

# SPA POOL RELATED CLUSTERS OF LEGIONNAIRES' DISEASE IN HUNGARY

ZSÓFIA BARNA<sup>1</sup>, JUDIT K HORVÁTH<sup>2</sup>, MIHÁLY KÁDÁR<sup>1</sup>, ILONA F PALUSKA<sup>3</sup>, ANITA SZAX<sup>1</sup>, TAMÁS PÁNDICS<sup>1</sup>, MÁRTA VARGHA<sup>1</sup>

<sup>1</sup>National Public Health Center, Public Health Laboratory Department, Budapest, Hungary

<sup>2</sup>National Public Health Center, Department of Public Health Strategy, Health Improvement and Health Monitoring, Budapest, Hungary

<sup>3</sup>National Public Health Center, Microbiological Reference Laboratory Department, Budapest, Hungary

---

## ABSTRACT

Three clusters (eight cases including two deaths in total) of spa pool related travel associated Legionnaires' disease cases were identified in Hungary between 2010 and 2012. The aetiological agent was *L. pneumophila* sg 1 in all three clusters. Clinical strains were available from cluster 1 and 2. In cluster 1, the spa pool water was negative for legionellae, but *L. pneumophila* 1 was isolated from the sand filter. In the other two clusters high *Legionella* counts were detected in the pool water (1,700 and 1,500,000 CFU/L, respectively). The domestic water distribution system was negative in all three hotels. In all three clusters, the residual disinfectant level was low or not recorded at the estimated time of infection, on-site measurements were not carried out properly, and records were incomplete. In clusters 2 and 3, the pool design was not suitable for community use and in the latter pool management practices did not meet the minimum standards. These results strongly support that the source of infection with high probability was the hotel spa pool. The pools were shut down, disinfected and refurbished where necessary and re-opened under strong supervision of the local health authority after negative results. The findings of the investigations served as a basis for the development of legislation on environmental *Legionella* risk assessment and risk management, covering spa pools among other settings.

**KEY WORDS:** Legionnaires' disease, cluster, spa pool, pool hygiene, Hungary

---

*Corresponding author: Márta Vargha, Ph.D.*

*National Public Health Center*

*Public Health Laboratory Department*

*Albert Flórián út 2-6, Budapest, Hungary, H-1097*

*Email address: vargha.marta@nnk.gov.hu*

*Phone: + 36 1 476 1173*

Received: 10<sup>th</sup> May 2019

Accepted: 19<sup>th</sup> June 2019

**ABBREVIATIONS:**

ELDSNet	European Legionnaires' Disease Surveillance Network
GVPC	Glycine Vancomycin Polymyxin Cycloheximide
PFGE	Pulse Field Gel Electrophoresis
SBT	Sequence Based Typing
ST	Sequence Type
TALD	Travel Associated Legionnaires' Disease

**INTRODUCTION**

In Hungary, thermal spas and associated health and recreational services are a major tourist attraction, thus the investigation and mitigation bathing related health risks is an economic as well as a public health imperative. However, before 2016, *Legionella* was not part of the mandatory pool water quality monitoring scheme of the Hungarian regulation on public pools and spas, though it has been included in a relevant Hungarian standard on best practice of operation since 2012 (Ministry of Welfare, 1996; MSZT, 2012, Ministry of Human Capacities, 2015). Spa-pools, especially whirlpools or pools with water features are known hazard for *Legionella* exposure, due to their temperature and aerosol formation potential (WHO, 2006; Barna, 2012; Leoni, 2018).

Spa pools are the third most common source of Legionnaires' disease outbreaks in the world (Jernigan et al., 1996; den Boer et al., 2002; De Schrijver et al., 2003; Coetzee et al., 2012; Vanaclocha et al., 2012, Hamilton, 2018). Increasing numbers and popularity of both public and private spa pools also contribute to the high incidence of Legionnaires' disease. However, the risk of infection can be minimized through adequate management measures (WHO, 2007; CDC, 2018). Most outbreak reports on pool and spa facilities flag mismanagement with insufficient disinfection as the primary risk factor, calling for more efforts on control and supervision (McEvoy et al., 2000; Ruscoe et al., 2006; Brousseau et al., 2013). A large cluster of travel associated Legionnaires' disease (TALD) in Calpe, Spain with 40 cases was also attributed to a spa pool (Vanaclocha et al., 2012).

