Water Sampling and Legionella in Danish hot water systems

A short review

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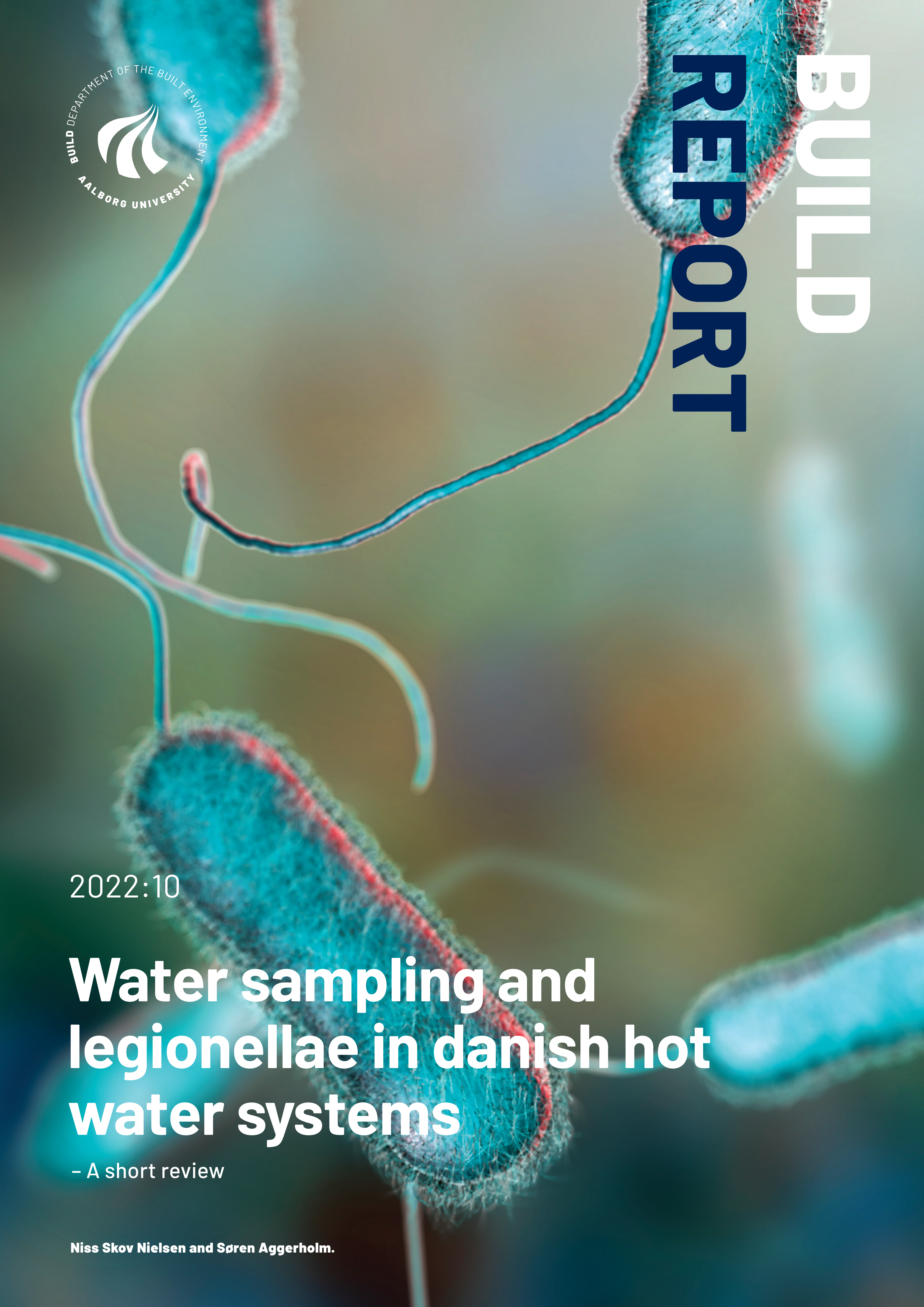

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– A short review

Niss Skov Nielsen and Søren Aggerholm.

WATER SAMPLING AND LEGIONELLA IN DANISH HOT WATER SYSTEMS

- a short review

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Søren Aggerholm

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1 PREFERENCE

This is a short review of a report evaluating the relevance of preventive water sampling in the effort to reduce Legionella levels in Danish hot water systems. The review is an English translation of a Danish review of an official Danish report prepared for The Danish Transport, Construction and Housing Authority (TBST-Agency) May, 2019. The project was led by the Danish Building Research Institute (SBi – name changed to BUILD in 2020), in collaboration with the Statens Seruminstitut,(SSI), the Danish Patient Safety Authority (STPS), and the Danish Technological Institute (TI) (1).

The project partners have contributed to the sub-studies in the project as follows:

- - Requirements in Denmark and in other countries: - BUILD in consultation with SSI
- - Municipal procedures: - BUILD
- - Installation and behaviour at 6 care homes: - TI and BUILD
- - Legionella cases from hot water systems: - SSI, STPS and BUILD

BUILD is responsible for this report.

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We thank the project group for their input and cooperation regarding the overall project. In addition, we thank representatives from the municipalities of: Copenhagen, Herlev, Elsinore, Odense, Kolding, Randers, Aarhus and Aalborg - for their cooperation and informative input.

2

PURPOSE

2 PURPOSE

The purpose of this report was to evaluate whether hot water sampling can be used as a method to assess the risk of being infected with Legionnaires' disease by Legionella bacteria from Danish hot water systems. The report also provides information about what requirements should be considered when establishing sampling procedures e.g. in relation to installations, vulnerable groups and particular bacterial strains. In addition, it is assessed whether knowledge among users and operating personnel can be expected to reduce the risk of legionella infection.

3

BACKGROUND

3 BACKGROUND

During recent decades, the number of legionella cases (Legionnaires' disease = LD) in Denmark and in many other European countries has increased (2). The aim of this project was to identify ideas and procedures for reducing the number of persons with Legionnaires disease in Denmark, a desire expressed in questions from the Danish Health and Elderly Committee to the Minister of Health in May 2017. The questions concerned whether the minster was aware that Denmark – unlike e.g. Germany and England – has no requirements for water sampling and for risk assessment of legionella growth in hot water systems. The minister's answer included – among other things – a promise that the Danish Transport, Construction and Housing Authority would conduct an investigation of how a Danish model could be designed. That model included requirements and possible effects of a permanent water sample strategy of Danish hot water installations.

This desire is also reflected in a March 2018 proposal for a parliamentary resolution to reduce the risk of infection with legionella from hot water systems in Denmark.

The overall aims of this report are addressed using 4 sub-studies, which are briefly described in the methods section and in the investigation models underlying the data collection (found at the end of this review).

A more detailed description of the issues and a more comprehensive review can be found in the full Danish report from this study (1).

