Increased information on waterborne outbreaks through efficient notification system enforces actions towards safe drinking water

Outi Zacheus and Ilkka T. Miettinen

ABSTRACT

In 1997, a compulsory notification system for waterborne outbreaks was introduced in Finland. The main aim of this notification is to obtain immediate information on suspected waterborne outbreaks in order to restrict and manage the outbreak promptly. During the past ten years, there have been 67 waterborne outbreaks in Finland, mainly associated with small groundwater supplies or private wells. The number of reported waterborne outbreaks has increased since the launch of the notification system indicating that the threshold limit of outbreak detection has most probably decreased. The number of cases of illness has fulfilled the national health target, which is below 0.01% of the population, but more action is still needed to ensure the production of safe drinking water under all circumstances. Ten years accumulation of knowledge on outbreaks has revealed that a compulsory notification system is an effective tool to gather information on waterborne outbreaks. The system has also increased awareness of possible problems related to the quality of drinking water. This article summarises management and legislative actions and policy measures taken so far in Finland to reduce the number of outbreaks and cases of illness related to them.

Key words | drinking water, groundwater, management action, microbiological quality, small water supply, waterborne outbreak

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INTRODUCTION

The quality of drinking water produced by small water supplies or private wells is a concern around the world including Europe (Hulsmann 2005; WHO 2010b). The quality of drinking water from these supplies is not always known and registered, but several reports have shown that the use of drinking water from either small water supplies or private wells can be a source of a waterborne outbreak (Nygård *et al.* 2003; Kvitsand & Fiksdal 2010; Ter Waarbeek *et al.* 2010). The concern is notable because the number of small water supplies is high in Europe. A questionnaire-based survey on the implementation of the drinking water directive 98/83/EC has showed that in many European countries more than 90% of water supplies are small serving fewer than 5,000 customers (Hulsmann 2005). One in ten citizens of the European Union is estimated to receive drinking water from small water supplies. According to a recent survey conducted in 2009 the quality of drinking water produced by these small water supplies is often poor. The results of this survey were presented by the European Commission in February 2011 during the meeting of the Committee under the Directive 98/83/EC.

The number of small water supplies and private wells is high also in Finland. According to the official record in 1999, the number of water supplies serving at least 50 customers is over 1,300 (Lapinlampi & Raassina 2002), but the number of smaller water supplies serving fewer than 50 customers is estimated to be even higher. In addition, around half a million people, mainly in sparsely populated areas, get their drinking water from private wells. Although the drinking water service in Finland is continuously being

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developed it will not be feasible to organise public water service everywhere in rural areas where the density of people is low.

The World Health Organization (WHO) has recently gathered information on the general health and environmental situation in the European region, and the progress made by the member states over the past 20 years (WHO 2010a). The report proves that although the access to improved drinking water has generally increased in the region there still are huge number of people who do not get drinking water of adequate quality. The situation is the worst in the east of the region where only 58–80% of the population get drinking water from improved water supplies.

Although waterborne outbreaks occur around Europe, information gathered from these episodes is not easily available and knowledge exchange is still limited. It is not common to exchange experiences and share lessons learnt. To improve this situation WHO has through the European Environment and Health Information System (ENHIS), collected information on waterborne outbreaks related to drinking water and bathing water in the European region, and published the results on its web page (www.euro.who.int/ENHIS) (WHO 2010a). The study highlighted the frequency of waterborne outbreaks. Between 2000 and 2007, there were over 350 waterborne outbreaks resulting in over 47,000 cases of illness in those 14 countries who took part in the study. Numbers of reported outbreaks vary from few episodes to nearly 30 episodes in a year. The abovementioned study showed that data on waterborne outbreaks is not available in each European country, and that there are wide variations in the numbers of waterborne outbreaks between different countries. One conclusion drawn from the study expressed that the differences in the numbers could reflect the efficiency and sensitivity of the surveillance system. The need for widespread, harmonised and effective surveillance systems for waterborne outbreaks was highlighted as one of the main results of the study. Against common belief, the study proved that waterborne outbreaks related to drinking water are a problem and challenge not only in developing countries, but also in developed countries having high quality drinking water services.

