Institute for Hygiene and Public Health
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Modelling characteristics to predict *Legionella* contamination risk

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Introduction

For the surveillance of drinking water plumbing systems (DWPS) and the identification of risk factors, there is a need for an early estimation of the risk of *Legionella* contamination (>100 CFU/100ml) within a building, using efficient and assessable parameters to estimate hazards and to prioritise risks. The precision, accuracy and effectiveness of ways of estimating the risk of higher *Legionella* numbers (temperature, stagnation, pipe materials etc.) have only rarely been empirically assessed in practice.

Table 1: Characteristics of buildings and drinking water plumbing systems (DWPS)

Bldg	Type of use	Building construction	DWPS construction	Material DWPS	No. floors	No. outlets	Volume PWH system	Size of calorifier
A	Residential home for disabled people	1960s	1960s	Stainless steel, copper, zinc coated iron	5	70	750 L	2x200 L
B	Nursing home	1995	1995	Plastic (PVC-C), stainless steel	5	290	4000 L	3x1000 L
C	Hotel	2000s	2000s	Plastic, stainless steel	8	1300	n/a	2x2500 L
D	Canteen kitchen	1987	1987	Copper (ER-coated)	4	90	4500 L	4x1000 L
E	Large sports facility	1975	2004	Stainless steel	1	250	2700 L	2x1000 L
F	Sports hall	1928	2006	Copper	1	60	280 L	n/a
G	Hotel	1863	1970	Copper, plastic, stainless steel	7	660	n/a	6x750L + 2x600 L
H	Sports hall	2009	2009	Stainless steel	2	60	2220 L	2x1000 L
K	Kitchen	1975	2004	Stainless steel	6	30	2900 L	2x1000 L

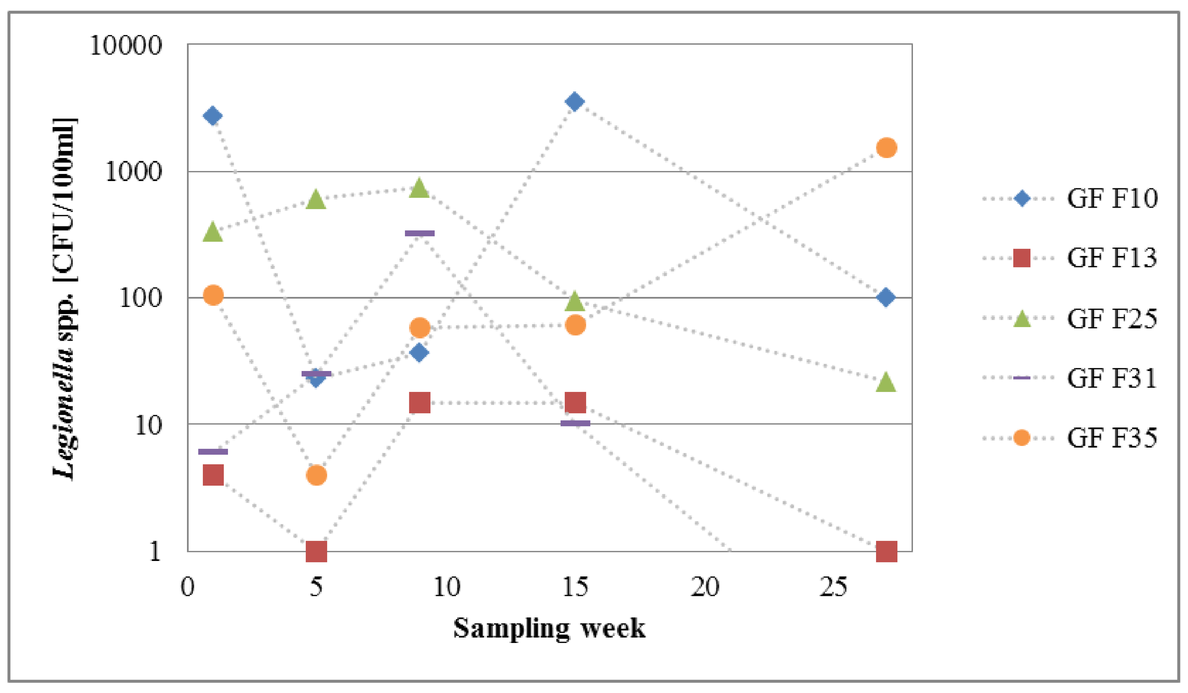

Figure 1: Presence of *Legionella* spp. over a half year period in building F at five sampling points (n = 143)