Legionellosis has been a statutorily notifiable disease in Hungary since 1998 (Ministry of Welfare, 1998). The reporting system covers the entire country. Case report data is collected in the national electronic communicable disease surveillance database through the local public health offices. TALD cases are immediately reported to the National Public Health Centre. Epidemiological investigation is conducted by the local public health authority; in case of TALD clusters site investigation and risk assessment is also mandatory. Response to TALD clusters is regulated by the Hungarian Guideline on Legionnaires' Disease and its Prevention (OEK, 2016), which is based on the European Legionnaires' Disease Surveillance Network (ELDSNet) Operating procedures (ECDC, 2017). The number of yearly reported cases is 3-5/1 million people. To date, there was no major outbreak identified in Hungary, but smaller clusters of 2-5 cases are reported every year. So far, only three TALD clusters were linked to the pools of the associated hotels, all three occurred between 2010 and 2012.

This is the first report on spa pool related clusters of travel associated Legionnaires' diseases in Hungary, the results of epidemiological and environmental investigations and remedial measures.

## METHODS

### *Epidemiological investigation*

National TALD cases were notified through the National Communicable Disease Surveillance System (Clusters 1 and 3). International cases (Cluster 2) were reported through ELDSnet. After notification of the cases, epidemiological investigations were conducted to identify the potential sources of infection. Cases were classified and clusters defined according to the ECDC standard definitions (ECDC, 2017). Patients were confirmed to have stayed in the suspected hotels and to have used the pool facilities. Detailed anamnesis did not reveal other probable sources for any of the clusters.

Site investigations were carried out in all three hotels by a multi-professional public health team after the clusters were identified. Examination extended to the potable and hot water systems and the pool facilities.

Other risk factors (e.g. decorative fountains, air conditioning system and solar heating system) were not present or did not operate at the time of exposure and at the time of investigation. There was no wet cooling tower in any of the hotels.

### *Environmental investigation*

Environmental sampling was carried out in accordance with the European Guidelines and the EN ISO 19458:2006 standard (Joseph et al., 2005; ISO, 2006; Joseph et al., 2011). The premise plumbing systems were sampled, including the endpoints nearest and farthest from the hot water storage tanks and all water outlets (shower and tap) in the rooms where the patients stayed. In the pool facilities, pool water and (where accessible) filtered water were sampled.

Water samples were tested for *Legionella* by cultivation on GVPC agar according to ISO 11731-2:2004 (ISO, 2004). The pool water samples were tested for microbiological (*E. coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and total coccus count) and chemical (pH, free active chlorine and combined chlorine) parameters (MSZT, 1989).

### *Typing of Legionella isolates*

Confirmation and serological identification of the *Legionella* strains was performed using both polyvalent and monovalent sera (Oxoid, France and Denka Seiken, Japan, respectively). The *L. pneumophila* sg 1 strains isolated from cluster 1 were MAb-typed in the Institute of Medical Microbiology and Hygiene, Technical University Dresden, Germany. Four selected environmental strains and the clinical isolate were further characterized by total genome restriction PFGE with

*SfiI* (Schoonmaker et al., 1992). Environmental and human isolates from cluster 2 were compared with sequence based typing (SBT) by the Swedish Institute for Communicable Disease Control Stockholm, Sweden (EWGLI, 2009). Human isolate was not available from cluster 3.

## RESULTS

### *Cluster 1*

Two related cases of Legionnaires' disease were reported in October 2010. The patients – an elderly Hungarian couple – were admitted to hospital with pneumonia. After the end of their 4-day stay at a four-star hotel in the Central Transdanubian Region, the husband became ill on the 1<sup>st</sup> and the wife on the 10<sup>th</sup> day. The 79-year old male patient with an underlying condition of leukaemia died of the *Legionella* infection, his 74-year old wife recovered. The male patient was diagnosed by urinary antigen test, PCR, direct immunofluorescence and culture, and his wife was diagnosed by PCR, single high titre and urinary antigen test. *L. pneumophila* sg 1 was identified from post-mortem culture of the bronchoalveolar lavage sample of the male patient.