WHO, together with stakeholders including many European countries, have already started actions to reduce the burden of water-related diseases in the European region. In 1999, the Protocol on Water and Health was adopted at the third ministerial conference on environment and health (UNECE/WHO 1999). The Protocol includes several targets, such as the access to safe water and sanitation, the quality of drinking water supplied and the reduction of the scale of outbreaks and incidents of water-related diseases to be established and published by each party. It also stipulates parties to have national surveillance and early-warning systems to identify outbreaks or incidents of water-related diseases or significant threats of them. To encourage and support this work, guidance documents on setting up, implementing and assessing surveillance systems on water-related disease have been under preparation by a task force under the Protocol. As a party to the Protocol, Finland has already set a national health target for waterborne outbreaks to be achieved. According to this target, the annual number of cases of illness caused by waterborne outbreaks should, on an average, be less than 0.01% of the Finnish population, which nowadays would comprise less than 530 cases of illness in a year. The similar health target, 1/10,000 cases of illness, has been previously stated also in the Netherlands (Schijven *et al*. 2006).

This article gives an overview of waterborne outbreaks in Finland during the past ten years. It also explains how the compulsory notification system of suspected waterborne outbreaks has affected drinking water supply in Finland, and what new management and legislative actions and policy measures, because of enhanced knowledge on outbreaks, have been taken in order to reduce the number of them. The material of this article is based on information gathered at the National Institute for Health and Welfare (THL), and on published reports and studies on waterborne outbreaks in Finland.

NOTIFICATION SYSTEM FOR WATERBORNE OUTBREAKS

In 1997, a new notification system for waterborne outbreaks was launched in Finland. In this system, municipal health protection authorities have an obligation to notify national authorities of all suspected waterborne outbreaks. Notification of an outbreak has to be given as soon as possible after a suspicion of an outbreak linked to the quality of

drinking water has come out, i.e. before confirmative microbiological and chemical analyses of the quality of drinking water have been carried out. The notification report is nowadays an electronic questionnaire available on the Internet. The questionnaire has to be completed by municipal health protection authorities who in Finland are responsible for frequent surveillance of the quality of drinking water. The main purpose of the questionnaire is to get immediate information about the extent of an outbreak including estimates of exposed and ill people, symptoms of patients, suspected causative agent of an outbreak, management and remedial actions already taken, and contact details of municipal authorities working in the case.

The information filed in the notification report is electronically available by national authorities and THL which under the ministry of social affairs and health collects information and statistics on waterborne outbreaks and gives expert help in controlling and solving them. According to the legislation given in 2007, a nominated expert group for foodborne and waterborne outbreaks must be established in every municipality. Representatives of health care, municipal health protection, veterinary treatment and the drinking water service shall be included in this group. The immediate notification system of waterborne outbreaks accelerates the co-operation between this municipal expert group and national authorities and THL. The system rapidly provides information on the outbreak necessary for the design of immediate management and remedial actions in order to prevent or minimise harmful health effects. Although the actions needed are often discussed together, municipal health protection authorities are the body responsible for giving final orders and instructions for consumers and water treatment plant in question.

INFORMATION ON WATERBORNE OUTBREAKS THROUGH THE NOTIFICATION SYSTEM

Outbreaks associated with small water supplies

Before the launch of the compulsory notification system, there was no effective and organised national mechanism to collect information on waterborne outbreaks in Finland. According to the data collected through ENHIS, this situation may, even today, be the reality in many European countries. It is most obvious that before 1997, restricted waterborne outbreaks associated with the use of drinking water from small water supplies or private wells have often been unreported or unknown. After launching the compulsory notification system even the smallest waterborne outbreaks resulting in fewer than 10 cases of illness were revealed, as can be seen in the higher numbers of waterborne outbreaks after 1997 (Figures 1 and 2). In most waterborne outbreaks the number of consumers exposed to the contaminated drinking water has been below 500 (Figure 3). These numbers often represent the total population served by the water supply in question. Although a recent study from Finland has shown that