4

METHODS – SUB STUDIES

4 METHODS – SUB STUDIES

4.1 Procedures in Denmark and in other countries

This section provides a review of legionella procedures in Denmark as well as in selected other European countries. The selected countries are: Sweden, Norway, Germany, the Netherlands and France. The review includes descriptions of preventive actions in place in each country, including primary prevention procedures (prevention of exposure e.g. by performing water sampling on installations where legionella presence has not yet been detected), and secondary prevention procedures (preventive procedures e.g. remedial actions such as raising the temperature in water systems where there is suspected but not confirmed presence of Legionella).

The following conditions are described for each of the selected countries:

- Existence of national limit values for presence of Legionella in water systems
- Use of preventive water sampling and existence of preventive procedures
- Possible effects of the national programme
- National trends in the occurrence of legionnaires' disease
- National mortality rate from legionnaires' disease
- Other characteristics

4.2 Municipality procedures in the field of Legionella

Danish municipalities have a duty to monitor local water systems when there is a suspicion of the presence of legionella. This sub-investigation involves a description of the local organisation and the procedures they carry out. Data comes from semi-structured interviews with key employees from 8 municipalities conducted during winter 2018/2019.

The elements of the interview guide are illustrated in Study Model 2 (see the end of this review).

The interview guide includes the following:

- Internal cooperation and organisation
- Written plans regarding legionella procedures
- Procedures in case of suspicion and/or detection of legionella bacteria in water systems
- Procedures for obtaining hot-water sampling from municipal buildings and from private building owners
- Existence of a legionella prevention programme
- Involvement of external persons or firms
- Communication procedures

In addition, this sub-study includes a brief review of the municipal representatives' proposals to a general improvement of legionella procedures in municipalities. A review of the proposals from the municipalities can be found in the full Danish report from this study (1).

4.3 Visits to 6 care homes

This sub-study includes an inspection of hot water systems (Study Model 1) and an evaluation of knowledge, behaviour and procedures of care homes regarding strategies for preventing legionella growth in water systems and for reducing exposure to legionella e.g. from showers and taps (Study Model 3). Data were collected from visits to 6 care homes in one municipality during 2019. None of the care homes have had cases of legionnaires' disease recently.

The selection included two cares homes with large occurrences of legionella in their hot water systems, based on measurements made by the municipality in 2018. Two care homes had medium occurrences, and two care homes had no/few measured occurrences of legionella bacteria in their hot water systems.

During the visits, the hot water systems were examined for the elements shown in Study Model 1 to investigate: typical construction of hot waters systems with a low legionella levels compared to hot-water systems with a high legionella counts.

Local technical personnel were interviewed about characteristics that could not be seen from the inspection of the hot water systems (Study Model 1).

Additionally, both technical personnel and representatives from the local staff were interviewed about the existence of and their knowledge of operational and behavioural procedures that could reduce legionella growth and/or exposure to legionella from showers and taps. A semi-structured questionnaire was used for investigating the elements shown in Study Model 3.

The purpose of the staff interviews was to answer the following questions:

- is there knowledge among technical personnel and local staff regarding special procedures or behaviours that can reduce the risk of legionella infections?
- have local procedures and behaviours been introduced recently that might have prevented new cases of legionnaires' disease (even though legionella might be present in the local hot water system).

4.4 Legionella cases in private homes

This sub-study includes the municipalities' inspection procedures in cases where local residents have been diagnosed with legionella. A total of 29 cases from 8 selected municipalities were investigated. All of the cases represent residents exposed at home in the selected municipalities between 2009 and 2018. Travel-related and hospital-related legionella cases are thus excluded from this study.

Data were collected using a questionnaire with elements similar to Study Model 1. Requests and an empty questionnaire were initially forwarded by the Danish Patient Safety Authority to the municipalities based on registered legionella cases in the municipalities. The completed questionnaires were returned to the Danish Patient Safety Authority and then passed on to SSI, which added social and health characteristics from their investigations of the 29 cases. Subsequently, the completed and anonymised questionnaires were sent to BUILD for data entry and analysis. Data collection was difficult – partly for reasons of confidentiality and partly because specific information about legionella cases was obtained and stored by a number of different public authorities.

Data are used for two purposes:

- To clarify what data is collected and stored by municipalities in relation to legionella investigations

- To analyse relationships between elements from the questionnaire and the legionella levels of the infected water systems, also with the purpose of investigating the significance of installations, procedures and behavioural data for the 29 cases.

5

RESULTS AND ASSESSMENTS

5 RESULTS AND ASSESSMENTS

5.1 Overall requirements and procedures in Denmark

As in many other European countries, the incidence of LD in Denmark has been increasing throughout the last decade. Denmark is one of the European countries with the highest incidence of LD cases per year. In the last decade, 250-300 LD cases, equivalent to four to five cases per 100,000 people, have been found each year (2-4). Most of the infected individuals are vulnerable, elder and male. The Danish cases are characterised by an overall lethality rate of 11% (ibid.).

In Denmark, drinking water in water systems and from taps is clean without the use of chlorine supplements. The Danish water supply is sourced from boreholes and collections from clean groundwater reservoirs stored in central water supplies. Water is delivered to homes and other peripheral taps from the central water supplies. The water quality of the central water supplies is continuously tested, and slightly contaminated water can be purified and mixed with clean water until sufficiently water quality is obtained. The EU Drinking Water Directive prescribes the use of regular water sampling to test for the presence of legionella bacteria in drinking water (6). The EU directive is part of the basis for the Danish Law for Water Supply Vandforsyningsloven (retsinformation.dk) and for the Drinking Water Act (Drikkevandsbekendtgørelsen (retsinformation.dk), which constitute the Danish guidelines for water supply. Neither of these two Acts prescribes an obligation to take regular preventive water samplings to test for the presence of legionella in drinking water. This may be partly explained by the fact that drinking water in Denmark only includes the cold water transported through pipelines from central water supplies. Unlike in the rest of the EU, where drinking water is equivalent with heated domestic water, where legionella is more likely to be present. Only a few occupational groups, such as dentists, have a duty to have their drinking water tested annually. Hospitals also have guidelines for regular inspections regarding the prevention of legionella in their water systems.

In Denmark, owners must secure drinking and domestic water against the presence of legionella in private as well as in public buildings (Danish Law for Water Supply). The Danish municipalities have a duty of supervision and can, in the event of suspicion of the presence of legionella in water systems, require water sampling and testing to be carried out on behalf of the owners (Drinking Water Act). If legionella is present, municipalities can demand that the level of legionella must be reduced. One problem with these obligations is that municipalities cannot by law impose requirements on owners for specific installations or for specific operating procedures with the aim of reducing the occurrence of legionella in buildings. In addition, there are to date no national limit values for the presence of legionella in water systems, which complicates municipalities' orders to reduce legionella in the domestic and drinking water of Danish buildings.

