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Prevention of Legionella Infections in Shipboard Medical Facilities: A Proposal to Include the Use POU Filters in the Preventive Plan †

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Abstract: Legionella is a public health concern on passenger ships and the the need to implement a Legionellosis prevention plan is even more important in on-board hospitals that are frequented by higher risk people who are more susceptible to infection. In this paper we proposed a prevention plan specific for shipboard medical facilities derived by the Italian National guidelines for Legionellosis prevention. We presented also data of efficacy and performance specifications (field evaluation), on a Legionella point-of-use filter. The point-of-use filters when they are used in synergy with the others prevention methods can play an important role, cost–benefits ratio positive, to minimize the risk of growth and spread of Legionella and other waterborne pathogens on passenger ships in case of specific conditions.

Keywords: Legionella; Legionellosis; Legionella control and prevention on ships; ship medical facilities; point-of-use filters

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1. Introduction

Since first ship-associated case was recorded in 1977 [1], Legionella it has continued to be a public health concern on passenger ships given the particularities of the ship's water system (considerable the complexity and length of it causing difficulty in maintaining a safe temperature in the hot/cold water system at all points).

The review of Mouchtouri [2], noted that legionella ship-associated cases are very common, and a high risk of contamination has been also confirmed by the study Legionella risk assessment in ships [3] where *Legionella pneumophila* sg 1 was isolated from the samples from shower and tap water in 70% of the ferries, and in 33% of the cruise ships that were examined (sg 2–14 in 80% and 16.7% of these ships, respectively).

The need to implement a Legionella prevention plan on passenger ships is even more important in on-board hospitals that are frequented by higher risk people who are more susceptible to infection (older age, smokers, suffering from common clinical conditions like diabetes, heart and kidney diseases, COPD, malignant tumors, alcoholism) and where respiratory therapy devices are used.

The aim of this work is to propose a prevention plan that is specific for shipboard medical facilities and to discuss the usefulness of point-of-use filters as a prevention method in specific conditions.

2. Material and Methods

The proposed prevention plan specific for shipboard medical facilities derived by the Italian National guidelines for Legionellosis prevention was issued by National Institute of Health (ISS) in 2015.

This study also contains data of efficacy and performance specifications (field evaluation), provided by the supplier, on a Legionella point-of-use filter that is 0, 2 μm (Pall Q Point®) and is available for faucets and showers.

Microbiological challenge tests (bacterial retention of Cytrobacter Koseri) were performed in accordance with the ASTM standard F838-15a in March 2021 at the Hygiene Laboratory of the Department of Translational Research University of Pisa (Accredia accreditation No. 1703L).

Further validation tests included: 1. microbiological challenging tests with *Brevundimonas diminuta*, *Legionella pneumophila* sg 1, *Pseudomonas aeruginosa*, *Escherichia coli*, *Mycobacterium gordonae* and *Cryptosporidium parvum*, and 2. microbiological challenging tests with a combination of *Legionella pneumophila* sg1 and *Aspergillus fumigatus* (ARCHA Laboratory Pisa, (Test Start Dates 5 February 2019 and 19 June 2019). Accredia accreditation No. 522 2003).

The filter is made up of two components: a non-sterile, reusable support and a disposable filter capsule that is to be changed every 60 days. The systems are equipped with a QR code that provides unambiguous indications in a software to detect the replacement times as well. It is possible to monitor, in real time, the data, location and destination of each positioned filter directly from the app, from which the report is sent to the contact person. It, therefore, makes the management and monitoring of it fast and intuitive.

3. Results

According to the Italian guidelines the parameters of Legionella prevention for hotel facilities (similar to ships) are broader in relation to those for medical facilities.

We, therefore, propose for medical facilities (department with greater risk), a specific Legionella monitoring, prevention and control plan (Table 1). The main differences are related to the frequency of sampling (3 vs. 6 months) and to the contamination level at which corrective actions are necessary (101 instead of 1000 CFU/ML).

Table 1. Legionella prevention plan in medical facilities.

Legionella (CFU/L)	Actions Required
<100	None
Between 101 and 1.000	**Consider Using Filter** **Absence of Cases:** -If less than 30% of the samples are proven to be positive, we must re-sampled, at least from the same dispensers that tested positive, after verifying that the current risk control practices have been correctly applied. If the result is confirmed, we must review the risk assessment in order to identify additional corrective measures. -If more than 30% of the samples are proven to be positive: (as above) If the result is confirmed, a disinfection and a review of the risk assessment must be carried out to identify the necessary further corrective measures. **Presence of cases:** We must carry out a review of the risk assessment and a disinfection of the implant.

Data from point-of-use filter validation tests are listed in Table 2.

A silver-based bacteriostatic additive was incorporated into the housing of the disposable water filter system, which is able to inhibit the growth of the externally introduced bacterial contamination by >99% within 24 h (its efficacy was maintained for a period of more than 2 months). The filter has shown efficacy of up to a temperature of 75° and a pressure of five bars.

Table 2. Pall QPoint® validation liquid challenge tests result.

Bacteria	Effective Filtration Surface Area CFU/cm^2
Legionella pneumophila sg 1	12.7×10^7
Pseudomonas aeruginosa	1.75×10^7
Escherichia coli	1.73×10^7
Mycobacterium gordonae	1.73×10^7
Brevundimonas diminuita	3.22×10^7
Cryptosporidium parvum	3.22×10^3

Considering the final costs (EUR 0.75 per filter/day) with the benefits that it has, the cost–benefits ratio is positive.

4. Discussion and Conclusions

The Centers for Disease Control and Prevention (CDC) estimate that 20% of the reported cases of LD are health care-acquired, with a mortality rate of 25%.

The-point-of-use filters can be used as a short-term measure for an outbreak response or as a long-term infection prevention approach in synergy with other methods.

As shown by the comparison among the preventive methods, provided by the Shipsan Guidelines, filters at the points of use do not have the typical disadvantage of the possibility of corroding the pipes and of increasing the risk of part of the biofilm detaching, giving rise to the formation of further colonies in other parts of the water system. Their use is important in high-risk conditions in synergy with other methods which can fail. (Garcia [4] has reported a clone of L. pneumophila sg1 that is capable of surviving for 17 years in a hospital water circuit, despite superchlorination treatments having been carried out).

The filters are effective to minimize the risk of a Legionella contamination and should be applied in the medical facilities, but also in the cabins of passengers with high risk of contracting the Legionella infection and in the event of massive contamination of the ship's water system while waiting for systemic corrective actions to be taken.

In conclusion, the point-of-use filters when they are used in synergy with the others prevention methods can play an important role to minimize the risk of growth and spread of Legionella and other waterborne pathogens on passenger ships in case of specific conditions.

The inclusion of specific provisions for Legionella prevention measures in ships medical facilities would be desirable in the next edition of the Shipsan Manual.

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