



Occurrence of Legionella sp. bacteria in hot water systems in hospitals and nursing homes in the Świętokrzyskie Province of south-eastern Poland

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation,

D – Writing the article, E – Critical revision of the article, F – Final approval of the article

Szczepanek A, Tyszko P, Kalinowski P, Chmielewski J, Choina P, Nowak-Starz G. Occurrence of Legionella sp. bacteria in hot water systems in hospitals and nursing homes in the Świętokrzyskie Province of south-eastern Poland. Ann Agric Environ Med. 2023; 30(4): 654–660. doi: 10.26444/aaem/176501

Abstract

Introduction and Objective. The occurrence of bacteria of the genus Legionella sp. in hot water supply systems in buildings is a real threat to human health, especially for patients in hospitals and residents of nursing homes. The aim of the study was determination of the degree of colonization of hot water systems in hospitals and nursing homes in the Świętokrzyskie Province in south-east Poland.

Materials and method. Between 2014 – 2018, samples were collected from hot water systems in 30 hospitals and 32 nursing homes in order to determine the degree of contamination. 631 samples collected of the bacteria Legionella sp were analyzed.

Results. Excessive contamination ($\geq 100\text{CFU}/100\text{ ml}$) with the bacteria Legionella sp. was detected in 12.12% (n=71) of samples. Contamination was significantly more frequently detected in samples from hot water systems in nursing homes, compared to hospitals (16.48% vs. 10.37%). Above-standard contamination of hot water systems with Legionella sp. bacteria occurred in 34.43% of the facilities, and was more frequent in hospitals (41.38%) than in the nursing homes (28.13%). In 21.3% of the facilities, contamination was detected many times during the study period.

Conclusions. Excessive contamination of hot water systems with Legionella sp. bacteria in the examined facilities was a common phenomenon. The presence of the pathogen in the installations of these facilities may constitute a considerable health hazard for patients and residents.

Key words

colonization, hospitals, Legionella pneumophila, nursing homes, Legionnaires' disease

INTRODUCTION

In 2021, according to the latest report by the European Centre for Disease Prevention and Control (ECDC), in the European Union, Iceland, Norway and Liechtenstein, 10,723 cases of legionellosis were reported (2.4 per 100,000 population). In Poland, the morbidity rate was only 0.1 per 100,000 population (46 cases) which may evidence a low detectability of the cases of infection [1]. An epidemic of unknown etiology which took place at the turn of August and September in 2023 in Rzeszów, south-east Poland, during which 165 people became ill – which was 43 persons more than in the whole of Poland in 2022 – of whom 25 died, showed that Legionella sp. bacteria constitute a big problem [2]. In 2003 – 2022, the number of cases of legionellosis reported in Poland increased from 3 to 118 [3, 4].

At present, there are 61 bacterial species known of the genus Legionella sp., and more than 82 serological groups, while 30 bacterial species belonging to the family Legionellaceae are considered pathogenic for humans [5, 6]. Approximately 90% of cases worldwide (95% in Europe) are caused by the species Legionella pneumophila, of which Legionella pneumophila belonging to serogroup 1, are responsible for 85% of infections. In New Zealand and Australia, 30 – 50% of infections are caused by Legionella longbeachae, and in the United States, Legionella bacteria may be responsible for 2 – 9% of the total number of cases of pneumonia. These data are confirmed by studies conducted in other countries [7, 8].

Bacteria of the genus Legionella sp. are commonly present in natural water reservoirs, such as rivers, lakes, coastal zones of seas and oceans, and ground waters. They may also occur in soil, compost, or in decaying bark and sawdust. A special case is Legionella longbeachae, rarely found in water samples, but frequently occurring in garden soil [5, 9, 10].