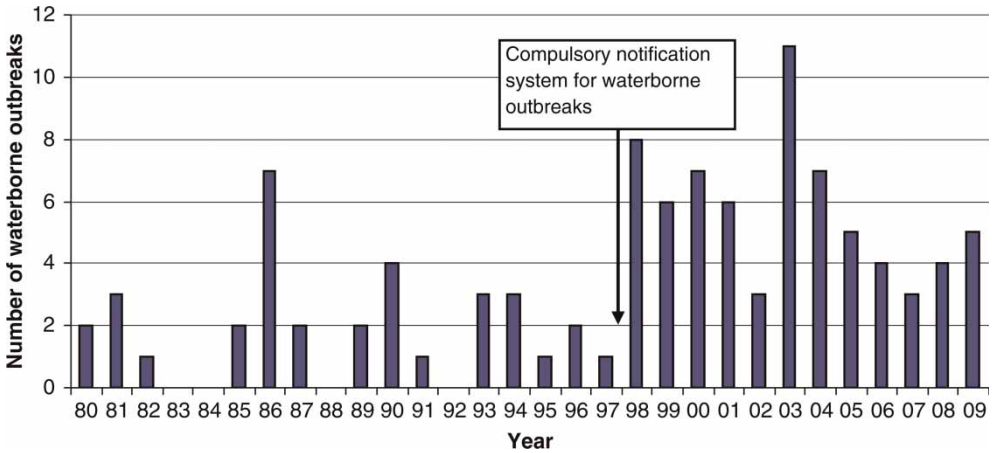

Figure 1 | Number of waterborne outbreaks in Finland during 1980–2009 (Source: Niskanen *et al*. (2010) and data gathered at THL).

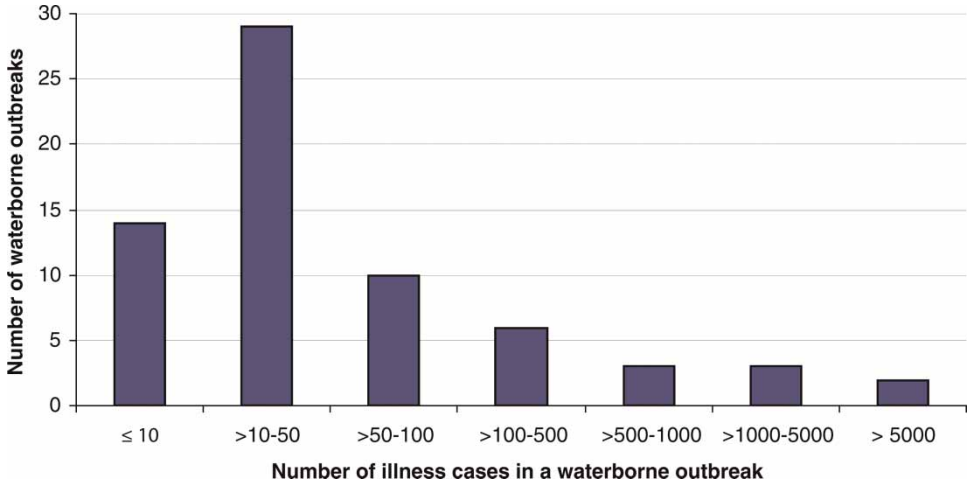

Figure 2 | Number of waterborne outbreaks ($n = 67$) during 1997–2009 divided by the number of cases of illness.

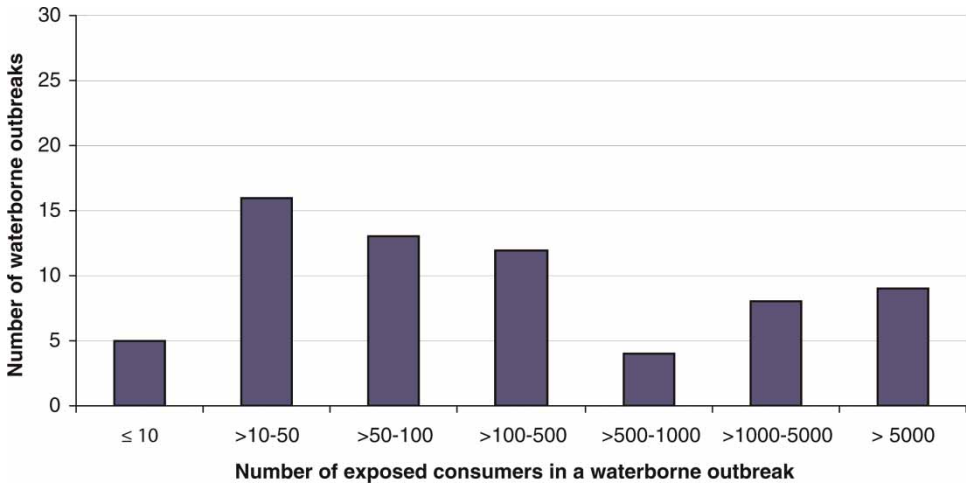

Figure 3 | Number of waterborne outbreaks ($n = 67$) during 1997–2009 divided by the number of exposed consumers.

microbiological non-compliance is more frequent in drinking water produced by small water supplies than by large water supplies serving more than 1,000 consumers (Pitkänen *et al.* 2011), a sudden decrease in the quality of drinking water produced by small water supplies cannot be an explanation of the increased numbers of waterborne outbreaks. A more realistic explanation of the finding is a decreased detection and reporting limit of waterborne outbreaks through the notification system. It is also most obvious that the figures on waterborne outbreaks are nowadays more realistic than before 1997 although the number of cases of illness and in a certain extent also the number of waterborne outbreaks may still be underestimated.