The 80-room hotel (154 beds total) was re-opened in 2009, following a complete reconstruction. The potable water ( $T < 20\text{ }^{\circ}\text{C}$ ) is derived from a private well, stored and disinfected by UV before entering the distribution system. Hot water is produced indirectly with gas boiler, stored and re-circulated. Hot water temperature was below  $50\text{ }^{\circ}\text{C}$  (Table I). *Legionella* was not detected ( $< 10\text{ CFU/L}$ ) in the water distribution system, including the showers in the spa area.

The indoor pool facility included 4 pools, two of which were likely to generate aerosols (a whirlpool and a “leisure” pool with overhead water spouts) (Table I). Pool water was circulated in all four pools, filtered by sand filters, and disinfected by automatically dosed chlorine. Cleaning and maintenance were not documented; on-site measurements were intermittently performed. According to the records, free active chlorine level in the whirlpool was unusually low (0.2 - 0.3 mg/L) during the likely time of exposure; subsequent readings were above 0.7 mg/L in all pools.

All pool water samples were negative for *Legionella*. *L. pneumophila* sg 1 and 2-14 were detected in the sand filtered water and the buffer tank of the spa pool (2,000 and 1,200 CFU/L, respectively, Table II). *Legionella* was also present in an immediate sample from an overhead waterspout (3,900 CFU/L *L. pneumophila* sg 1). Free active chlorine level in the “leisure” pool was not sufficient (0.22 mg/L). All filtered water samples were positive for *P. aeruginosa*, indicating biofilm formation in the sand filters.

All strains (17) isolated from the positive water samples were identified as *L. pneumophila*, 11 strains were sg 1, and 6 strains were sg 2-14 by latex agglutination. The clinical isolate cultured from a bronchoalveolar lavage sample of the male patient and the tested environmental *L. pneumophila* sg 1 isolates identified as type Knoxville by MAb typing. Their PFGE profiles were also identical.

**TABLE I.**

**DESCRIPTION OF THREE SPA-POOL ASSOCIATED HUNGARIAN LEGIONNAIRES' DISEASE CLUSTERS (2010-2012), INCLUDING THE MAIN CHARACTERISTICS OF THE PROBABLE EXPOSURE SITES.**

	<b>Cluster 1</b>	<b>Cluster 2</b>	<b>Cluster 3</b>
<b>Number of cases</b>	2 (1 death)	3	3 (1 death)
<b>Travel</b>	Domestic	International	Domestic
<b>Region</b>	Central Transdanubian Region	Central Hungary	Western Transdanubian Region
<b>Probable site of exposure</b>	4-star hotel	4-star hotel	3-star hotel
<b>Hotel characteristic</b>	Supplied hot water temperature		
	50.7 °C	57.3 °C	50.9 °C
	Temperature decrease in the hot water system		
	2.9 °C	3.2 °C	21.9 °C
	Spa pool (32-34 °C)	Spa pool (34 °C)	Spa pool (36 °C)
	Entertainment pool (32-34 °C)	Indoor swimming pool (30 °C)	
<b>Pools (pool temperature)</b>	Children's splash pool (32-34 °C)		
	Sitting pool (34-36 °C)		

**TABLE II.**

**RESULTS OF THE ENVIRONMENTAL INVESTIGATION. THE RATIO OF LEGIONELLA POSITIVE SAMPLES AND LEGIONELLA COUNTS ARE GIVEN FOR EACH SAMPLED WATER TYPE (DOMESTIC WATER DISTRIBUTION SYSTEM AND POOLS) IN THE INVESTIGATED HOTELS.**

<b>Site</b>	<b>Sample type</b>	<b>Number of positive samples/ all samples</b>	<b>Legionella count (CFU/L)*</b>	<b>Legionella species</b>
<b>Hotel 1</b>	Domestic cold water	0/2	-	-
	Domestic hot water	0/7	-	-
	Pool water	0/4	-	-
	Filtered pool water	1/4 (whirlpool)	2,000	L. pneumophila sg 1
<b>Hotel 2</b>	Domestic cold water	0/2	-	-
	Domestic hot water	0/4	-	-
	Pool water	1/2 (whirlpool)	1,700	L. pneumophila sg 1 Legionella species
	Filtered pool water	0/1	-	-
<b>Hotel 3</b>	Domestic cold water	0/1	-	-
	Domestic hot water	0/6	-	-
	Pool water	1/1	1,500,000	L. pneumophila sg 1 L. pneumophila sg 2-14
	Filtered pool water	-	-	-