In conducive conditions Legionella sp. bacilli enter water systems from natural sources and colonize artificial water

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reservoirs [11]. Potential sources of infection are installations and devices producing water aerosol, especially with a droplet size of $< 5 \mu\text{m}$ [12]. Data from literature demonstrate that in more than 50% of cases of legionellosis the sources of infection were cooling towers and external elements of air conditioning systems. In addition, infections may be associated with the use of hot water systems, swimming pools and whirlpool bathtubs, staying in air-conditioned rooms, or in the vicinity of fountains and sprinklers [7, 13]. In the USA, 25% of the total number of cases of legionellosis reported to the Centers for Disease Control (CDC) originated from health care facilities. Patients in hospitals and nursing homes, due to their individual traits such as advanced age, chronic diseases, immunodeficiencies, and exposure to aerosol which may contain the bacteria *Legionella sp.*, are the group especially at risk [14, 15].

Infections with *Legionella sp.* bacilli occur mainly by inhalation of aerosol containing the pathogen, and infection due to choking on contaminated water is also possible. Single studies suggest the possibility of the direct transmission of *Legionella sp.* bacteria between two persons [16, 17].

Legionella sp. bacteria penetrate in aerosol droplets to the distal parts of the lungs, where they show affinity for macrophages, monocytes, and type I and II alveolar epithelial cells and fibroblasts, where the disease continues to develop [18]. Three types of legionellosis are distinguished according to the type and severity of symptoms: pulmonary (Legionnaires disease), extrapulmonary (Pontiac fever), and severe extrapulmonary form. Legionnaires disease is a non-specific pneumonia, the symptoms of which may resemble an infection with pneumococci, or other bacteria. Initially, the disease is characterized by headache and muscle pain, anxiety, lack of appetite, fever and bradycardia. Legionnaires disease differs from other types of pneumonia by gastrointestinal symptoms: diarrhea, nausea, vomiting, or abdominal pain. In approximately 50% of patients, cough occurs with purulent sputum and pleural pain. Recovery may take up to several weeks [8, 19, 20]. Mortality is 8 – 12% (in the case of hospital-acquired infections, up to 80%) and depends on many individual factors [21].

The bacteria *Legionella sp.* may cause Pontiac fever with a milder course than Legionnaires disease [18]. Pontiac fever causes a number of non-specific flu-like symptoms. In the course of the disease, pneumonia characteristic of Legionnaires disease does not occur. Infected persons do not require pharmacological treatment, the infection resolves spontaneously after 2–5 days. To-date, no cases of death have been observed resulting from contracting Pontiac fever [22, 23].

In a few cases, in patients who had undergone surgical procedures, with weakened immunity, or undergoing immuno-suppression, the bacilli cause a severe extrapulmonary form of legionellosis. While infecting tissues and organs, *Legionella sp.* bacteria may cause inflammation of the myocardium, pericardium and endocardium, nephritis, peritoneum, spleen, joints, pancreas, connective tissue, and the central nervous system [19, 24].

Due to individual traits, state of health, life style, socio-economic status, and environmental factors, a part of the population is more exposed to the pathogenic factor which are *Legionella sp.* bacteria, and more susceptible to contracting the disease. One of the main factors increasing the risk of infection is age. In 2017, in the countries of the

European Union and the European Economic Area, more than 91% of cases of legionellosis were noted in persons aged 45 and over. Males 2.4 times more often than females contract legionellosis-related pneumonia. In addition, morbidity is increased by alcohol abuse and tobacco smoking, the risk increasing with the number of cigarettes smoked daily. Nicotinism is the most frequently observed risk factor occurring in 40% of patients. The risk factors resulting from the state of health are: obstructive pulmonary disease and other lung diseases, heart diseases, renal failure, blood cancers and diabetes, and immunodeficiencies [25, 26].

OBJECTIVE

The aim of the study was determination of the percentage of hospital buildings and nursing homes (DPS) in the Świętokrzyskie Province of south-east Poland during 2014 – 2018, where an excessive contamination of hot water systems with *Legionella sp.* bacteria was found, and whether the type of the facility (hospital, DPS) exerts an effect on the occurrence of contamination and its level.