Statens Seruminstitute (SSI) has recommended that drinking water may contain a maximum of 10,000 cfu/liter of drinking water or 1000 cfu/liter of drinking water of legionella pneumonia (2-4). Most municipalities are following these recommendations. A few municipalities have also, on a voluntary basis, introduced regular water sampling from water systems in their own buildings with the aim of monitoring legionella levels in care homes, kindergartens, schools and sports facilities, all of which are municipal institutions.

Statens Seruminstitut has issued guidelines for the testing of water samplings for the presence of legionella in water systems (5). A distinction is made between 3 sample types:

A-samples (immediate, first flush samples). A positive legionella A-test does not necessarily confirm the presence of legionella in the water system, which may be completely without legionella, even when a high level of legionella is present at the source of the sample, e.g. in a shower.

B-samples (at constant temperature) - Samples are taken at constant water temperature (cold or hot), either at a tapping point or directly from the source (spa, cooling tower, plumbing, etc.).

C-samples - inoculations from biofilm. These samples are taken from taps (e.g. showers) or other locations where one can see the growth of biofilms (shower heads, fountains, cooling towers). There is no standard for taking these samples.

The samples (1000 ml) are tapped directly into bottles. The samples are then stored at 6-18 degrees Celsius until testing at the laboratory, which is performed within 2 days after the sample is taken.

The presence of legionella can be tested using the PCR technique, a relatively fast method of legionella detection. These results are not very accurate, however, since PCR detects both living and dead bacteria. Cultivation is therefore the standard test method in Denmark, and the reference method used for detecting the number of living colony-forming units (cfu) of legionella bacteria in the water samplings (4,8). Using this technique, initial results are usually available within 2-4 weeks; a qualitative result showing which types of legionella are present is not available until at least 4 weeks after the sample is taken.

5.1.1 Requirements in other countries

Overall, the comparable countries Sweden, Norway, Germany, France and the Netherlands have had an increase in the number of LD detections during recent decades, and a stagnation in cases since 2019-20 (2). The overall lethality rate in these countries is in the same order of magnitude as the Danish rate of around 11% (2). Further studies have shown lethality rates from 5-30% depending on legionella type and the age and health condition of exposed populations (9).

Four of the countries, Norway, Germany, France and the Netherlands, have included preventive water samplings and a limit value for the number of legionella bacteria – or a proportion of samples with legionella – as central parts of their national legionella programmes (9-15). The Swedish approach to a legionella policy includes a consideration of that legionella is "commonly" present in water systems. Use of preventive water samplings is probably therefore only included for certain types of occupations, or when certain high-risk indicators for legionella growth are present, e.g. high cold-water temperatures (16-18).

Norway had a stabile low number of LD cases until 2009, after which cases have increased steadily (2,4). In France, similar numbers of cases were seen in 2018 as in 2009 (2,4), although the number of annual cases has fluctuated throughout this period. In Germany and the Netherlands, the number of LD cases generally increased steadily during recent decades (2,4). The German authorities implemented a new legionella programme in 2018. This programme seems to have had a positive effect, as the number of LD cases has decreased since 2019 (4,10,11). This programme is based on a building technological approach incorporating up-to-date knowledge of legionella growth in hot water systems. Preventive water samplings are to be taken from older buildings with long pipes, while newer buildings with shorter, small-bore pipes are not included in the programme. The initial standard interval for water samplings is yearly. If the limit value for legionella is met for 3 consecutive years, the interval for taking water samples is extended to every three years. Behavioural recommendations are also included in the German programme.

The Norwegian approach includes an initial risk assessment of the water system and of the potential health consequences for exposed people. An overall evaluation of these elements defines a subsequent water sampling schedule established by the Norwegian municipalities but executed by building owners. Water systems determined to be high-risk are included in a comprehensive and frequent sampling programme, which might include several annual samplings. In addition, an alternative assessment method is used to define high-risk of legionella in water systems. The risk is assessed in relation to the proportion of samples/taps where legionella is detected (> 30% = high-risk) (9).

In France, new focus areas and procedures have regularly been added to the programme as knowledge of new risk areas has emerged. An overall geographical difference, with more annual occurrences related to floods in the eastern part of the country compared to the western part of the country, combined with general annual fluctuations, seems to be the main cause of the fluctuations in France between 2009 and 2018 (15,19).

The Legionella programme in the Netherlands is primarily based on annual preventive water sampling from taps and aerosol-producing installations. In 2002, a national detection programme was introduced in order to analyse all legionella cases with the aim to further reduce infections. However, in 2006 this detection programme was reduced to a follow-up effort that is performed only sporadically. While the annual number of LD cases decreased shortly during the period with the detections programme, the overall number of cases has generally increased during recent decades (2,12,20).

In summary, the Legionella programmes of Norway, Germany, the Netherlands and France all include preventive water sample tests and limit values – or proportions of samples with legionella – as central parts of their programmes. Furthermore, the programmes in Norway, Germany and France are supplemented with other unique preventive and targeted initiatives, which might be relevant for these countries' stagnant numbers of LD cases during recent years. The programme in the Netherlands, primarily based on annual water sampling alone, has not been sufficient to prevent an ongoing increase in the number of LD cases during recent decades. Use of preventive water sampling therefore seems to be an important part of a country's Legionella prevention programme. But – based on the Dutch results – it seems to be insufficient for controlling and reducing the annual number of LD cases in a country. A country-wide programme with continuous updates and new targeted initiatives also seems essential for the success of a national legionella prevention programme. A focus on sampling of high-risk installations and water systems which supply vulnerable groups also seems vital for reducing the number of annual LD cases in a country.

5.2 Municipal procedures in the field of Legionella (based on interviews of key personal)

All the investigated municipalities had implemented legionella programmes with descriptions of how to carry out water control tests from water systems suspected of containing legionella. The larger municipalities among the investigated municipalities had also established checklists of information like "What to do", "How to" and "Who does what" diagrams, including communications procedures, in their overall legionella programmes. Some of the municipalities had established co-operations with external firms and partners in order to quickly perform tests and analyses of the investigated water systems.

The local staffs consist of one or more employees from relevant departments in their legionella groups. Relevant departments are: building, health, environment, social and elder care, and even educational departments within the municipalities. The groups had been established according to local political contexts, the incidence of legionella cases and the size of the municipality (1).

Some of the municipalities had also included primary preventive procedures in their local legionella programmes. One of the municipalities had installed oxiperm filters on taps in their care homes in order to prevent exposure to potential legionella-containing water systems. Another municipality regularly teaches municipality-employed care assistants about behaviours that can reduce exposure among users. Two of the 8 investigated municipalities had introduced annual preventative water sampling of municipality institutions. In the first municipality, the sampling strategy was established based on an initial risk evaluation of the local institutions (ibid.). The risk evaluation was based on a risk assessment of the local water system for existence of legionella and an assessment of the potential health consequences among exposed groups. Further, previous findings of legionella in the individual institution's water system. Institutions deemed most at-risk are to be checked annually using preventive hot-water sampling (ibid.).