During 1998–2009, 67 waterborne outbreaks were reported in Finland which means 3–10 outbreaks in a year. There have been over 27,000 reported cases of illness in these outbreaks. It is evident that the numbers of cases of illness can vary a lot in different years. During 2008 and 2009, the annual number of cases of illness varied between 100 and 200, but in 2007, the number was nearly 10,000 mainly because of one large and severe waterborne outbreak in the town of Nokia where thousands of consumers became ill after consuming drinking water contaminated by treated waste water (Maunula *et al.* 2009; Rimhanen-Finne *et al.* 2010; Laine *et al.* 2011). The numbers of cases of illness are typically an estimate made by

municipal health care and municipal health protection authorities responsible for the management of the outbreak. The information can be based on study estimates of cases of illness among consumers or epidemiological studies which nowadays may also be conducted by using the Internet for data collection (Kuusi *et al.* 2004a). The number of cases of illness is, however, most probably underestimated because epidemiological studies to strengthen the evidence of an outbreak have not been carried out in every outbreak. Furthermore, it is known that in a case of a few days lasting diarrhoea only 1–2% of sick people contact health care (Kukkula *et al.* 1999). Many cases of illness may thus not be included in the final figures and statistics.

Contaminated ground water behind outbreaks

Most waterborne outbreaks detected in Finland during the last ten years have been associated with the use of groundwater. Contaminated groundwater has caused over 90% of all waterborne outbreaks, and around 56% of the outbreaks have been linked to the use of water from private wells. The use of groundwater and artificially produced groundwater for the public drinking water supply has continuously increased in Finland comprising today around 60% of the total production. Due to high microbiological quality, groundwater is usually distributed without disinfection. However, groundwater sources in Finland are often very vulnerable to microbiological contamination. One main factor enabling the contamination of aquifers is a thin layer of top soil protecting groundwater. It has been shown that the thin soil layer above the groundwater table may be associated with the findings of faecal bacteria and coliform bacteria in groundwater (Pitkänen *et al.* 2011). Flooding and surface run-off caused by heavy rains or rapid melting of snow have been one of the most common technical reasons behind the contamination of groundwater sources (Miettinen *et al.* 2001). Also, leakage in a pipeline or insufficient treatment of raw water have been causes of some waterborne outbreaks (Lahti & Hiisvirta 1995; Kukkula *et al.* 1999; Maunula *et al.* 2005; Miettinen *et al.* 2005). Microbiological contamination of groundwater can lead to a waterborne outbreak if water is not disinfected before its distribution and consumption.

Waterborne outbreaks have typically been detected in small communities having fewer than 500 consumers or in private water systems serving small camping sites or holiday villages (Miettinen *et al.* 2005). Outbreaks related to public water service have been reported all year round, but outbreaks related to camping sites or holiday villages have been reported during summer months when the places are open. Camping sites and holiday villages often have their own private wells for drinking water production and the quality of water is not always monitored each year and before the start of the camping season. Contamination of drinking water is not detected until the sites are opened and first customers arrive and start to use water (Miettinen *et al.* 2001).

Noroviruses and *Campylobacter* as common pathogens

In most waterborne outbreaks the causative agent of an outbreak was identified. Noroviruses and *Campylobacter* have been common pathogens causing waterborne outbreaks in Finland, and they also have been responsible for the majority of cases of illness (Lahti & Hiisvirta 1995; Miettinen *et al.* 2001, 2005; Hänninen *et al.* 2003; Kuusi *et al.* 2004b, 2005; Maunula *et al.* 2005; Pitkänen *et al.* 2008). According to the data gathered at THL it is possible to estimate that 95% of cases of illness have been caused by these two pathogens. In two outbreaks where drinking water had been contaminated with waste water, salmonella was also isolated from drinking water samples. Rotaviruses have been associated with two waterborne outbreaks. Today, confirmatory analyses of an outbreak can often been done by comparing pathogenic microbiological species identified from stool and drinking water. Due to improved microbiological methods the number of waterborne outbreaks remaining unidentified is continuously reducing. These are typically small and restricted outbreaks with small number of cases of illness.