MATERIALS AND METHOD

The analysis covered 631 results from hot water quality tests for the occurrence of *Legionella sp.* bacteria carried out between 2014 – 2018 by the representatives of the State Sanitary Inspectorate, as part of ongoing sanitary supervision. The results were obtained from the Water Databases EXCEL (BDWE) maintained by the authorities of the State Sanitary Inspectorate in the Świętokrzyskie Province. All hospitals and nursing homes located in the province were included in the study. The number of institutions in the study was determined based on registers kept by the Świętokrzyskie provincial authorities. In the case of an institution operating in several locations, or several buildings possessing an independent hot water system, each building was treated as an independent facility. The samples were collected in 25 hospitals (30 facilities), i.e. all in those registered, and 32 nursing homes; at the time of the study, 7 DPSs were not functioning or their managers did not express their consent to participate in the research. In addition, the results of studies conducted in 2018 in 16 buildings in hospitals providing health care, such as inpatient and 24-hour health services hospitalizing patients with weakened immunity, or those covered by immuno-suppressive treatment, were analyzed. In accordance with Annex 5 of the Regulation of the Minister of Health of 7 December 2017 *on the quality of water intended for human consumption*, this class of facilities was sampled with a volume of 1,000 ml [27], which guarantees a higher detection of the pathogen at lower levels of contamination. (Tab. 1).

Legionella sp. bacilli were determined in the laboratories of the State Sanitary Inspectorate by the method of membrane filtration, based on the methodology specified in Annex No. 9B to the Regulation by the Minister of Health of 29 March 2007 *on water intended for human consumption*, i.e. in accordance with the standard PN-ISO 11731-2:2008, and based on the methodology set out in the Annex No. 6A to the Regulation by the Minister of Health of 7 December 2017 *on water intended for human consumption*, i.e. in accordance

Table 1. Characteristics of the examined group

Variable		n	%
Facilities	hospital	30	48.4
	DPS	32	51.6
Samples collected (100 ml)	hospital	405	69.7
	DPS	176	30.3
Samples collected (1000 ml)	hospital	50	100.0
	DPS	0	0.0

n – size of the subgroup; DPS – nursing home; % – percentage.

with the standard PN-ISO 11731 [27]. Hot water samples were collected in 1,000 ml sterile glass bottles and tested by membrane filtration after delivery to the laboratory. Samples of 1 ml, 10 ml, 100 ml and 500 ml were passed through cellulose filters with a pore diameter of 0.45 µm. To remove accompanying microflora, the filters were soaked in pH 2.2 buffer for 5–10 minutes and then rinsed with Ringer's solution (dilution 1:40), and placed on plates containing buffered charcoal agar and yeast extract (BCYE), supplemented with glycine, vancomycin hydrochloride, polymyxin B sulphate and cycloheximide (GVPC). The culture was incubated at 36±2°C in a humid atmosphere for 7–10 days, with daily observations of colony growth (colonies growing in the first 2 days were considered as accompanying microflora). A confirmatory test was performed using BCYE with cysteine (*Legionella* sp. growth) and BCYE without cysteine (no *Legionella* sp. growth). The level of contamination of the sample and hot water system in a building was evaluated according to the number of bacteria and size of the sample (Tab. 2).

Table 2. Evaluation of contamination according to the number of Legionella sp. bacteria

No. of Legionella sp. in the sample		Evaluation of contamination
100 ml	1000 ml	
0 CFU	0 CFU	no contamination
1–100 CFU	<50 CFU	marginal contamination
100 – 1000 CFU	≥50 CFU	medium contamination
1000–10000 CFU	≥100 CFU	high contamination
>10000 CFU	≥1000 CFU	very high contamination

CFU – colony forming units; ml – millilitre.