In the second municipality, 3x10 preventive hot-water sampling are to be taken annually at municipal institutions including care homes, schools, care centres and leisure facilities. The frequency is such that each institution can expect to be tested approx. every 3 years. These initiatives – adapted to the size and local context of the municipality – might be used as inspiration for other municipalities.

Several of the other municipalities investigated mentioned that they were open to including a preventive legionella programme utilising preventive hot-water sampling in their local legionella programmes if national limit values for the legionella levels of water systems were established (ibid.).

The test programme in which municipal institutions with vulnerable groups and high-risk installations are regularly assessed and tested is very similar to the Norwegian approach, while the programme where individual institutions can expect to be tested preventively every three years is similar the guidelines for the German water sampling programme. These two programmes are not mutually exclusive, however. High-risk institutions (such as care homes and institutions with vulnerable people) and institutions with older, over-dimensioned hot water systems could e.g. be tested annually, while the other institutions (e.g. newer schools) could be tested every three years.

There are major differences between the municipalities' initiatives regarding secondary prevention strategies to avoid further growth and exposure from water systems under investigation for the presence of legionella bacteria (1).

Relevant secondary prevention initiatives that some municipalities perform or have suggested are:

- Development and distribution of a leaflet or checklist for preventing further growth in local water systems to owners, users and operating staff. Additional information about how to ensure sufficient use from taps and flow in the water systems. Finally, information about behaviours that can reduce exposure from water systems possibly containing legionella. That could include a recommendation to wait for the hot water before entering the bath or instructions about how to empty the shower hose after use.

Another suggested measure includes directly communicating measured values – e.g. temperature and the legionella counts of the hot water system investigated – to owners and operating staff in order to speed up relevant initiatives lowering the legionella levels of investigated water systems.

Further measurements and disclosure of other relevant information regarding the investigated water systems were also suggested. For example, the results of inspections of the hot water capacity and the insulation around water pipes etc. could be relevant information to communicate to owners, users and technical staff in order to prevent further growth and exposure from potentially infected water systems.

Another key element is the optimisation of the water sampling procedure and the analysis process in order to reduce the time that elapses between the ordering of a water sample, the receipt of the results and the implementation of subsequent initiatives. A rapid sampling policy (e.g. initially ordered and paid for by the municipality, as is the practice in one of the investigated municipalities) would likely ensure faster water sampling and analysis according to standardised criteria.

Using the standardised cultivation technique in common use, at least four weeks generally elapse before answers regarding type and number of growing legionella bacteria are available. Analyses in two tempi could speed up this process. An initial analysis using the PCR technique could establish whether or not legionella bacteria are present. (This technique cannot currently distinguish dead colonies from living colonies, however, and thus only indirectly quantifies the legionella levels in samples). From a health point of view, however, this is not crucial - partly because the antigens from dead legionella bacteria can expose humans (21), and partly because the large distance in time from a person is hospitalized with pneumonia due to legionella to the result of the water test for levels of legionella in the persons' hot-water system in question is so long that the amount of legionella at the time of exposure cannot be determined anyway.

If the PCR tests indicate the presence of legionella, cultivation techniques could be used to determine the amount and types of legionella bacteria in the water samples. Since culture tests must be performed within 48 hours of sampling, a test process in two tempi would offer an optimised solution for obtaining fast and trustworthy results. Such an optimisation of the analysis process could also speed up the overall measurement process considerably.

The municipalities also suggested the following proposals for improvements: A clear assessment of the health hazards of legionella counts in water systems in order to be able to weigh the expense of the initiatives against the expense of the consequences of legionella levels. Official guidelines for water temperatures and regular flow in water systems. Guidelines regarding procedures for a safe upstart and cleaning of water systems after periods with low or no water use (e.g. after holidays). Additional proposals were made to regulate government-determined restrictions of the municipalities' annual use of finances for local initiatives, which often prevent renewal of hot water systems. One of the suggestions to reduce these financial barriers was a graduation or an exception for initiatives vital to citizens' health. Finally, the municipalities suggested government initiatives to improve their ability to take action on leased properties. It is the owner who has the obligation to determine the need for renovating or updating heating and hot water systems (1). This makes it difficult for municipalities to get updated water systems in older, leased privately-owned institutions.

The interviews also revealed that the municipalities primarily act and support institutions regarding the construction of hot water systems and only to some degree on procedures, e.g. recommendations for the regular use of heat shock (up to 70 degrees Celsius) to kill potentially existing legionella bacteria in the water systems, or the installation of legionella filters on taps in care homes with high legionella counts in their water systems. Only one of the interviewed municipalities had included behavioural procedures by teaching care assistants about behaviours that can reduce exposure among users of hot water systems that potentially contain legionella.

5.2.1 Other municipality actions in the field of legionella

One of the investigated municipalities did put on peripheral legionella filters on taps in all their care homes. Another municipality initially performed tests for the presence of legionella in the hot water systems at all their care homes. Peripheral filters were then put on all taps in care homes where the legionella counts exceeded 1,000 colonies per litre in water samples based on stable temperature (B-tests) (1). In total, peripheral filters were installed on the taps in 18 care homes. Retests of the legionella contents were performed after two months and the results showed that the filter action resulted in a mean reduction in the number of legionella colonies of 77% compared to the starting point (in two of the care homes water sampling showed higher counts of legionella after fitting the filters, indicating that they were fitted incorrectly). The filter action on the remaining 16 care homes showed a mean reduction in the number of legionella colonies from the hot water of 83 per cent.

A "maintenance package" was introduced at 5 randomly selected care homes in one of the investigated municipalities to prevent legionella growth. At the 5 care homes, an annual cleaning of boilers and central pipes was introduced, a weekly boost of hot water temperature up to 70 degrees (Celsius) and ensuring that the central temperature is at least 55 degrees (Celsius). An intervention period of three month was used before a retest of the legionella contents took place. The interventions led to an average of 68% reduction of Legionella colonies in the water systems. The observed decrease at three of the care homes ranged from 58% to 99%. The two remaining care homes had low levels of <1000 CFU/L both before and after intervention. The intervention procedures were subsequently introduced permanently at all the municipality's care homes.

Considerations

Despite the significant reduction in legionella contents from the hot tap water based on the filter action, the filters do not contribute to a reduction of legionella contents in the hot water systems. In addition, is it costly as such filters must be replaced every 3 months to maintain the capacity. The “maintenance packet” seems effective for reducing the legionella counts in hot-water systems - but this solution was only tested for 3 months. New results for long-term effects is not available.

5.3 5.3 Visits to 6 care homes (interviews with staff and inspection of hot water systems)

5.3.1 Cooperation between municipality and care homes regarding legionella

Based on information from the technical staff, inspections of water flow and capacity in the 6 visited care homes’ water systems were not performed by the municipality, nor had the municipality suggested such investigations. Likewise, no inspections of the insulation around the water pipes and its dimensions had been performed, and none of the care homes had been offered central water treatment solutions like ion exchange systems to reduce the potential presence of legionella in the local hot water systems.