Pathogens such as *Vibrio cholerae*, enterohaemorrhagic *Escherichia coli*, hepatitis A virus (HAV), *Shigella* spp. or *Salmonella typhi* have not been observed causing waterborne outbreaks in Finland. However, infections caused by these pathogens, like other infectious diseases, are under surveillance and all cases have to be reported and registered

into a national database (National Institute for Health and Welfare 2010). In addition, although *Giardia* spp. and *Cryptosporidium* spp. are found in surface waters in Finland (Hörman *et al*. 2004), there is no evidence that these pathogens have caused waterborne outbreaks in the country. The multistage purification processes of surface water including coagulation, filtration and disinfection are apparently efficient enough to remove these pathogens from raw water. In one large and severe waterborne outbreak when a large amount of treated waste water spill was discharged into the drinking water distribution network, several pathogens, including *Campylobacter* sp., noroviruses, *Giardia*, *Salmonella* sp., *Clostridium difficile* and rotaviruses could be identified from both stool and drinking water samples (Maunula *et al*. 2009; Rimhanen-Finne *et al*. 2010; Laine *et al*. 2011).

Improved awareness on the quality of drinking water

Municipal health protection authorities are obliged to inform consumers about any problems concerning the quality of drinking water which could be harmful for consumers' health. In the case of non-compliance or an outbreak, municipal health protection authorities must give appropriate information, including temporary restrictions of the use of drinking water or boiling instructions, if assessed as necessary. It is highly recommended that the first information to consumers should be given within a few hours. Afterwards, updated information could be given less frequently, but at least once a day. For immediate information several different media, such as the Internet, leaflets, radio, television and newspapers can been used together in order to reach as many consumers as possible. Personal visits are sometimes needed to reach elderly people living in rural areas.

Directive 98/83/EC on water intended for human consumption stipulates that information on the quality of drinking water should be available to the public. In Finland, these national reports are available on the Internet. In addition, many water works have their own web pages for public information. Information on, for example the quality and type of raw water, water treatment technologies used for the production of drinking water, recent monitoring results or the average quality of drinking water can be made available on these web pages.

Because of this effective and extensive information on the quality of drinking water, authorities, employees in water treatment plants and consumers are today more conscious of the state of drinking water supply and possible problems related to it than earlier. Public awareness about the consequences of waterborne outbreaks has also increased. Waterborne outbreaks receive always huge public interest. Large outbreaks attract great attention around the country and sometimes also abroad. The need for information is enormous and authorities should therefore be prepared to answer questions and comments raised by consumers receiving drinking water of insufficient quality.

MEASURES TO PREVENT AND RESTRICT WATERBORNE OUTBREAKS

Enhanced disinfection

In Finland, chlorine compounds have been used for the disinfection of drinking water produced from surface water, but seldom for the treatment of groundwater. As an efficient disinfectant with long-lasting effects chlorine is, however, the most common tool for primary, immediate disinfection of contaminated drinking water. The concentration of chlorine used for disinfection is dependent on the suspected causative agent of an outbreak. Chlorine concentration to be achieved in the contaminated distribution network has generally varied between 0.5 and 2 mg/l (Miettinen *et al*. 2001, 2005). Higher concentrations up to 10 mg/l have been used in severe contamination (Rimhanen-Finne *et al*. 2010). Sometimes the task of chlorination is challenging because the deposits on the pipelines reduce the efficiency of chlorine and it may take days or even weeks before adequate chlorine concentration is reached in the remote distribution network. Mechanical cleaning of drinking water pipelines has sometimes been needed to strengthen the effect of disinfection. In addition to the start of chlorination, immediate boiling instructions to consumers combined with the use of alternative drinking water sources are needed as an effective primary action to restrict an outbreak and to minimise harmful health effects (Miettinen *et al*. 2001, 2005).