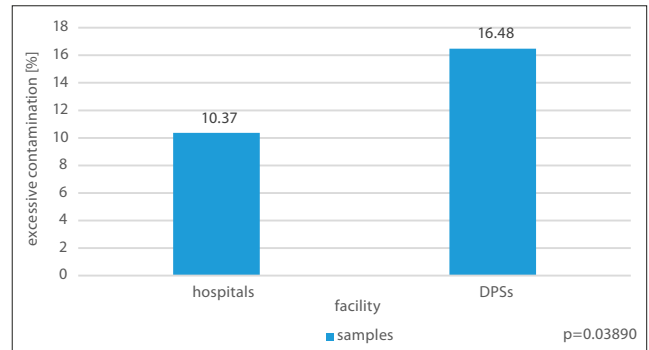
Source: Based on the regulation by the Minister of Health of 7 December 2017, 'On water intended for human consumption'.

In accordance with the provisions of law, when in subsequent tests carried out in a given facility at annual intervals < 100 CFU/100 ml was found, based on risk assessment, it is considered that the problem of colonization of a hot water system does not occur (positive evaluation), a subsequent test is performed after 3 years.

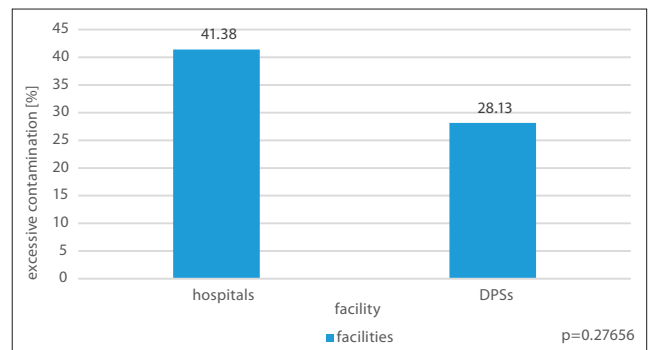
The collected data have been compiled in a database prepared in the EXCEL software, within the package Microsoft Office 2021. Calculations were performed using the statistical package STATISTICA (v. 13). Differences between the analyzed groups were investigated by means of chi-square test. The level of significance was set at p<0.05.

RESULTS

An excessive (≥ 100CFU/100 ml) number of *Legionella* sp. bacteria was detected in 12.12% (n=71) of samples. The contamination was significantly more often found (p=0.03890) in the samples from hot water systems in hospitals than DPSs (10.37% vs. 16.48%) (Fig. 1).

**Figure 1.** Excessive contamination with *Legionella* sp. of collected samples in hospitals and DPSs during 2014–2018

Generally during the study, the problem of the occurrence of an excessive number of the bacteria *Legionella* sp. (≥100CFU/100 ml) concerned installations in 34.43% (n=21) of hospital and DPS buildings in the Świętokrzyskie Province. Contamination was observed more often in hospital buildings – 41.38% (n=12), compared to DPSs – 28.13% (n=9); however, the differences were statistically insignificant (p=0.27656) (Fig. 2).

**Figure 2.** Excessive contamination with *Legionella* sp. of hot water systems in hospitals and DPSs during 2014–2018

A detailed analysis of the results of studies showed significant differences (p=0.01215) in the determined number of bacteria for individual classes of facilities (Tab. 3).

Table 3. Level of contamination of Legionella sp. bacteria in samples collected in hospitals and nursing homes

Facility	Level of samples contamination (sample volume 100 ml)							
	none		marginal		medium		high	
	n	%	n	%	n	%	n	%
hospitals	198	48.89	165	40.74	40	9.88	2	0.49
DPSs	80	45.45	67	38.07	22	12.50	7	3.98
Total	278	47.85	232	39.90	62	10.67	9	1.55

test: chi-square; p=0.01215

n – samples; DPS – nursing home; % – percentage

The percentage of samples collected in DPSs, where the contamination was evaluated as medium and high, was higher (12.50% and 3.98%, respectively), compared to hospitals (9.88% and 0.49%, respectively).

