

Road traffic injuries constitute a major public health and development crisis, and are predicted to increase if road safety is not addressed adequately [31].

Precautions in the countries to be visited include obtaining information on the regulations governing traffic and vehicle maintenance and on the state of the roads. Travellers should not drive after drinking alcohol, drive within the speed limit at all times, always wear a seat-belt. In addition, travellers driving vehicles abroad should make sure they carry their personal driving licence as well as an international driving permit and that they have full insurance cover for medical treatment of injuries [3].

Drownings

Drowning is an important public health issue with major impacts on children and youth. Drowning is preventable. Lack of barriers controlling exposure to water bodies and lack of adequate, close supervision for infants and young children are a drowning risk, as are poor swim skills and low awareness of water dangers. In addition, high-risk behaviour, including consuming alcohol while engaging with water, is a risk among young people and adults. Other risk factors are transport on water and water crossings, lack of safe water supply, and flood disasters [32].

SPEED OF PAN CONTINENTAL TRANSMISSION

Today's highly mobile, interdependent and interconnected world provides myriad opportunities for the rapid spread of diseases. A number of factors have underscored the fact that infectious disease events in one country may be of potential concern for the entire world. These factors include: increased population movements; growth in international trade in food; biological, social and environmental changes linked with urbanization; deforestation; alterations in climate; and changes in meth-

ods of food processing, distribution and consumer habits. Consequently, the need for international cooperation in order to safeguard global health has become increasingly important. It is critical that all countries have the capacity to detect, assess, and respond to public health events. They will then be able to contain the spread of diseases within their borders, thus minimizing the international spread of diseases [33].

Keeping healthy is not only a common personal priority and a moral issue, but it is also a legal obligation.

CONCLUSION

Information, epidemiological data and surveillance are fundamental to obtain reliable information about the local health status and to prevent potential health problems. Vaccination entry requirements, road traffic safety requirements, food safety requirements and other specifications confirm the improtance of public health. By taking simple precautions, that are described in this essay, travellers avoid plenty of risks and prevent the spread of diseases. Every traveller should travel safely and should be responsible for protecting the health of others and his own health. Keeping healthy is not only a common personal priority and a moral issue, but it is also a legal obligation.

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