LEGIONELLA SPP. RISK ASSESSMENT IN RESIDENTIAL CARE HOMES FOR ELDERLY PEOPLE: DEVELOPMENT OF A RISK MATRIX

Cristiana Silva[1], Andreia Rebelo[1], Manuela V. da Silva[1,2]

[1.] Department of Environmental Health, Health and Environment Research Centre, School of Health of the Polytechnic Institute of Porto, Porto, Portugal

[2.] Epidemiology Research Unit (EPIUnit), Institute of Public Health, University of Porto, Porto, Portugal

Abstract

The genus Legionella spp. includes a group of pathogenic bacteria, which are frequently associated with natural or artificial freshwater environments, but usually in insufficient levels to cause infection. However, in the case of the presence of Legionella pneumophila constitute always a public health concern. The risk of occurrence of Legionella spp., especially in places on the presence of human risk groups and workers, such as residential structures for the elderly, represent a relevant activity for prevention. This work aimed to develop a risk instrument to assess the presence of Legionella spp. in building structures and equipment's. The methodology was based on previous knowledge acquired within the context of health and safety, the simplified W.T. Fine method and the methodology developed by the DGS of Portugal for the management of biological risks. From the risk assessment carried out, it was possible to identify potential non-compliance instances associated with the different equipment and characteristics of the facilities, such as "Inadequate hygiene/cleaning", "Poor condition (e.g. filters, pipes, taps)" and "Water Stagnation", being that "Taps/Showers" are those with the highest level of risk. The risk analysis and categorization proves to be an important tool used to prevention by the early risk identification and measures to avoid the occurrence of Legionella spp. in residence care homes buildings.

Keywords: Legionella spp., Legionnaires' disease, Retirement homes, Risk assessment, Risk matrix.

Introduction

Legionella spp. is a bacterium commonly present in freshwater environments and some species can be a problem in terms of public health, such as the Legionella pneumophila (Hamilton & Haas, 2016; Papadakis et al., 2018). It is responsible for most cases of Legionnaires' Disease, a particularly serious disease in susceptible individuals (Filippis et al., 2018), assuming both relevance for occupational workers. Legionella spp. are commonly spread by the inhalation of contaminated aerosols or dusts (Correia et al., 2016). Favorable environmental conditions, such as moderate temperature (35ºC-45ºC) and high-pH water (5-8), relative humidity above 60% and areas where water flow is reduced or stagnant (for example: water reservoirs, cooling towers, building piping grids, underused grid endpoints, etc.) are associated to presence of Legionella spp. (DGS, 2017).

In recent years due to the increase in cases of Legionnaires' disease worldwide, it is important to define strategies to risk prevention, namely in terms of water distribution systems, as well as aerosol-producing equipment to minimizing the human exposure (CDC, 2018; Kruse et al., 2016; Prussin et al., 2017; Yunana et al., 2019) by conducting a continuous risk assessment together with water quality surveillance actions.

Despite the Portuguese legal obligation for organizations to implement a Legionella spp. prevention and control plan (Portuguese Law nº. 52/2018, dated August 20th), there are no standardized risk matrix that allows an objective to assess the potential presence of Legionella spp. in building structures and equipment's. Accordingly, given the importance associated with this type of methodology, various authors referred the relevance to produce a work instrument to carry out such assessment (Papadakis et

al., 2018). This study aimed to develop a risk instrument to assess the presence of Legionella spp. in structures, equipment's and health activities, in residence places such as Residential Structures for the Elderly (ERPIs – Estruturas Residenciais para Pessoas Idosas).

Materials and Methods

Visits and characterization of the ERPIs

This activity included some visits to ERPIs in north of Portugal, within the coverage area of the ACES Póvoa de Varzim / Vila do Conde. It was considered a ERPIs comprising a universe of about 30 users and 6 professionals.

Structures and equipment's associated to the presence of Legionella spp.

This was conducted in scientific databases such as b-On, Pubmed, Science Direct and Web of Science. Therefore, for the characterization, the definition of the research keywords was carried out, namely "Legionella spp.", "Legionnaires' Disease", "Nursing Home", "Biofilm", "Equipment", "Growth Control" and "Building/ Edified".

Production of a risk matrix

The risk matrix described by Bartram et al., 2001 and by Deere et al., 2001 were consulted, while basing it on a semi-quantitative approach. This methodology proves to be simple and easy to apply, demonstrate to be effective to prioritization of risk and allowing for the adequacy of preventive measures. In addition, the adaptation of the risk matrix previously described was made taking into account the think on hazards and critical control points, similar to HACCP, the probability and the severity of the occurrence of such risk. The assessment instruments used in the Simplified Method, in the W.T. Fine and the method developed by the DGS (2013) for the management of biological risk were applied. These methods are also based on a semi-quantitative approach, they allow to establish a risk hierarchy by identifying the intervention priorities.