Based on the results of examinations of the collected water samples, the level of contamination of hot water systems in hospital buildings was assessed (Tab. 4). During 2014–2018, no contamination of hot water systems occurred in 27.87% (n=17) of buildings, while in 37.70% (n=23), only a marginal contamination was detected (according to the legal regulations treated as the lack of contamination). Medium and high contamination was noted in 29.51% (n=18) and 4.92% (n=3) of the facilities, respectively. A high level of contamination was more often observed in the DPS buildings, than in hospitals, (6.25%; n=2 vs. 3.45%; n=1). An opposite situation was noted in the case of medium contamination, which was more frequently detected in hospital buildings 37.93% (n=11) than in DPS 21.88% (n=7).

Table 4. Level of contamination with *Legionella sp.* bacteria in hot water systems in hospitals and nursing homes

facility	Level of contamination hot water systems (sample volume 100 ml)							
	none 0 CFU		marginal 1–100 CFU		medium 100–1,000 CFU		high 1,000–10,000 CFU	
	N	%	N	%	N	%	N	%
hospitals	8	27.59	9	31.03	11	37.93	1	3.45
DPSs	9	28.13	14	43.75	7	21.88	2	6.25
Total	17	27.87	23	37.70	18	29.51	3	4.92

test: chi-square; p=0.52688

N – facilities; DPS – nursing home; % – percentage

In detail, a negative assessment of installations was mainly due to the occurrence of contamination on the medium level (100–1000 CFU/100ml), and concerned from 3.33% (DPS, 2016) – 18.52% of facilities (hospitals, 2016) (Fig. 3). A high level of contamination (1,000 – 10,000 CFU/100ml) was found in 2014 (n=1), 2016 (n=2), and 2017 (n=2). In the case of one of the facilities (DPS), contamination on a high level was noted in as many as 3 years (2014, 2016, and 2017). Maximum level of *Legionella sp.* bacteria detected during the study was noted (3,300 CFU/100 ml) in the case of a DPS, and (1,570 CFU/100 ml) in a hospital building. During the study, no contamination of hot water system on a very high level was observed ($\geq 10,000$ CFU/100ml). Between 2014–2018, the percentage of buildings in which an excessive contamination

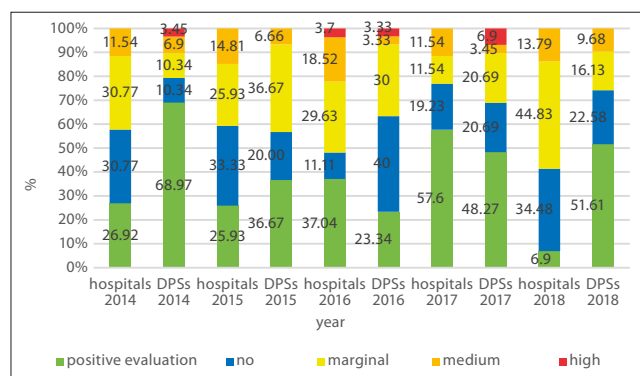


Figure 3. Level of contamination with *Legionella sp.* bacteria of hot water systems in hospitals and DPSs during 2014–2018

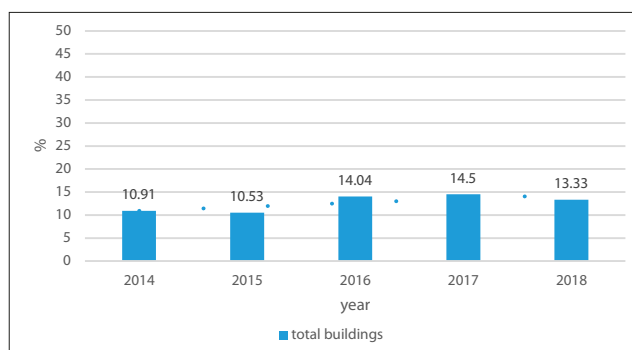


Figure 4. Percentage of buildings (total) where an excessive contamination with *Legionella sp.* was observed in 2014–2018

of hot water systems with bacteria of the genus *Legionella sp.* increased from 10.91% – 13.33% (Fig. 4).