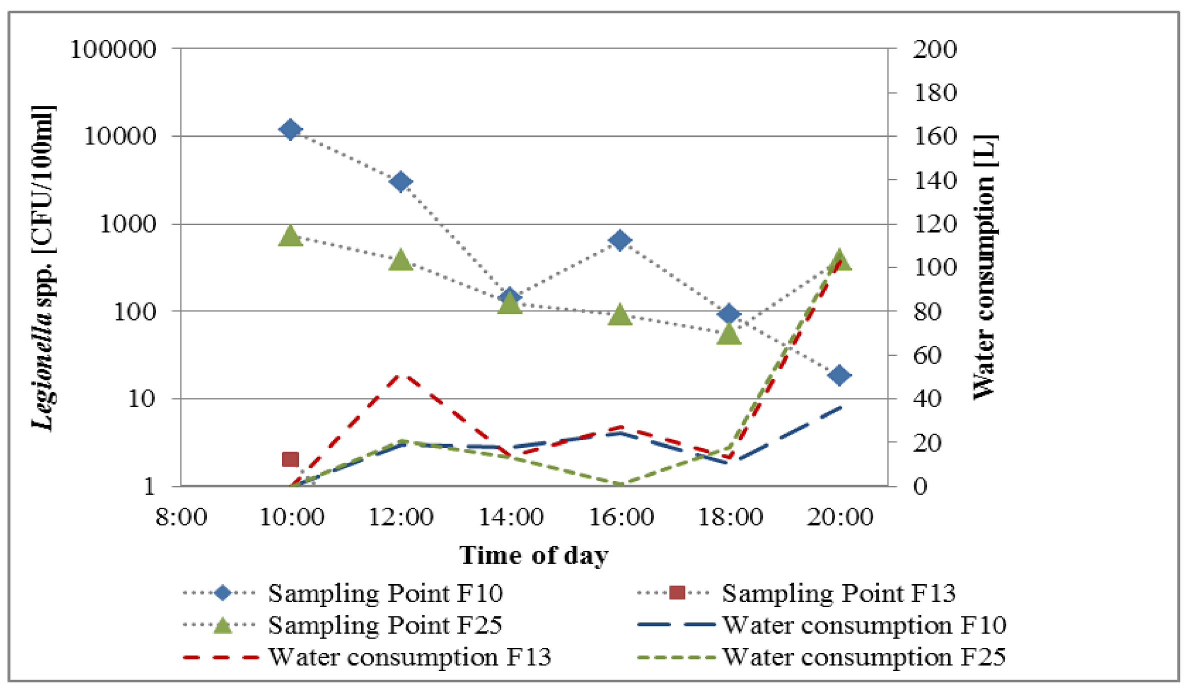

Figure 2: Short term presence of *Legionella* spp. over a day in building F at three sampling points in August 2012 (n = 18)

Research questions

- Under standard conditions in an already contaminated drinking water plumbing system, how intense does the presence of *Legionella* at an outlet change over short and long term intervals?
- Which outlet specific parameters are pertinent for an early prediction of the risk of *Legionella* contamination at single outlets?

Methods

We collected n = 807 drinking water samples from 9 buildings which had had *Legionella* spp. occurrences of >100 CFU/100ml within the last 12 months covering a wide range of building characteristics (e.g. type of use, use patterns, age, pipe materials, calorifier volumes) (Tab. 1). Before sampling the drinking water, we recorded the structures and characteristics of the DWPS in detail to enable precision, accuracy and $F_{0.5}$ score calculations. We determined a close-meshed network of representative sampling points for each building and tested for *Legionella* spp., *L. pneumophila*, HPC 20 °C and 36 °C (culture-based). Each building was sampled for six months under standard operating conditions in the DWPS.