The nursing staff interviewed at the 6 visited care homes claimed that they had not received any instructions from the municipality regarding preventive procedures or behaviours that might reduce exposure during use of the showers. Only one of the care homes visited had received the results of the legionella measurements taken of their water system. At this care home, the information had apparently resulted in an increased awareness of legionella, as the local management contacted the municipality with the intent to order new hot-water samplings to test for the presence of legionella after a couple of residents suffered from pneumonia. Knowledge of the local results might therefore constitute valuable information encouraging care homes to keep an eye on legionella occurrences in the hot water systems based on possible effects on residents (ibid.).

Considerations
Based on interviews with key figures in the municipalities (section 5.2), it is no surprise that care homes are missing information from municipalities regarding procedures and of behaviours that might reduce growth of and exposure to legionella, as there seems to be a general lack of knowledge on the part of the municipalities themselves. Based on experiences from The Danish Technological Institute it will be valuable knowledge for municipalities to think in preventive technical solutions as well, which they can implement or advise care homes about. Water treatment systems and the “maintenance packet” for the water systems might be effective as complementary interventions to reduce growth of legionella in legionella containing water systems which is not easily renovated. As shown in section 5.2.1 legionella filters on taps might be another effective action to reduce exposure from legionella. But even when filters are fitted correctly, they can never provide long-lasting protection, as they do not prevent legionella growth in water systems

5.3.2 Knowledge of legionella exposure and of risk-reducing procedures among the technical staff of six care homes
None of the technical staff members interviewed at the six care homes knew about the risks of showering (aerosols), or that water containing legionella can be drunk without risk. There was only partial knowledge of what hot-water samplings are used for. None of them knew about the risk of legionella formation at tapping points, or that this risk is higher when water temperatures are low and taps are rarely used. Furthermore, none knew about the risk of biofilm formation in pipes and the central water system at low water temperatures, or that biofilm protects and contributes to legionella growth in water systems (ibid.). Only the two care homes with low legionella counts had knowledge about the importance of reducing hot water boiler capacity from the generally over-dimensioned hot water systems in the care homes.

As a result, none of the care homes had introduced behaviours (e.g. emptying shower head and hose after showering) or procedures (e.g. reduction in boiler capacity or the use of central filters) that can reduce the risk of infection with legionella.
None of the care homes regularly offer training in or teach new staff to promote legionella-preventing procedures and behaviours (1).

5.3.3 Risk-reducing procedures and behaviours in the daily health care work at six care homes
Weak residents in care homes usually bathe only once a week – with help from the nursing staff. In general, no procedures have been established to reduce exposure to legionella bacteria in such situations (e.g. allowing the water to run for a few minutes before the weekly bath).

Furthermore, none of the care homes had introduced procedures for flushing out the shower and cleaning the local water system upon resident turnover.

In this context, several weeks may pass from the last time a former resident used the bath (e.g. if he or she was ill before death) until a new resident uses the shower for the first time. A single care home had introduced procedures for the local cleaning staff to clean the bathroom using water from the shower’s hot water tap in order to ensure regular water use, regardless of residents' usage.

Overall considerations regarding knowledge and procedures at six care homes
Based on updated knowledge in municipalities and among staff at the institutions, it should be possible to publish a document with instructions on how to maintain and/or renovate older, high-risk water systems in care homes. It also seems essential to publish a document informing staff and users of preventive behaviours and procedures regarding the use of

showers in the care homes, especially considering the regular turnover of both staff and residents, and the lack of regular training of new personnel at the care homes. Often useful knowledge of ways to reduce risk of exposure to legionella is not passed on to others. It also seems important to inform employees of any updated information.

Another useful suggestion for improving knowledge among technical staff and reducing the risk of legionella growth is the publication of a regularly updated document with operating procedures for inspections and maintenance of hot water-systems in care homes. Distributing updated documents containing suggestions of procedures for regular water use to the cleaning staff seems relevant as well. Finally, regularly education of the nursing staff, supported by documents detailing how to avoid exposure to legionella in the bathing situation, might also be relevant to introduce in care homes – especially when renovations of installations are not possible and normal operating procedures are insufficient to prevent legionella growth in older institutions' hot water systems.

5.3.4 Results from inspections of the water systems

The hot water systems in six care homes were inspected regarding capacity and dimensions, water treatment, water flow, length and insolation around water pipes. The selection of care homes included two homes with high levels of legionella in samples from the hot water systems (> 70,000 CFU/L), two with medium levels (7,000–8,000 CFU/L), and two with little to no detectable Legionella (< 100 CFU/L). The aim was to record distinct characteristics of care homes with high legionella colony counts compared to those of care homes with lower counts.

It was noted that current daily water consumption was considerably less than the amount of water the systems were designed for 30-50 years ago (1). Long, large-bore pipes, as well pipes with old and inadequate insulation, were also present in most of the water systems (ibid.). A large overcapacity in boiling tanks was observed at the four care homes with the highest legionella counts. The care homes with low legionella levels had reduced their hot water boiler capacity by not using one of the boilers present.

The care homes with low legionella counts also used a central control mechanism with regulation of the water temperature and a hydrochloride water treatment device. The hot water systems of the other four care homes were characterised by older electrolytic protection devices that promote sludge development, which can encourage legionella growth. These care homes also had corrosion in their long water pipes, which results in a loss of heat along the water pipes and an increased risk for biofilm formation and subsequent increased legionella growth (1).

In one of the care homes with medium legionella levels, it was noted that the legionella counts were low in all taps measured, except for one tap which had very high legionella counts (based on results from A-test - first flush sample). This is likely due to the fact that this particular tap was rarely used (1).

Overall considerations

Water treatment initiatives (e.g. hydrochloride) to reduce legionella levels of the water systems, the use of biocides or central filters and a reduction in boiler capacity might to some degree compensate for the overcapacity of older water systems (1). Regular use of all taps is also important in preventing high levels of legionella in taps. Removing rarely-used taps and pipes is another possibility. Finally, central control and regulation of water temperature, a circuit heating system and additional insulation around long pipes might further contribute to reduced heat loss, biofilm formation and legionella levels in the hot water systems (1).

5.3.5 Overall assessment

The following observations are most relevant to the overall purpose of the investigation of the care homes:

- There seems to be a general lack of knowledge among the technical personnel of the six care homes regarding procedures and behaviours that might reduce the risk of legionella infections
- There also seems to be a general lack of knowledge among the nursing staff at the six care homes regarding procedures and behaviours that might prevent new cases of legionnaires' disease

It therefore seems important to regularly educate and update staff regarding these procedures and behaviours due to the regular turnover of both employees and residents.

5.4 Legionella cases in private homes

The collection of data from 29 specific legionella cases was complicated, partly for reasons of confidentiality and partly because the necessary information was distributed among various institutions.