Thus, the risk matrix used in this study includes two levels of assessment: the Probability Level (PL) and the Severity Level (SL). For calculation of PL, two parameters were considered: the Exposure Level (EL) and the People Exposed Level (PEL). The former concerns the number of hours to which users and/or professionals are exposed with a score being given proportionally to the exposure time. The latter, which includes 5 scoring levels, increasing as the number of the people exposed. The PL is obtained by multiplying these two variables, thus obtaining a level that varies with the increase in the probability of an event happening. Regarding the Severity Level (SL), this includes five categories, with the maximum score being assigned to the occurrence of an event catastrophic or fatal severity. For obtaining the final risk level involve multiplying the value of the PL with the value of SL,

consequently being classified into five sub-levels (very low, low, medium, high and very high). After obtaining the RL, the measures to be taken according to the level of risk obtained.

Results

In accordance with the research carried out based on literature and from the visits of several ERPIs, the equipment and characteristics of the facilities associated to Legionella spp. risks were identified as: (1) Drinking water (piped water distribution, including cold and hot domestic water); (2) Faucets/showers (including thermostatic mixers) (present in changing rooms, hairdresser's, barbershop, etc.); (3) HVAC system and other air-cooling systems (air conditioning system, split, among others); (4) Equipment usedin respiratory therapy (e.g. nebulizers, pulmonary ventilators); (5) Dish washers and washing machines; (6) Sprinkler Irrigation System; (7) Ornamental/Decorative fountains; (8) Whirlwind; (9) Whirlpool bath; (10) Therapeutic pools; (11) Assisted bath stretchers and bath tubs; (12) Jacuzzi; (13) Water tanks (associated with solar panels, firefighting or irrigation); (14) Cooling towers; (15) Evaporative condensers and humidifiers.

According to the aim of the study, the constructed risk matrix is presented in table 1. Non-compliance were identified and included in the risk assessment. The organization of the equipment or characteristics of the building took into account the probability of their existence in the ERPIs, and this probability decreases throughout the assessment list. Due to the length of the table, only the most relevant parts are presented.

The non-compliance more frequent regardless to equipment or the building characteristics, were related to the "Inadequate hygiene/cleaning", "Water Stagnation" and "Bad state of conservation". In addition, "Drinking Water (distribution of piped water) Points", corresponding to 9 of the 34 of potential non-compliance identified (Figure 1).

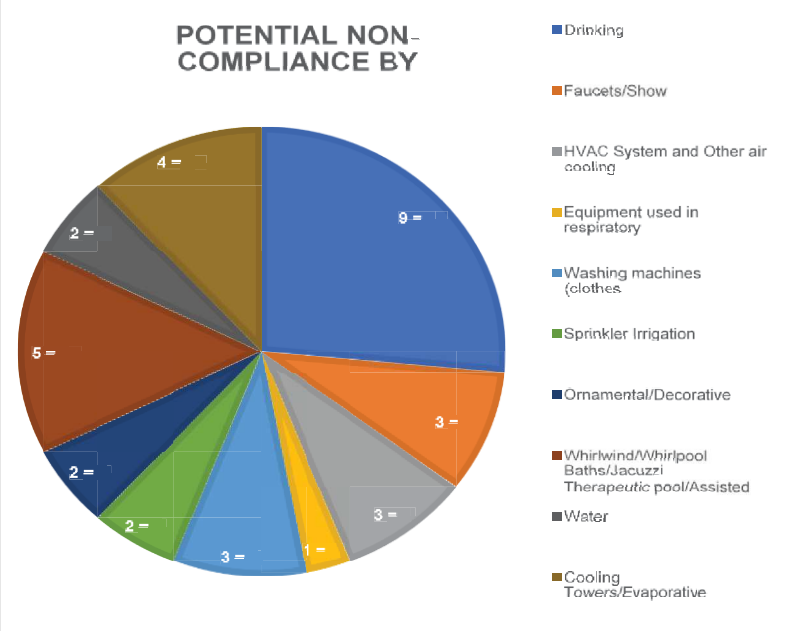

Figure 1 - *Potential non-compliance by equipment/facilities.*

All equipment/facility revealed as potential non-compliance was classified at least as “one medium risk” associated to “Inadequate hygiene/cleaning”, “Poor condition of filters”, “Water stagnation”, instead the “Faucets/Showers” were classified as “High” risk level, as observed in the Figure 2.