Due to enhanced information on possible problems related to the quality of drinking water, municipal health protection authorities and employees in water treatment plants are today perhaps more willing to start preventive and remedial actions to assure the quality of drinking water than earlier when information was not widely and easily available. High number of waterborne outbreaks associated with the use of groundwater in Finland has, for example, resulted in an increase of the use of ultraviolet disinfection. Even small groundwater treatment plants having fewer than 500 consumers may have considered additional use of ultraviolet disinfection in order to guarantee the production of safe drinking water in all circumstances. It is known that the quality of groundwater can vary because of seasonal changes. Melting of snow during spring, drought and dry seasons during summer or heavy rains during autumn can be the reasons behind the changes. Additional treatment, such as the use of ultraviolet disinfection allows some minor and temporary changes in the quality of groundwater. Ultraviolet disinfection has thus been used as a remedial action for small water supplies in Finland, but most probably also in other parts of Europe, especially in Switzerland, Austria and Norway where this method has been used for water disinfection for a long time (Kruithof *et al*. 1992).

In Finland, there is a strong possibility that obligatory readiness for disinfection will be included in the legislation on drinking water. In practice, it would mean that disinfection have to be started in water treatment plants within a certain timeframe if the microbiological quality of drinking water has or is strongly suspected to have deteriorated. If this revision comes about it will force all water companies either to maintain readiness for disinfection, including knowledge and know-how required, or oblige water companies to co-operate. This revision would mostly affect water supplies that normally do not use any disinfection for the production of drinking water. The revision of the legislation is assumed to be completed in 2011.

Supplementary education and skill tests for employees at water treatment plants

Awareness of problems and challenges related to the production of drinking water has already led to the revision of the national legislation. The amendment of legislation which entered into force in 2006 stipulates supplementary education and skill tests for all employees working at water treatment plants and responsible for production of drinking water. Personnel should, at five-year intervals, accomplish a certificate which verifies their proficiency in drinking water treatment technology and hygiene.

The main target of the skill test is to maintain the educational level of employees at water treatment plants. Supplementary education and skill tests oblige all employees to reach and maintain at least a minimum knowledge and know-how needed for the drinking water production. The test includes questions on the most relevant educational subjects, such as microbiological and chemical quality of water, treatment processes at treatment plants processing surface water or groundwater, operational monitoring of processes, legislation on drinking water and personal hygiene behaviour at the treatment plant. By the end of year 2010, over 15,000 employees at water treatment plants have gained certificates for this test.

In order to extend knowledge and practical know-how on drinking water production and subjects related to it, several publications and guide books have recently been published. These publications are typically used for education and professional use, but they are mostly available also for the public. A survey on small water treatment plants in 2004 revealed many problems on the production of drinking water at these plants and it was evident that there was a need for a guide book focused on the operation and maintenance of small water supplies. The guide book (Isomäki *et al*. 2008) is now available on the Internet. In 2008, the book was presented at a workshop on small water supplies organised by the Federal Environment Agency in Germany and WHO, and afterwards also distributed to several countries in the European region encountering similar challenges related to small water supplies as in Finland. In addition, guide books on, for example chlorination, water supply in exceptional situations, security of water supplies in both densely and sparsely populated areas, location of a well and communication in exceptional circumstances have recently been published. Research programmes have been and are being developed to promote research activities related to water supply and sanitation.

Assessment and management of threats and risks

Contingency plans for exceptional situations, such as floods, drought, storms, accidents or power failure are highly recommended to be established by water treatment plants. The objective of the plan is to identify factors threatening drinking water production and distribution and to draw up a plan for management actions to prevent or minimise their effects. Contingency plans can be easily performed by large water treatment plants, but many smaller water treatment plants do not necessarily have enough financial or human resources and knowledge to perform this task.

In 2008, the European Commission together with member states and other stakeholders started discussions for the revision of the drinking water directive 98/83/EC. During these discussions, risk assessment and risk management of the whole drinking water production and distribution chain received strong support. After three years of preparations the European Commission has now decided not to start the revision of the directive. Member states may, however, include a risk-based approach in their own legislation. It is clear that some sort of risk assessment and risk management are needed for all water supplies in order to guarantee safe drinking water and to reduce the number of outbreaks related to it. According to the survey by Hulsmann in 2005, a water safety plan was introduced as a management tool for small water supplies only in Northern Ireland. Many countries have, however, been interested in risk assessment and risk management and some trials have been carried out.