5.4.1 Registered data in the municipalities

The municipalities had primarily registered the number of legionella colonies in A-samples and constant temperature of the water flow. For some cases, B-samples were also recorded, as well as temperature of the return water from buildings with district heating systems. A few municipalities had also registered installation data such as age and type of hot water system, and whether there were heating circulation or water treatment functions on the system. Other installation data, as well as operational and behavioural data, were recorded to a lesser extent or not at all (1).

Results showed that all the registered cases involving heating systems (1) had district heating systems. All the registered heating systems were of the older type. Of these, 4 were over 20 years old and 11 were over 40 years old.

Three of 16 registered cases had a constant temperature of less than 50 degrees in their hot water systems, and 7 of 10 registered cases had a return water temperature of less than 40 degrees Celsius. In 8 of 11 registered cases, ion exchange support or another type of water treatment was installed on the hot water system. In 6 of 13 registered cases, a permanent heating master, a janitor or a plumber on-call were responsible for maintaining the functionality of the hot water systems.

Finally, in 7 of the cases the insulation around the water pipes was recorded as intact. The annual water consumption of hot and cold water, respectively, had not been registered in any of the 29 cases.

5.4.2 Analysis of relationships between measured data and legionella counts in the hot water systems

Wilcoxon Rank Sum W (independent) was used to analyse whether the measured installations, operating and behavioural parameters were significant related to the number of legionella colonies. Above or below 10,000 colonies per litre in the hot water system were used as outcomes in the analysis ($p <= 0.05$). Legionella counts in A-samples (first flush) as well as in B-samples (at constant temperature) were used in these analyses.

Only one parameter, "regular service of the hot water system", was significantly correlated ($p = 0.025$) with an occurrence of colonies below 10,000 cfu/L in the A-samples(1).

Considerations

Although it seems important to have “a regular service” on the hot water system, the significance of this parameter may be an expression of mass significance. The number of parameters examined was about 20 and the p-level was 0.05, which is equivalent with the risk that one of the parameters could be significant for random reasons.

That only one of the indicators is significant could also be explained by the paucity of data investigated or registered by the municipalities, or by the fact that municipalities had not received such information from the companies that conducted the legionella investigations of the hot water systems.

This lack of investigated or registered data in the municipalities might lead to a lack of updated knowledge regarding legionella among employees of the municipalities, which might further lead to inadequate sparring and collaboration with staff in care homes. This lack of data also represents a missed opportunity to support local legionella prevention efforts by informing others in the municipalities about local legionella procedures.

The overall importance of construction, procedures and behaviour for the high number of LD cases in Denmark annually was investigated in the analysis of data from the 29 legionella cases in private homes. As shown elsewhere, the only variable which was significant for a low presence of legionella was a “procedure” variable. In general, the municipalities investigate and store data concerning water temperature and legionella counts in the hot water systems, which also may constitute “procedure” variables. Since the municipalities also, to a lesser degree, investigate and store data from other procedures (e.g. use of water treatment procedures) and constructional details (e.g. the age of the water system), it may be concluded that procedures and secondary constructional data are most important to the municipalities, and that behavioural data are of no importance. On the other hand, municipalities are of course most interested in data that can be used to establish lasting conditions that prevent new LD cases – and since the resident is already infected when the study of the presence of legionella in the water system takes place, behavioural data might be of minor importance.

An assessment of the importance of construction, procedures and behavioural data for onset of LD is therefore not possible based on analysis of data from the 29 LD cases.

6

OVERALL CONSIDERATIONS REGARDING RELEVANCE OF PREVENTIVE WATER SAMPLING

6 OVERALL CONSIDERATIONS REGARDING RELEVANCE OF PREVENTIVE WATER SAMPLING

Most of the 8 municipalities surveyed would like to introduce preventative hot-water samplings in a prevention programme, and they called for a fixed limit for the number of legionella bacteria in domestic hot water systems in order to justify the introduction of preventive water sampling. The municipalities also wanted fixed procedures for water sampling, and for subsequent actions and legionella tests (1).

However, it should be mentioned that the introduction of such procedures – e.g. in form of regular intervals for "preventive hot-water sampling" and standardised procedures for subsequent actions – will result in a need for further training of operating personnel and municipal administrative staff to process data and manage water sampling schedules (1).

All the municipalities interviewed called for support and for inspiration from each other in order to improve their procedures to reduce legionella growth and their recommendations regarding behaviours that reduce exposure to legionella from water systems. Some municipalities further argued for an overall health-economic assessment in order to be able to prioritise the legionella effort relative to other efforts in the municipalities. Finally, it was suggested to adjust the guidelines for water system constructions with the aim of reducing legionella levels of the water systems (1)

In 2004, the Danish Environmental Protection Agency concluded (21) that there was not enough evidence to be able to introduce limits and procedures. It is impossible to demonstrate an unambiguous dose-response relationship for legionella due to:

- the multiplication of bacteria occurring in amoebae and biofilm. There may thus be a risk of infection via amoebae present in the water systems.
- the generally fluctuating levels of legionella in domestic water, e.g. in pipes. Increased water pressure can cause parts of the biofilm to detach, which may cause a significant increase in the legionella counts of the water.
- varying virulence among different Legionella species and serogroups.
- varying virulence within the same type, i.a. depending on life-cycle.
- varying susceptibility of different people depending on health status.
- usually only legionella that can be cultured are detected, which can lead to an underestimation of the risk – as dead cultures can to some degree be harmful to health.

The points are still relevant in 2021. Due to the missing evidence for a health-related limit of legionella levels in water samples, it is also hard to predict the success rate and subsequent health economy of preventive water testing. The evidence of effects from the use of preventive water testing in other countries is not solid either (see e.g. the programme in the Netherlands). Even if the evidence were solid, the context in Denmark is not the same as in the other countries. For example, France has a pronounced east/west gradient and a different climate. The types of buildings common in Denmark are also significantly different from most of the other countries (22). Furthermore, there are unique national characteristics of the water supplies, e.g. technical differences, surface water versus groundwater, chlorinated water versus unchlorinated water, drinking water versus domestic water, etc.

Most European countries have nonetheless introduced preventive water sampling and fixed values for the legionella bacteria levels of the water samples, as recommended by WHO and the EU despite the missing evidence of effect (6,8,23).

It may be relevant to introduce regular preventive water sampling in Denmark as well - from both an administrative and an overall health point of view. This would also meet the need expressed by municipalities for overall coordinated procedures. In this context, WHO, the European Parliament and the ECDC, as well as the SSI, have recommended graduated limits of 1000 cfu/L and 10,000 cfu/L, respectively, depending on the type of legionella present: 1000 cfu/L for sero-group 1: Legionella Pneumonia and 10,000 cfu/L for other types (4-8, 23,24).