\* colony forming unit

Operation of the pool facility was suspended immediately; pools were drained and disinfected. Sand filters were repeatedly shock disinfected by chlorine dioxide until filtered water was negative for both *Legionella* and *P. aeruginosa*. The facility was re-opened after the negative results. Free active chlorine was advised to be above 1 mg/L in the spa pool and the “leisure” pool and above 0.5 mg/L in the other pools. The operator was requested to measure free chlorine levels twice a day and to take immediate action or suspend the use of the pool in case of non-compliance. Monitoring of the pools and filtered water for *Legionella* every 3 months was ordained by the local public health authorities. Preventive measures on the water distribution system (hot water temperature > 55 °C, weekly superheating, flushing unused outlets, de-scaling of taps and showers) were also prescribed, though the system was not found to be colonized with *Legionella*.

### **Cluster 2**

Three TALD cases were reported through the ELDSNet (one Norwegian case with date of onset in November 2010 and two Swedish cases with date of onset in October 2011). The tourists – independently of each other – were staying in a four-star hotel in Budapest. The diagnosis of Legionnaires' disease of all three cases was confirmed by detection of *L. pneumophila* antigen in urine. *L. pneumophila* sg 1 ST 42 was identified in both Swedish cases.

Hotel 2 opened in 2010 in the centre of Budapest, with 272 rooms. The drinking water was supplied from the city mains (T < 20 °C). The hot water production and management was in line with the requirements of *Legionella* risk prevention: temperature was between 54.1 and 57.3 °C on the taps, and the hot water storage tank was superheated at nights to 70 °C. These measures were introduced after the first case notification but prior to the subsequent cases and the investigation. All hot and cold water samples were free from legionellae.

The hotel featured an outdoor pool (not operating at the time of exposure) and an indoor swimming pool and a whirlpool (Table I). Pools were chlorine disinfected; the swimming pool was automatically, the spa pool manually dosed (once a day, after draining, cleaning and re-filling). Water circulation was continuous, filters were backwashed daily. Chlorine concentration and pH were measured irregularly. At the time of the investigation, free chlorine level of the swimming pool was satisfactory (0.53 mg/L), but critically low in the whirlpool (0.1 mg/L). Records on the disinfectant level at the time of exposure were unavailable. The whirlpool was colonized with *L. pneumophila* sg 1 and with an autofluorescent *L. species* strain (1,700 CFU/L total, Table II). Sampling of the filtered water was technically not feasible. All samples from the swimming pool (fill, pool and filtered water) were negative for *Legionella*.

*L. pneumophila* sg 1 isolate from the whirlpool was found to be identical to the clinical strains of both Swedish patients by sequence based typing (ST 42). The non-*pneumophila* autofluorescent strains were not typed further.

Operation of the whirlpool was suspended, and the pool was subjected to shock disinfection. As the results were still unsatisfactory, the pool was subsequently reconstructed (paper filter was replaced by sand filtration) and treated with a peroxide-based disinfectant. The local public



health authority ordained *Legionella* analysis (every 3 months) and operation compliant with the legal regulation and the best practice standard (Ministry of Welfare, 1996; MSZT, 2012).

### **Cluster 3**

The third cluster was linked to a 3-star hotel in West Hungary. In March 2012 a couple was hospitalized with pneumonia after visiting the hotel. The 57-year old woman was diagnosed by urinary antigen positivity (*L. pneumophila* sg 1, confirmed case), and his 58-year old husband died of severe bilateral pneumonia at home before any laboratory investigations could be performed (probable case). A 66-year old male patient, who stayed in the hotel in April 2012, was also confirmed to have Legionnaires' disease by urinary antigen testing.

Hotel 3 (44 beds) was built in 1998 in Western Hungary. It is on the premises of a large thermal spa complex but separately operated. The hotel has its own hydrotherapy area including a whirlpool in the basement.