Assessment of multiple contaminations of hot water systems did not show any relationship between the type of the facility, and the number of cases of detection of excessive number of bacteria in the same facility (p=0.51360) (Tab. 5). In 13.12% (n=8) of the facilities, contamination of hot water system was detected only once. In 24.14% (n=7) of hospital buildings and in 18.74% (n=6) of DPS buildings an excessive number of bacteria was detected twice or three times (a triple contamination was noted only in the case of one hospital building and one DPS building).

Table 5. Occurrence of an excessive number of *Legionella sp.* bacteria in 2014–2018 in hot water systems in hospitals and DPS buildings

Occurrence of excessive contamination	hospitals		DPSs		Total	
	n	%	n	%	n	%
none	17	58.62	23	71.88	40	65.57
once	5	17.24	3	9.38	8	13.12
two or three times	7	24.14	6	18.74	13	21.31
Total	29	100.00	32	100.00	61	100.00

test: chi-square; p=0.51360

n – size of subgroup; DPS – nursing home; % – percentage.

In 2018, in hospitals providing health care in the form of inpatient and 24-hour health services, for patients with weakened immunity, including those undergoing immunosuppressive treatment, 50 samples were collected with a volume of 1,000 ml (Tab. 6). Excessive contamination was found in 37.55% (n=10) of buildings, including 4 facilities where the contamination was on a high level (25.00%), and 2 on a very high level (12.50%). Generally, contamination

Table 6. Maximum level of contamination of samples and hot water systems with *Legionella sp.* bacteria in hospital buildings (CFU/1,000 ml)

Level of contamination	Hospitals		Samples	
	n	%	n	%
none	4	25.00	19	38.00
marginal	6	37.50	18	36.00
medium	0	0.00	1	2.00
high	4	25.00	8	16.00
very high	2	12.50	4	8.00
Total	16	100.00	50	100.00

n – size of subgroup; % – percentage.

with the level of bacteria inconsistent with regulations was observed in 26% of the examined samples. A maximum contamination of a sample was 1,700 CFU/1000 ml.

DISCUSSION

Due to the prevalence, low nutritional requirements, and resistance to temperature and disinfectants, colonization of hot water systems in buildings by *Legionella sp.* bacilli poses an important problem for public health. The occurrence of *Legionella sp.* bacteria in water distribution systems in hospitals and nursing homes – facilities providing care for persons classified to groups at risk – is especially dangerous [25, 26].

The presented study confirmed the prevalence of *Legionella sp.* bacteria in water samples collected from hot water systems in hospitals and nursing homes in the Świętokrzyskie Province. This pathogen in the numbers >100 CFU/100ml was detected in 12.12% (n=71) of 581 samples of hot water. An excessive number of the bacteria was significantly more frequently ($p=0.03890$) present in the samples from hot water systems in DPSs (16.48%), compared to hospitals (10.37%). In the samples collected in DPS buildings, statistically more often than in hospitals ($p=0.01215$) the contamination was on the average level (12.50% vs. 9.88%) and on a high level (3.98% vs. 0.49%). The mean number of *Legionella sp.* bacteria in the examined samples was from 51 CFU/100ml in 2015 (\bar{X} :51.88; $SD\pm 108.49$; $Me:25.00$) to 191 CFU/100ml in 2017 (\bar{X} :191.2; $SD\pm 415.04$; $Me: 25.67$). A maximum number of bacteria determined during the study was 3,300 CFU/100ml (DPS), and 1,570 CFU/100ml (hospital).

During the analyzed period, the problem of the occurrence of an excessive number of *Legionella sp.* bacteria concerned 34.43% (n=21) of hospital and DPS buildings in the Świętokrzyskie Province. Contamination of installations was more frequently present in hospital buildings – 41.38% (n=12), compared to DPS – 28.13% (n=9). In 2014 – 2018, no contamination was noted in 27.87% (n=17) of buildings, while in 37.70% (n=23) of buildings the contamination was marginal (according to the regulations treated as no contamination). Medium and high contamination was found in 29.51% (n=18) and 4.92% (n=3) of the facilities, respectively. In the presented study, in none of the facilities the level of colonization of installations was evaluated as very high.