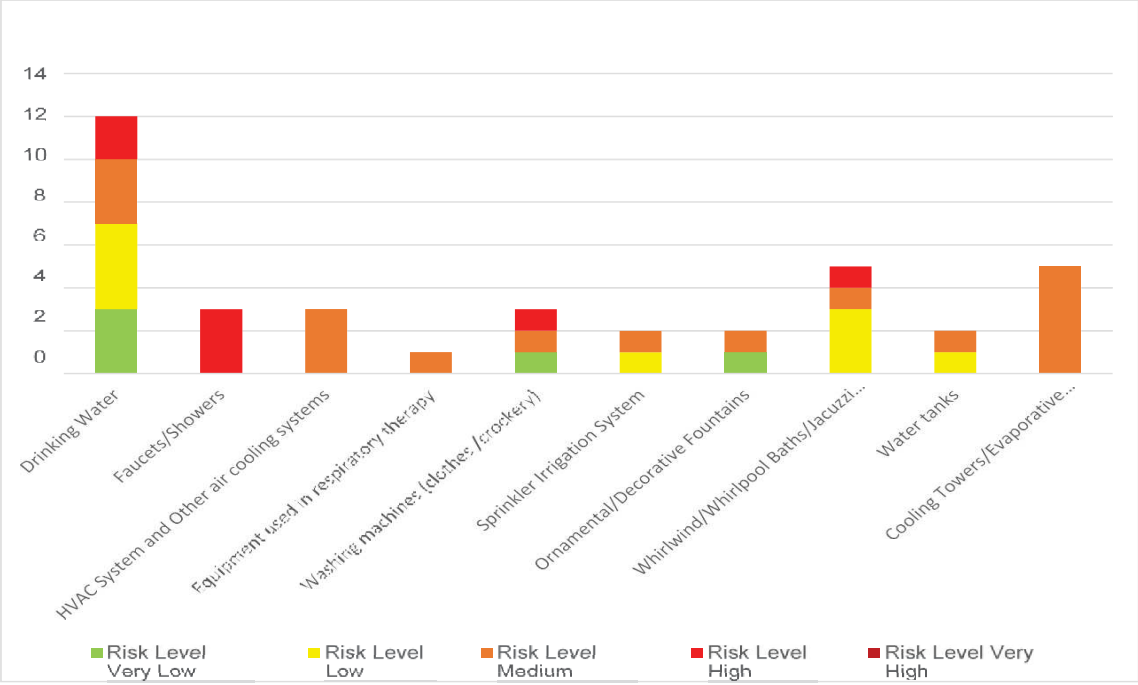

***Figure 2** – N° of potential NC for each equipment/characteristic of the facilities.*

Through the analysis of the table 1, it is also possible to verify the existence of a high points classified as “High” risk level related to "Inadequate cleaning of the shower heads/taps", "Hot water circuit temperature <50ºC (after 1 minute of flow/circulation)", "Insufficient water renewal", among others.

Discussion

Given the impossibility of applying on-site the risk matrix developed within the context of the present study, the risk assessment was based on an annual-operational ERPIs comprising a universe of about 30 users and 6 professionals, and based on a set of theoretical information and visits made as explained in the methodology. The theoretical number of hours and the number of users and professionals potentially exposed to risk were also considered, always with a worst-case scenario. Whenever it was not possible to quantify the level of exposure and the level of people exposed, a simulate value was attributed to the level of probability.

According to Freitas (2008), the risk is exactly “the probability for damage of a certain severity” and for this reason, it is only relevant to assign the values and not go into detail on these points. The level of severity was a constant, as to the severity associated with exposure to Legionella pneumophila, varying solely when dealing with exposure to other pathogenic microorganisms. It was found that there might be several non-compliance present in ERPIs, thus highlighting the importance of risk assessment in the prevention and control of Legionella spp., in order to guarantee an adequate and hierarchical decision-making process regarding preventive and/or corrective measures.

The conduction of this study allowed to identify and prioritize the levels of risk associated with potential non-compliance. The highest percentage is, therefore, associated with structures, which, directly or indirectly, are related to the misuse of public water. The use of water within the temperature range 25ºC-50ºC, good temperatures for the proliferation of the bacteria, and often observed in baths and treatments, constitutes a medium or high risk. This information corroborates that described by Filippis et al. (2018), since the setting of temperatures below those recommended making it possible to reach the aforementioned range of values, in many cases to avoid burns in users, constitutes a risk for users and professionals, in what the spread of the bacteria is concerned. In addition, the information described in some studies supports the potential non-compliance identified in the risk assessment, as it is the case of the strong correlation between bath water and the fact that this constitutes a source of infection in these institutions (Kanatani et al., 2017; Prussin et al., 2017). Also related to drinking water, it is relevant to highlight the presence of other potential pathogenic microorganisms (Salmonella, Clostridium, E. coli O157:H7 and Hepatitis A Virus), which may trigger non-conformities associated with the quality of water. Although these present a "Low" risk level, they must be taken into account, as this has the potential to introduce a large number of intestinal diseases (Andersson et al., 2001).