Risk-based approach including adequate surveillance system for all water treatment plants despite the size of the system would undoubtedly improve the quality of drinking water and minimise the probability of waterborne outbreaks. The procedure of risk assessment and risk management could take into account the size of a water supply. The higher production and supply of drinking water, the more comprehensive procedure for risk assessment and risk management. At small or very small supplies, an adequate procedure could be based on, for example a check list evaluating the vulnerability of a supply. In addition, technical survey of raw water sources, water treatment plant and its surroundings is an easy and cheap task to be performed and it may reveal possible threats to the drinking water supply, such as broken or leaking structures of a well, wrong or vulnerable location of a well, sloping surfaces of soil around a well allowing surface runoff water to enter the well or risk activities in the near vicinity of a well. In Finland, it is not rare for risk activities, such as septic tanks, sewer pipes, cultivated fields or salted roads, to be located very near the abstraction groundwater well (Isomäki *et al.* 2008).

Timely and targeted monitoring and surveillance

It is known that the frequency of routine drinking water quality surveillance of small water supplies and private wells is often inadequate (Charrois 2010; WHO 2010b). Also in Finland, where many waterborne outbreaks have been associated with small water supplies and private wells, more attention should be paid to timely and adequate surveillance and monitoring of these kind of supplies. Monitoring obligations for both large and small water supplies are included in the legislation, and health-based quality requirements for microbiological and chemical parameters are the same for all drinking water, but the frequency of monitoring depends on the size of the system (Decrees of the Ministry of Social Affairs and Health 461/2000 & 401/2001). Very small water supplies serving fewer than 50 consumers are monitored seldom, once a year to once in three years. For private wells, there are no monitoring requirements which mean that the owner of a well can decide the time and the frequency of the monitoring. Municipal health protection authorities can stipulate that a well should be monitored only if the use of well water poses a risk for consumers' health.

It is clear that more frequent and targeted monitoring before, e.g. a temporary use of a well serving a camping site or a holiday village could prevent some waterborne outbreaks. Furthermore, additional monitoring of drinking water from both large and small public and private water supplies should be applied in vulnerable seasons and periods, such as during spring months when snow is melting and after heavy rains when there is a strong possibility of surface runoffs and flooding. Risk-based assessment of a water supply together with adequate and targeted monitoring would undoubtedly improve the production of safe drinking water also in small water supplies.

CONCLUSIONS

Each year a few waterborne outbreaks are detected in Finland. The outbreaks have typically been associated with the use of small water supplies or private wells supplying groundwater. After launching the notification system for suspected waterborne outbreaks the detection and reporting limit of outbreaks has most likely decreased and surveillance efficiency increased at the same time. Today, even the smallest waterborne outbreaks caused by the microbiological contamination of a private well are revealed. In addition, the numbers of waterborne outbreaks and cases of illness related to them are nowadays more realistic than before the launch of the system although they may still be underestimated.

The detection of a waterborne outbreak is not an easy task. There is normally disbelief about the outbreak. This is typically related to the fact that the water treatment plant in question has operated for decades without any detectable problems and the microbiological quality of drinking water has complied with the requirements. Sudden increase in cases of illness among consumers may be the only symptom of an outbreak. Direct and intensive co-operation between health care and municipal health protection authorities are therefore needed to link sporadic cases of illness to the consumption, and furthermore to the quality of drinking water. An efficient notification system for waterborne outbreaks strengthens this co-operation.

It is clear that an effective national system for waterborne outbreaks is needed to obtain essential information on problems and challenges relating to the drinking water supply and to improve methods to distinguish cases of illness acquired from drinking water from those acquired from other sources. An efficient system most probably also decreases the threshold to start investigations and management actions when the contamination of drinking water is detected or the quality of drinking water is strongly under suspicion. Partly because of enhanced information and better knowledge and improved awareness about possible problems related to the quality of drinking water, management and legislative actions can be targeted to reduce the number of waterborne outbreaks as described in this article.

The numbers of waterborne outbreaks and cases of illness related to them should be as low as possible, and the production of safe drinking water should always be under evaluation and development. As a party to the Protocol on water and health, Finland has set a national health target for the maximum number of cases of illness related to the waterborne outbreaks. The annual number should, on an average, be less than 0.01% of the population which in practice mean below 530 persons. It has to be emphasised, however, that this target can only be acceptable for cases of illness caused by less harmful pathogens such as noroviruses but not for severe infectious diseases, e.g. cholera, typhoid fever or hepatitis A. The target has been reached in recent years but more actions are still needed to ensure the production of drinking water and to prevent the occurrence of new waterborne outbreaks. Implementation of a risk assessment and risk management approach and frequent monitoring based on it could be an effective tool for this task.

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