Drinking water was supplied from the city mains ( $T < 20\text{ }^{\circ}\text{C}$ ). The domestic water system was under on-going reconstruction. Hot water was produced by gas boiler and heat exchanger, and re-circulated. Hot water temperature was critically low (29.9 - 46.1  $^{\circ}\text{C}$ ) on all endpoints, and the temperature drop within the building was over 20  $^{\circ}\text{C}$  (Table I). Though the system characteristics indicated a high risk of *Legionella* proliferation, *Legionella* was not detected in any hot or cold water samples.

The whirlpool in the hotel basement was not registered with the public health authority, although it is a legal obligation for all public pools. It was a commercial device licensed solely for domestic use. The pool was irregularly drained and cleaned after 4-9 days of use. Chlorine tablets were added at the time of filling the pool but were not replenished during operation. Chemical or microbiological measurements were not performed. The pool had no standard operational procedure. Records only covered the time of cleaning; there was no information on the backwashing of the filters.

The water was last changed four days before the investigation; free chlorine level was below the limit of detection. The spa pool water was heavily colonized with legionellae; 1,500,000 CFU/L *L. pneumophila* sg 1 and sg 2-14 were isolated (Table II). The swab sample taken from the overflow system was positive for *L. pneumophila* and other non-*pneumophila* species.

The hygienic status of the spa pool was highly objectionable. Other tested microbiological parameters also exceeded the legal limit values (total coccus count  $> 600\text{ CFU}/100\text{ mL}$ , *Staphylococcus aureus*  $> 300\text{ CFU}/100\text{ mL}$ ; *P. aeruginosa*  $> 300\text{ CFU}/100\text{ mL}$ ).

The local health authorities ordered immediate closure of the illegal spa pool and fined the owner of the hotel. The entire spa unit was fully cleaned and disinfected, proper management measures were introduced. Water quality was tested repeatedly. The pool was re-opened after negative results, under strict supervision of the local authorities and regular *Legionella* monitoring.

## DISCUSSION

Legionnaires' disease is a mandatory notifiable disease in Hungary. However, in spite of the efforts of surveillance, Legionnaires' disease remains largely underreported: reported incidence rate was 3.2 cases/million citizens in 2011 and 6.0 cases/million in 2017 while the European average was 9.7 cases/million and 18.0 cases/million (in 2011 and 2017, respectively) (ECDC, 2013; 2019). Sporadic cases are difficult to recognize, as symptoms are unspecific and usually respond well to antibiotic treatment. Introduction of the TALD surveillance in Hungary facilitated the recognition of clusters and the identification of the infection routes.

At the time of the outbreaks, there was no legal regulation in Hungary on the environmental monitoring of *Legionella* either in hot water systems or spa pools. The National Centre for Epidemiology and the National Institute for Environmental Health published guidelines on the prevention of Legionnaires' disease, and recently a Hungarian standard on pool management recommending *Legionella* testing of warm aerated pools was also published (OEK, 2016; MSZT, 2012). However, neither of the provisions is mandatory, and the documents are only known to a small segment of operators.

Neither the potable water system nor the pools of the involved hotels were monitored for *Legionella* prior to the first case report. Hotel owners and staff were not aware of the risks associated with *Legionella*. There was no *Legionella* prevention scheme in place.

The water distribution systems of the three investigated hotels were not colonized by legionellae, though in two of the three systems hot water temperature was in the risk range for *Legionella* proliferation. A previous survey showed high colonization rate in Hungarian hotels (77.3 %) (Barna et al., 2016).

Common feature of the three pool facilities was the inadequacy of management practices. Most important non-compliance was the low level of residual disinfectant, however, negligence in on-site measurements and record keeping also contributed to the risk. Cluster 1 demonstrated that even a well-designed pool, seemingly under control (i.e. negative pool water result) poses a risk of infection if the system is colonized by *Legionella*. The reservoir (in this case, the sand filter) is continuously "dosing" the pool with legionellae, and a temporary flaw in disinfection allows it to reach infective levels. In case of Clusters 2 and 3, the use of devices designed for domestic use and thus having insufficient filtration capacity for public bather load also aggravated the problem. Increasing popularity of so-called "wellness" services in hotels leads to the installation of whirlpools in sites where neither the technical nor the operational conditions are adequate.