The problem of occurrence of *Legionella sp.* bacteria in hospitals and nursing homes is widely undertaken by researchers in Poland and many countries worldwide. It is noteworthy that the comparison of the results of studies conducted in various countries may not be reliable due to the local legal context, guidelines of authorized bodies, and the testing methodology used.

In south-western Greece, Fragou et al. investigated the level of colonization of hot water systems in hospitals and confirmed that 33% of the installations were colonized by *Legionella sp.* bacilli. In 7.7% of the tested samples the number of the bacteria remained within the range from 100 – 1,000 CFU/100ml, whereas in 18.7% – within the range 1,000 – 10,000 CFU/100ml [28].

In a study carried out in the USA, England and Scotland the bacteria were present in 12 – 70% of hospital buildings [29–31]. An even higher percentage of facilities with colonized hot water systems was presented in a study conducted during

2000 – 2009 by Napoli et al., which included 129 health care buildings in south-eastern Italy. *Legionella sp.* bacilli were present in hot water systems in 79.1% of facilities (33.9% of the collected samples) [32].

Gładysz et al. analyzed the results of examinations of the quality of hot water in 221 hospitals in the whole of Poland. An excessive number of *Legionella sp.* bacilli was confirmed in 29.0% of the collected samples (18.1% 100 – 1,000 CFU/100ml; 9.6% 1,000 – 10,000 CFU/100ml; 1.3% 10,000 – 100,000 CFU/100ml); mean number of the bacteria – 1,541.0 CFU/100ml ($SD\pm 381$; $Me:118.0$) [33]. In an all-Polish study which included 56 DPSs, the percentage of facilities where the detected number of bacteria was inconsistent with the standard was 14.2% in 2014 and 2015, and 12.4% in 2016; mean number of colonies of *Legionella sp.* – 1,369 CFU/100ml ($SD\pm 4305$) [34].

In a study by Szczerbiński et al., contamination was detected in 26.9% of the tested samples collected in hospital buildings (13.21% 100 – 1,000 CFU/100ml, 9.91% 1,000 – 10,000 CFU/100ml, 3.77% 10,000 – 100,000 CFU/100ml), and 3.85% of samples from DPSs. According to this report the problem of an excessive number of bacteria concerned 62.07% of hospital buildings, and only 3.45% of DPS buildings in the Białystok Voivodeship. The maximum contamination noted was 20,636 CFU/100ml (hospital building), and as high as 40,000 CFU/100ml in the case of a sample collected from the DPS system [35]; the results were considerably higher than those in the presented study. In a report concerning the occurrence of *Legionella sp.* bacilli in public utility facilities in the Opole Province in south-east Poland, Matejuk et al. detected contamination of the installations in 63% of hospitals and in 23% of DPSs in 2010, and in 57% of hospitals and 55% of DPSs in the subsequent year. In 2010, an excessive number of bacteria was present in 41.1% of samples collected in hospitals, and in 20.9% of samples from DPSs, while in 2011 these numbers were 35.7% and 41.3% of samples, respectively [36].

Sikora et al. found above-normative contamination in 34.1% of samples taken (28.3% 100 – 1,000 cfu/100ml, 6.07% 1,000 – 10,000 cfu/100ml) from hot water distribution systems of hospitals in the Lublin Province in south-east Poland; maximum contamination of the sample – 3,300 cfu/100ml [37]. An even higher percentage (65.7%) of contaminated water samples taken from hot water systems of hospitals in the Lublin Province was reported in the study by Stojek et al. The maximum contamination level was 350 cfu/100ml, much lower than in the research conducted by the authors of the current article [38].