New, faster methods for determining both the presence and types of legionella present in hot water systems would improve municipality efforts to prevent new cases of LD. Using the current standard methods, more than a month elapses from the time an infected person falls ill until the nature of the legionella in the person's hot water system can be determined. One could suspect that the conditions in the hot water system might have changed during this time. Furthermore, a faster determination would also reduce the amount of time during which other users of hot water systems that potentially containing legionella could be infected.

Despite the differences between countries, a preliminary conclusion seems to be that other countries' use of preventive water testing and of fixed limits for legionella levels in water samples is likely to have an effect on countries' efforts to limit the number of citizens contracting LD annually. However, use of preventive water sampling should not stand alone as the only element in a prevention programme. Three countries (Germany, Norway and France) have central elements in their programmes which could be relevant for a Danish programme. All three countries have introduced preventative water sampling, and two of them have set limit values for the water levels of legionella bacteria as a central part of their programme. However, their programmes also contain many other context-dependent actions, which makes it impossible to draw precise conclusions regarding the effect of preventive water sampling alone. In this context, it should be mentioned that the Dutch programme contains something like a total model for preventive water testing alone, and that this programme has not been able to prevent a continued increase in the number of annually registered cases of LD in recent years.

A relevant preventive legionella programme should therefore be based on the Danish context. A Danish preventive programme could focus on the elderly and other vulnerable groups, and on hot water systems that potentially expose these citizens.

Efforts could be concentrated on water systems with construction characteristics that increase the risk of legionella bacteria growth. The programme’s design could, in principle, resemble parts of the Norwegian and German legionella prevention programmes. These parts could include e.g. an initial risk assessment of the hot water system and an evaluation of the potential health effects among exposed (vulnerable) citizens. The overall risk could be assessed on the basis of a total scale of e.g. 3 risk levels, as in the Norwegian programme.

Inspiration for a Danish programme can also be found in the approach of one of the municipalities interviewed. The municipality has introduced annual preventive water tests for the buildings rated highest-risk, based on an assessment of the risk of legionella in the hot water system as well as the potential effects of legionella on the health of vulnerable persons.

Alternatively, another of the municipalities has introduced a general preventative water testing programme which results in the testing of all institutions at least every three years (as in the German programme). These two approaches are not necessarily mutually exclusive. Annual preventive water tests could be implemented at high-risk institutions, with tests every three years at other institutions.

Alternative ways of assessing sampling and risks may also be considered. A programme introduced in Norway and the United States (and which the ECDC has partially recommended (2,3)) considers the following:

- the number of water samplings is calculated based on the number of risk elements in the water system, e.g. dead ends on pipes, age and dimensions of the system.
- the risk from legionella is calculated from measurements of legionella in the water samples, based on the proportion of taps with Legionella occurrences
- the frequency of sampling is considered from these calculations and from the potential health effects on vulnerable persons

In the Norwegian programme, the risk of being infected is considered to be high if the proportion of water samples containing legionella exceeds 30% of the water samplings taken (> 30% = high-risk). But even in that context, it seems necessary to have a more or less fixed limit value, according to which the measurements can be assessed. For example, is a legionella test positive if less than 1000 cfu/L (WHO/EP/ECDC/SSI recommendation) but more than 100 cfu/L (detection limit) are measured? If, on the other hand, the number of colonies is not involved, the PCR method can be used to assess the presence of legionella bacteria in the hot tap water. This technique would improve the speed of results from analysis, but also the frequency of false positive results, since DNA from dead microorganisms in the sample are also detected by this method.

An overall preventive legionella programme may also include travel-related cases, which make up a considerable number of LD cases in Denmark annually (1). Potentially, these cases could be reduced through annually updated campaign leaflets with risk assessments from other countries and recommendations for elderly people to avoid destinations with high risks of infections. The leaflet might also contain the most important recommendations of how to avoid legionella exposure from potentially infected water systems.

A similar leaflet could be prepared for staff and residents at institutions to reduce behaviour-related exposure in care homes and other high-risk institutions.

Furthermore, it could be relevant to include instructions for how an individual can regulate the heating and hot water system in private homes and institutions, including systems with district-heated water. Regulation of the structural design for hot water systems in new buildings may also be relevant to reduce overcapacity, improve flow and reduce the occurrence of stagnant water in hot water systems.

Finally, regulation or recommendations for the renovation of older, oversized water systems that cannot achieve sufficiently high water temperature and flow rates may also be relevant. Specifying guidelines for this may also partly meet municipal proposals for including construction/technical expertise in legionella prevention/control efforts.

It is recommended to monitor continuously and include new regulations and procedures based on the newest results (as is known from the French programme). Such an approach seems important since once and for all solutions are not expected to be effective over time. For example, while chlorination of DHW systems has been shown to cause an initial immediate decrease in the number of legionella colonies in DHW systems, such solutions have proven to be insufficient in producing long-lasting effects. In this case, after some time, the levels of legionella bacteria were similar to the levels measured before the intervention, but with other types of legionella bacteria (14,15).

Likewise, intermittent high temperature “shock” programmes have been shown to be effective for reducing legionella levels in central parts of the water systems, but less effective in reducing legionella counts in peripheral parts of the hot water system – especially if the system is contaminated with biofilms (25). Finally, a recommendation to reduce calcium in the Danish water supply might be important, since calcium encourages the growth of amoebas that protect and promote the growth of legionella (26).

The supplemental aim of this study to assess the overall importance of construction, procedures and behaviour for the high number of LD cases in Denmark annually was investigated using data from 29 LD cases from private homes. As shown in section 5.4.2, analyses of these data primarily show that procedures, and to a certain extent construction data, are important to measure for the municipalities. An assessment of the importance of behavioural data for onset of LD is not possible based on analysis of these data only.

In relation with data from the care homes, it could be stated that there are constructional as well as procedural differences between the care homes with high legionella levels in the hot water systems and those with low counts. This indicates that such elements constitute basis for existence and for a high levels of legionella in hot-water systems. Furthermore, the expected “missing data” from many lung infections among the elderly, as well as our data from interviews with the care home staffs, suggests, that certain behaviours may be beneficial to prevent infections among users of water from legionella-holding hot water systems. The included health data from the 29 LD cases further showed that the health conditions among users are of extreme importance for the onset of LD – as most of the cases could be characterised as vulnerable based on their age and the presence of chronic diseases. Overall, onset of LD requires an exposure element (construction and water system procedures) as well as an element of behaviour (bathing procedures and behaviour) and finally, an element of susceptibility (vulnerability) in the user that determines whether he or she ends up getting sick from the exposure. The order in this chain may indicate a hierarchal structure for presence of and for exposure from legionella in hot-water systems. At the same time, this chain of elements also indicates possible areas for action in order to prevent users from getting LD. A vulnerable person should take all elements into consideration. In particular the behavioural procedures if showering is a rare event – and if the buildings has over-dimensioned water systems.