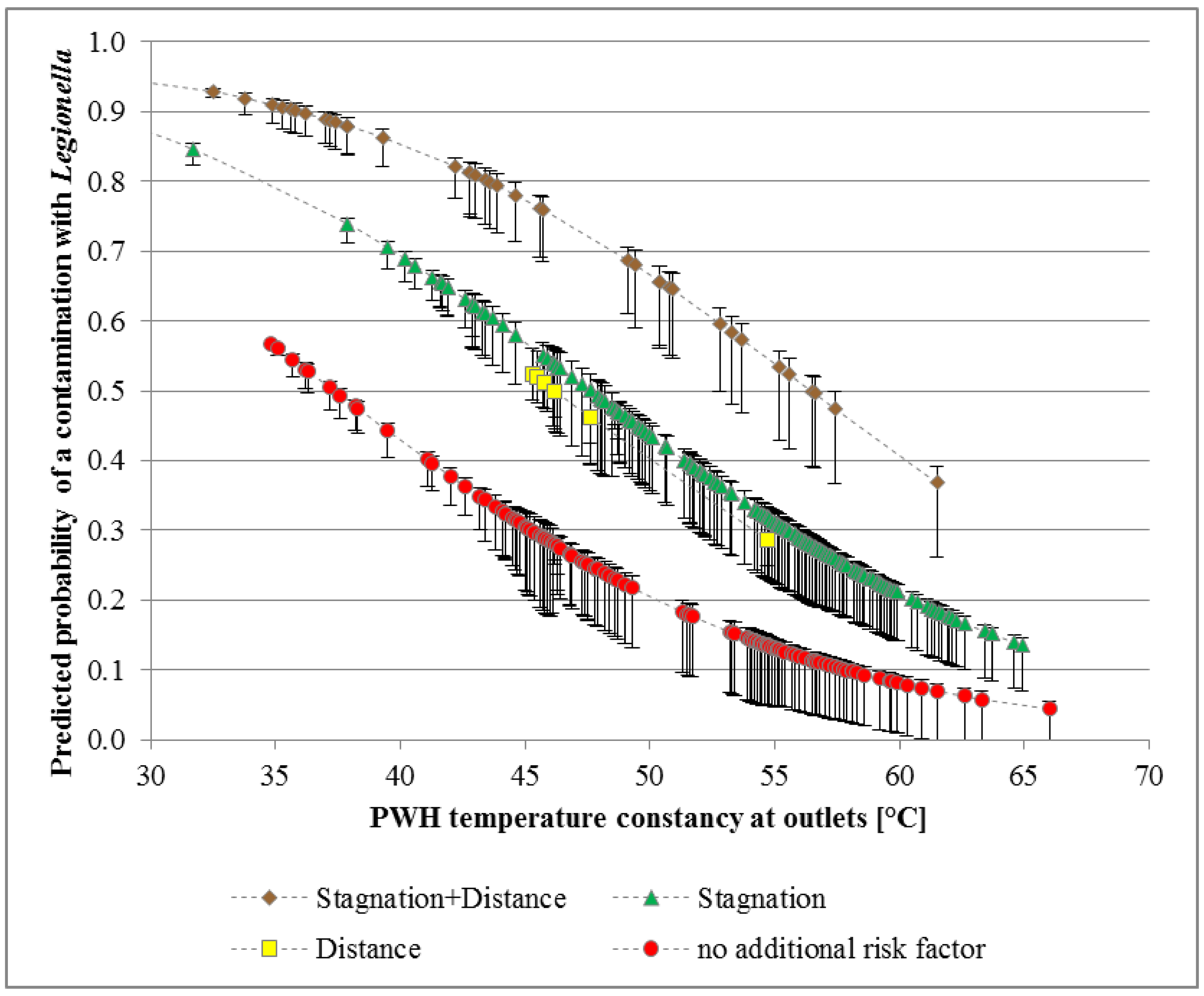

Figure 3: Relation of the predicted risk of contamination with *Legionella* and PWH (potable water hot) temperature constancy at single outlets with additional risk factors, including 95% Confidence Intervals (n = 411). Stagnation is assessed qualitatively and reveals low withdrawal at an outlet; the factor distance is represented by the 9^{th} decile of the proportion of the total length between calorifier and the furthest outlet.

Results

Incidences of *Legionella* have a strong spatial and temporal (short- and long-term) variability under standard operating conditions of a drinking water plumbing system (Fig. 1 and 2). None of DWPS structures and characteristics met the criteria of precision, accuracy, and $F_{0.5}$ score well enough to predict *Legionella* contamination. Logistic regression modelling (Fig. 3) revealed three parameters (temperature after flushing until no significant changes in temperatures can be obtained, stagnation (low withdrawal, qualitatively assessed), pipe length proportion) to be the best predictors of *Legionella* contamination at single outlets.

Conclusions

The required investigations with classical culture methods cannot always reliably reveal contamination and infection risks. A longitudinal sampling approach and better risk estimate for outlets within a building may help to better display the DWPS situation through a linked amount of samples.

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