In the group of hospitals where patients undergoing immuno-suppression, with weakened immunity or respiratory failure were hospitalized, the water samples were tested while observing more stringent standards. In this type of facilities, the number of bacteria must be lower than 50 CFU/1,000 ml sample. A study conducted in 2018 in hospitals in the Świętokrzyskie Province confirmed the presence of bacteria in 75.0% of facilities (62.0% of samples). Excessive contamination occurred in 37.50% of buildings (24.0% of collected samples). The mean number of colonies of *Legionella sp.* bacteria in this class of facilities detected during the study was on the level of 166 CFU/1000ml. (\bar{X} :166.67; $SD\pm 322.37$; $Me: 29.33$). The highest contamination determined was 1,700 CFU/1,000ml.

According to scientific reports, contamination of water systems in hospitals designed for patients from groups at

special risk is a common problem. In a number of reports, the presented percentage of facilities with colonized systems was higher than in the presented study. Patterson et al. examined 69 transplant centres in the UK for the presence of bacilli. The presence of *Legionella sp.* bacteria was confirmed in internal water supply installations in 55% of facilities [39].

During a study by Deiane et al., which lasted for 10 years and conducted at the University Hospital of Sassari in Italy, 305 samples were collected in wards where patients at high risk were hospitalized. An excessive number of *Legionella sp.* bacteria (in accordance with the Italian guidelines > 100 CFU/1,000 ml) was detected in 39.4% of samples. In 4 samples the contamination was within the range 15,200 – 60,000 CFU/1,000 ml [40]. Similar results were obtained by Abdalla et al., who detected bacilli in 47% of the tested samples (31.8% > 100 CFU/1,000 ml) [41].

The current Polish Regulation of the Minister of Health of 7 December 2017 on the quality of water intended for human consumption [27], only regulates the issue of testing hot water for the presence of *Legionella sp.* and the patterns of action in the case of detection of above normal contamination. These provisions are not sufficient to ensure the health safety of hot water users, especially in hospitals and DPSs, where high-risk individuals reside. It seems necessary to implement obligatory organizational and technical solutions (e.g. monitoring of water temperature, cleaning and disinfection of the parts of hot water installation, as well as continuous training of personnel and development of documentation for monitoring water quality) in order to reduce the risk of excessive colonization of the water installation, and thus the possibility of infection of hospital patients and residents of DPS with *Legionella sp.*

The above solutions are in line with Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption, and in particular Article 10: 'Risk assessment in indoor water supply systems' [42]. The Directive amending approaches to the monitoring of indoor water systems and the quality of hot water should have been implemented into the Polish legal system by 12 October 2023. Despite the fact that 11 months have passed since the deadline, the Directive has still not been introduced into the Polish legal system.

CONCLUSIONS

- 1) The occurrence of excessive contamination of hot water systems with *Legionella sp.* bacteria in hospitals (also in the form of inpatient and 24-hour services for patients with weakened immunity, including those undergoing immunosuppressive treatment) and DPSs in the Świętokrzyskie Province of south-east Poland is a common phenomenon, which should be considered as a negative factor.
- 2) In the samples collected in DPS buildings, more often than in hospitals, the improper quality of water was found due to the number of *Legionella sp.* bacteria, which is inconsistent with the regulations in effect. In nursing homes, the detected contamination of hot water systems was encountered more often on medium and high levels.
- 3) During the 5-year period of the study, in a considerable percentage of facilities an excessive contamination was confirmed more than once.

- 4) Implementation of the Directive will impose appropriate control and management measures to prevent the occurrence of contamination of hot water systems, and thus outbreaks of legionellosis.
- 5) The competent authorities and institutions should seek implementation of the Directive into Polish law without delay.

Limitations of the study. The study was based on a retrospective analysis of hot water test results. Identification of *Legionella* bacteria at species level was not performed. In addition, the study covered only a limited number of facilities located in one province.

Acknowledgements

Project financed under the program the Minister of Education and Science called "Regional Initiative of Excellence" in the years 2019-2023, project no. 024/RID/2018/19, amount of financing 11 999 000,00 PLN

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