7

LITTERATURE

7 LITTERATURE

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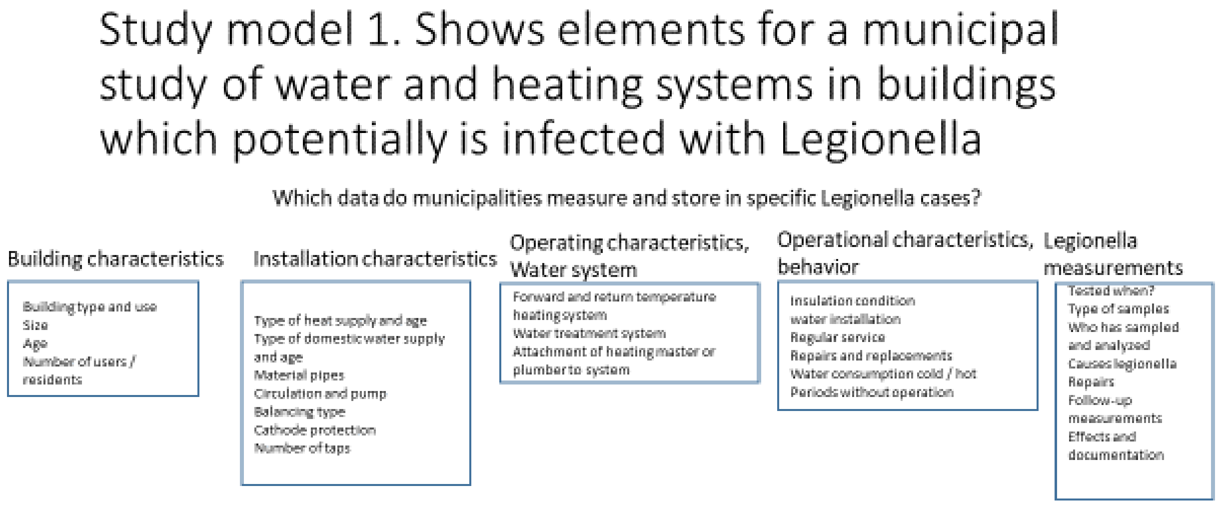
8

STUDY MODELS

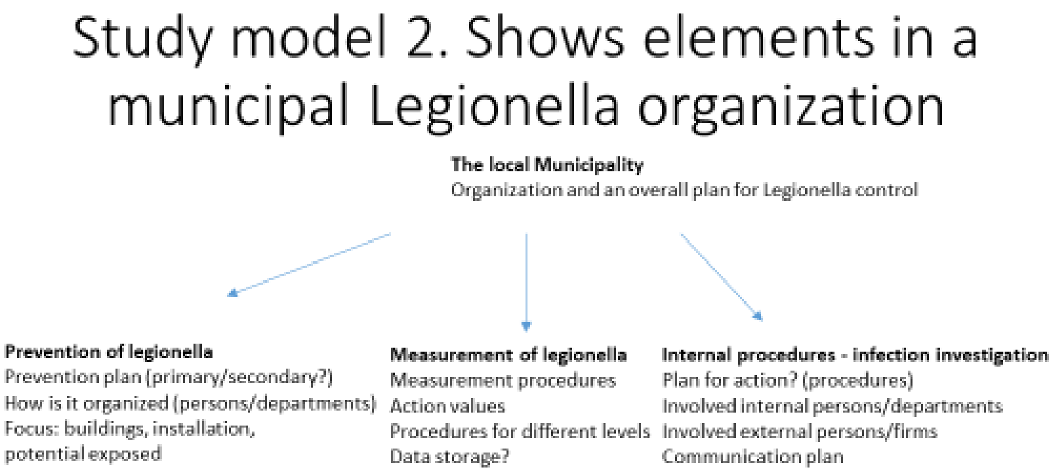
8 STUDY MODELS

Study model 1: Investigation of legionella in hot water systems based on 29 LD cases in 8 Danish municipalities. The model was used to elucidate the installation, operation and behaviour characteristics of the local hot water systems. The 29 housing-related legionella cases took place between 2009 and 2018. This model was also used for investigating hot water systems in 6 care homes in a Danish municipality.



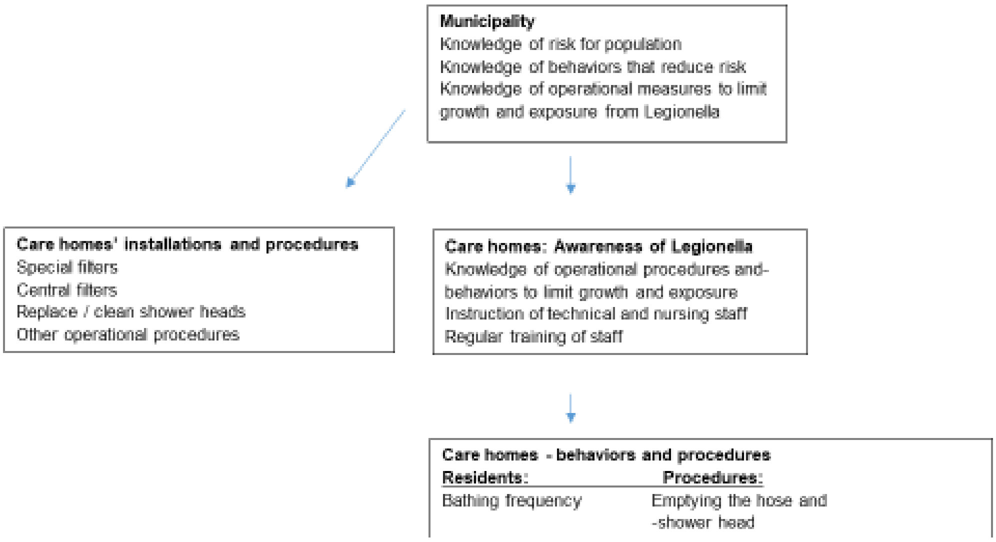
Study Model 2: Organisation and procedures in Danish municipalities for preventing and investigating local growth of legionella. Data were collected based on semi-structured interviews with key persons from 8 municipalities during winter 2018/2019.

Preventive procedures are defined as primary prevention procedures (procedures for preventing occurrence of bacteria/conducting water tests where legionella has not yet been detected) - and as secondary prevention procedures (preventing new cases – by recommendations or by performing remedial actions, e.g. raising the temperature in water systems where the presence of legionella is suspected.)



Study Model 3: Shows expected causality between knowledge and knowledge-sharing from municipalities to staff in care homes. During visits to 6 care homes, the local operating staff were asked about the elements in the present model. This was done using a semi-structured questionnaire.

Study model 3. Show expected causal relationships between key elements in knowledge sharing regarding operation and behavioral parameters between municipality and care homes



BUILD RAPPORT 2022:10

Water sampling and legionellae in danish hot water systems

This is a short review of a report evaluating the relevance of preventive water sampling in the effort to reduce Legionella levels in Danish hot water systems.