The local public health authorities were involved in the investigation of the clusters and the enforcement of remedial actions. In the presented cases, interventions were adequate, no further cases were observed in connection with the investigated hotels. The series of small outbreaks led to the development of a dedicated legal regulation on the public health requirements of *Legionella* infection risk environments and facilities (Ministry of Human Capacities, 2015). The Decree identifies aerosol generating pools as increased risk environments, and prescribes mandatory risk assessment and monitoring for *Legionella*. Since the introduction of the new



regulation, no further pool related outbreaks were reported, though monitoring results confirmed the prevalence of *Legionella* in Hungarian pools. Whirlpool spas are especially difficult to control since the long, thin airducts and the warm (> 30 °C) water temperature provide ideal conditions for *Legionella* proliferation. Further improved management practices and technological developments from the side of pool manufacturers are necessary to prevent future infections.

## ACKNOWLEDGEMENTS

The authors acknowledge the work of Jürgen H. Helbig† (Medical Faculty of Technical University Dresden, Germany) for MAb typing, Judit Pászti (National Center for Epidemiology, Hungary) for PFGE typing, Jonas Lundström (Swedish Institute for Communicable Disease Control Food and Water) for SBT typing, Ágnes Csohán (National Center for Epidemiology) for critical review and the local public health authorities, namely Erzsébet Frankó (Budapest Capital Government Office VI., VII. District Public Health Institute), Krisztina Szlama (Budapest Capital Government Office Policy Administration Services of Public Health), Katalin Sári, Lászlóné Benkó, Tamásné Sipos (Esztergom Subregional Public Health Institute of Subregional Government Office), Erika Krisztián (Fejér County Government Office Policy Administration Services of Public Health), Ferencné Busznyák (Veszprém County Government Office Policy Administration Services of Public Health), Piroska Bogdán (Mosonmagyaróvár Subregional Public Health Institute of Subregional Government Office). Affiliations are indicated as valid at the time of the study.

Funding: None

Competing interests: None declared

Ethical approval: Not required

## REFERENCES

BARNA Z., and KADAR M. (2012): The risk of contracting infectious diseases in public swimming pools. A review. *Ann Ist Super Sanita*, 48(4): 374-386.

BARNA Z., KÁDÁR M., KÁLMÁN E., et al. (2016.). Prevalence of *Legionella* in premise plumbing in Hungary, *Water Res*, 90:71-8.

BROUSSEAU, N., LEVESQUE, B., GUILLEMET, T. A., et al. (2013). Contamination of public whirlpool spas: factors associated with the presence of *Legionella* spp., *Pseudomonas aeruginosa* and *Escherichia coli*. *Int J Environ Health Res* 23(1): 1-15.

CDC – Center for Disease Control and Prevention (2018). Model Aquatic Health Code (MAHC). 3rd Edition, United States of America

COETZEE, N., DUGGAL, H., HAWKER, J., et al. (2012). An outbreak of Legionnaires' disease associated with a display spa pool in retail premises, Stoke-on-Trent, United Kingdom, July 2012. *Euro Surveill* 17(37): pii=20271.

DE SCHRIJVER, K., DIRVEN, K., VAN BOUWEL, K., et al. (2003). An outbreak of Legionnaire's disease among visitors to a fair in Belgium in 1999. *Public Health* 117(2): 117-124.

DEN BOER, J. W., YZERMAN, E. P., SCHELLEKENS, J., et al. (2002). A large outbreak of Legionnaires' disease at a flower show, the Netherlands, 1999. *Emerg Infect Dis* 8: 37-43.

ECDC – EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL (2012). European Legionnaires' Disease Surveillance Network (ELDSNet): Operating procedures. Stockholm, Sweden.

ECDC – EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL (2017). European Legionnaires' Disease Surveillance Network (ELDSNet) – Operating procedures for the surveillance of travel-associated Legionnaires' disease in the EU/EEA. Stockholm, Sweden.

ECDC – EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL (2013). Legionnaires' disease in Europe 2011., Stockholm, Sweden.

ECDC – EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL. Legionnaires' disease (2019). In: ECDC. Annual epidemiological report for 2017. Stockholm, Sweden.

EMMI – MINISTRY OF HUMAN CAPACITIES (2015) – Ministerial Decree 49/2015 (XI. 6.) on the public health requirements of *Legionella* infection risk environments and facilities. Budapest, Hungary.