On the other hand, when the results of the risk levels are verified for each non-compliance associated with the different pieces of equipment/facility, it can be concluded that an intervention is required, with the adoption of corrective and preventive measures targeted at the aforementioned equipment. This categorization of risk allowed us to conclude that a significant part of the potential non-compliance identified fall within the "Medium" risk level. This allows us to conclude that an intervention should be carried out as soon as possible, albeit of non-urgent nature, in order to improve, as much as possible, the conditions of their installation, reasoning such intervention by scheduling and establishing a timeframe for the implementation of the respective measures Another important fact relates to the fact that taps and showers have been awarded a "High" risk level for all potential non- compliance. These data allow to affirm that these pieces of equipment constitute significant means of transmission of the bacterium, in the establishments covered in the study (Sharaby et al., 2019; Sydnor et al., 2012). Consequently, such equipment must be subject to immediate intervention, by correcting and adopting the necessary and appropriate control measures, and interrupting, therefore, the operation or use of this equipment until the risk is controlled or minimized. With regard to the most frequent potential non-compliance, we note the occurrence of a significant number of those associated with "Inadequate hygiene/cleaning". This was due to the fact that, within the context of the spread of Legionella spp., the cleaning or sanitization of the equipment likely to produce aerosols constitutes a major step towards its persistence and proliferation. The application of a risk matrix, constitutes a fundamental complementary method in the determination of the risk of occurrence of Legionella spp. and in the definition of the necessary strategies for its elimination/reduction.

It is common knowledge that Legionella spp. is often associated with water that runs in the pipes of a building, thus constituting a risk, namely for elderly people in nursing and residential care homes or ERPIs (Filippis et al., 2018), by being able to lodge in different man-made equipment or systems. According to Yoshida et al. (2018) and to ascertain the potential for washing machines to become a reservoir for this bacteria in healthcare institutions, namely residential homes, the presence of

Legionella spp. was detected in this appliance and there was evidence of the existence of a direct correlation with the pipes leading to the taps, where it was also detected. Other studies show that bath water is also one of the main sources of infection in nursing homes and that poor risk management constitutes a risk situation for both users and professionals in these institutions (Kanatani et al., 2017; Prussin et al., 2017). Another important factor is the fact that, due to the high temperatures especially felt in the summer, institutions increase the use of cooling towers and air conditioning systems to acclimate the spaces and obtain a comfortable temperature, thus increasing the risk of occurrence of Legionella spp. (Prussin et al., 2017).

The adoption of equipment-inherent water stagnation are factors that promote the proliferation of this bacteria. According to a recent study carried out in Hungary, in 24 health care facilities regarding the presence of Legionella spp., 92% (corresponding to 22 institutions) reported the presence of the bacteria, which was lodged in hot water systems (Springston & Yocavitch, 2017). To reduce or eliminate the risk of infection by Legionella spp., it is necessary to minimize the concentration in the affected system and prevent its transmission to susceptible individuals, particularly the elderly and those with pathologies, who attend locations where health care or long-term health care services are provided (Sidari, 2019). One of the most used treatments, which is feasible in several establishments, to eliminate/ reduce the bacteria, consists of increasing water temperature up to 70ºC for 24h and disinfecting each water outlet for about 30 minutes, so the water temperature measured in these places reaches at least 60ºC (Springston & Yocavitch, 2017). According to the study by Yoshida et al. (2018), after detecting Legionella spp., it was found that the water temperature in the boiler was 65ºC, so it only reached between 44ºC and 57ºC in the piping system. In the following two weeks, a treatment with 2 ppm chloride and washing with hot water for 10 minutes a day was carried out. The water temperature was also set at 70ºC in the boiler, which led to the elimination of the bacteria (Yoshida et al., 2018).

This study focused on the issues associated with the dissemination and spread of Legionella spp. in ERPIs. It has become relevant because these structures offer permanent housing to individuals whose characteristics make them susceptible of contracting Legionnaires' Disease. This aspect becomes an increased risk given the use of aerosol-producing equipment in most treatments provided and in baths.

According to the DGS (2013) and ARSLVT (2011), the prevention of risk in different workplaces, namely those intended for the provision of health services, must be based on the correct and permanent assessment of risk. A risk matrix was created, with the goal of carrying out a risk assessment in these institutions, minimize de human exposure. This study allowed for the identification of potential non-compliance associated with the different equipment and characteristics of the facility and it would be relevant to apply this tool to a wider number of ERPIs, including different characteristics, in order to ascertain its suitability.

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