EWGLI – European Working Group for Legionella Infections (2009). Sequence-based typing (SBT) protocol for epidemiological typing of Legionella pneumophila. Version 4.2. 9 Oct 2009. [http://www.hpa-bioinformatics.org.uk/legionella\\_/legionella\\_sbt/php/SBT%20protocol%20for%20website%202008%20v4.2.pdf](http://www.hpa-bioinformatics.org.uk/legionella_/legionella_sbt/php/SBT%20protocol%20for%20website%202008%20v4.2.pdf). London, UK.

HAMILTON, K. A., PRUSSIN, A. J., AHMED, W., and HAAS, C. N. (2018). Outbreaks of Legionnaires' Disease and Pontiac Fever 2006–2017. *Curr. Environ. Health Rep.* 5: 263–271.

ISO – International Standard Organization (2004). ISO 11731-2:2004. Water quality - Detection and enumeration of Legionella - Part 2: Direct membrane filtration method for waters with low bacterial counts. Geneva, Switzerland.

ISO – International Standard Organization (2006). ISO 19458:2006. Water quality - Sampling for microbiological analysis. Geneva, Switzerland.

JERNIGAN, D. B., HOFMANN, J., CETRON, M. S., et al. (1996). Outbreak of Legionnaires' disease among cruise ship passengers exposed to a contaminated whirlpool spa. *Lancet* 347(9000): 494-499.

JOSEPH, C., LEE, J., SURMAN-LEE, S., et al. (2011). EWGLI Technical Guidelines for the Investigation, Control and Prevention of Travel Associated Legionnaires' Disease. The European Working Group for Legionella Infections (EWGLI), London, UK.

JOSEPH, C., LEE, J., VAN WIJNGAARDEN, J., et al. (2005). European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease. The European Working Group for Legionella Infections (EWGLI), London, UK.

LEONI, E., CATALANI F., MARINI S., and DALLOLIO L. (2018). Legionellosis associated with recreational waters: A systematic review of cases and outbreaks in swimming pools, spa pools, and similar environments. *Int. J. Environ. Res. Public Health* 15: 1612.

MCEVOY, M., BATCHELOR, N., HAMILTON, G., et al. (2000). A cluster of cases of legionnaires' disease associated with exposure to a spa pool on display. *Commun Dis Public Health* 3(1): 43-45.

MINISTRY OF WELFARE (1996). Decree No. 37/1996. (X.18.) of the Minister of Welfare on health requirements of establishing and operation of public baths. Ministry of Welfare (NM), Budapest, Hungary.

MINISTRY OF WELFARE (1998). Decree No. 18/1998 (VI.3.) of the Minister of Welfare on Epidemiological Protocols for Preventing Communicable Diseases and Outbreaks. Ministry of Welfare (NM), Budapest, Hungary.

MSZT – Hungarian Standards Institution (1989). MSZ 13690-2:1989 Bathing water. Sampling and bacteriological test. Budapest, Hungary.

MSZT – Hungarian Standards Institution (2012) MSZ 15234:2012. Water treatment for bathing-pools by recycling. Budapest, Hungary.

OEK – National Center for Epidemiology (2016). Hungarian Guideline on Legionnaires' Disease and its Prevention. 2nd edition. *Epinfo* 22. (3rd special issue), Budapest, Hungary.

RUSCOE, Q., HILL, S., BLACKMORE, T., and MCLEAN, M. (2006). An outbreak of Legionella pneumophila suspected to be associated with spa pools on display at a retail store in New Zealand. *N Z Med J* 119(1243): U2253.

SCHOONMAKER, D., HEIMBERGER, T., and BIRKHEAD, G. (1992). Comparison of ribotyping and restriction enzyme analysis using pulsed-field gel electrophoresis for distinguishing Legionella pneumophila isolates obtained during a nosocomial outbreak. *J Clin Microbiol* 30(6): 1491-1498.

VANACLOCHA, H., GUIRAL, S., MORERA, V., et al. (2012). Preliminary report: outbreak of Legionnaires disease in a hotel in Calp, Spain, update on 22 February 2012. *Euro Surveill* 17(8): pii=20093.

WHO – World Health Organization (2006). Guidelines for safe recreational water environments; volume 2: Swimming pools and similar environments. Geneva, Switzerland.

WHO – World Health Organization (2007). Legionella and the prevention of legionellosis. Geneva, Switzerland.