Parasitter i drikkevann – ikke bare i Bergen

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Sammendrag

Utbruddet av vannbåren giardiasis i Bergen vinteren 2004 gjorde norske myndigheter og befolkningen oppmerksomme på muligheten for at man kan bli smittet av parasittiske protozoer gjennom forurenset vannforsyning. En risikovurdering utarbeidet av Vitenskapskomiteen for mattrygghet i 2009 konkluderte med at parasittene *Giardia* og *Cryptosporidium* finnes i hele Norge, og at ikke alle drikkevannanlegg er like godt beskyttet. Data fra Frankrike og Storbritannia har vist at det er en risiko for at *Cryptosporidium* og *Giardia* i små vannforsyningsanlegg overskrider den akseptable daglige risiko. I Norge, mottar minst 1 av 4 personer vann fra slike vannverk. Data tyder på at disse forsyningene er mindre sannsynlig å ha et beskyttet nedbørsfelt, og at det også er mindre sannsynlig at behandlingen av drikkevannet gir en tilstrekkelig beskyttelse mot parasitter.

Summary

The outbreak of waterborne giardiasis in Bergen in winter 2004 alerted the Norwegian authorities, and the Norwegian population as a whole, to the potential for being infected by parasitic protozoa via contamination of the water supply. A risk assessment completed by the Norwegian Scientific Committee for Food Safety in 2009 reported that although there are considerable gaps in our knowledge, the parasites *Giardia* and *Cryptosporidium* are widely distributed throughout Norway and not all water supplies are equally well protected. Data from France and UK have suggested that the risk of *Cryptosporidium* and *Giardia* in small water supplies and very small water supplies exceeds the maximum acceptable daily risk. In Norway, at least 1 in 4 persons receive water from such supplies. Data indicate that these supplies are less likely to have protected catchments and that the treatments are less likely to provide an adequate barrier against parasites.

Introduction

The outbreak of waterborne giardiasis in Bergen in winter 2004 (Nygård et al, 2006; Robertson et al, 2006), in which over 1500 people were diagnosed with this infection, was the pivotal event that alerted the Norwegian population to the fact that their water supplies were not necessarily as good as had previously been supposed. This was borne out by a contamination incident in the water supply for Oslo in 2007, in which low numbers of both *Giardia* cysts and *Cryptosporidium* oocysts were detected in the distribution network, and resulted in a boil-water recommendation being issued for five days, although no associated infections were detected (Robertson et al, 2009). These incidents in particular resulted in the Norwegian Food Safety Authority requesting the Norwegian Scientific Committee for Food Safety (VKM) to undertake a risk assessment of parasites in Norwegian drinking water (VKM, 2009). Although other outbreaks of cryptosporidiosis and giardiasis have occurred in Norway (e.g. an outbreak of cryptosporidiosis in a hotel in Asker in 2007 affecting at least 25 adults (Hajdu et al, 2008), and a further outbreak of cryptosporidiosis at Langedrag nature reserve in March 2009 affecting over 70 people, mostly school children (Rimseliene et al, 2009), these have not been definitively linked to the water supply.

Taking the VKM risk assessment as a starting point, and then considering other information, this presentation intends to discuss whether it is reasonable to assume that these previous contamination events associated with parasites in Norwegian drinking water should be considered only as anomalies. Were they associated with specific, unusual events in Bergen, and, indeed, Oslo, that are unlikely to be repeated again elsewhere in Norway? Or should there continue to be concern about whether outbreaks of parasitic infection might recur in Norway due to contamination of the water supplies? Indeed, are parasites in the water a potential problem Norway-wide, "*not only in Bergen*"?

VKM risk assessment on parasites in Norwegian drinking water

The VKM risk assessment on parasites in Norwegian drinking water (published in August 2009 and freely available on the www; VKM, 2009) was based on 10 questions sent from the Norwegian Food Safety Authority, and follows the standard risk assessment format. Thus, following the list of questions, it contains an introduction to the problem, a hazard identification section, a hazard characterisation, an exposure assessment, and a risk characterisation. Places of importance and relevance where data are unavailable are listed, followed by answers to the original 10 questions, as based on the information available and the elements of the risk assessment conducted.

Awareness of those areas in which data are missing is important. These data gaps mean that some of the assessment must be based on conjecture or assumptions, and it is important that this is realised by the reader. With this risk assessment, several data gaps were identified, see Table 1.

Data gaps in the Risk Assessment on Parasites in Drinking Water (VKM, 2009)
There is an absence of data on the occurrence on cryptosporidiosis in the Norwegian population.
Information on the occurrence of giardiasis in the Norwegian population is considered to be poor (the infection is under-diagnosed).
There is an absence of information on the immunity developed following chronic exposure to small numbers of parasites, the extent to which immunosuppressed individuals are vulnerable to infection with these parasites, and the proportion of the Norwegian population which has antibodies against Cryptosporidium and/or Giardia.
There is an absence of information on whether the main source of parasite contamination of drinking water supplies in Norway is animals or humans, and how this varies between localities. Additionally, information on the species and genotypes of these parasites that occur in the Norwegian animal populations is limited.
There is an absence of information on the extent to which parasite contamination of drinking water supplies in Norway increases under extreme weather conditions, particularly prolonged or intense rainfall or snow-melting, and how this varies between localities.
There is an absence of information on the extent to which local contamination will impact on different water supplies, and how this may vary between constant low level contamination, as compared with individual large contamination events.
There is an absence of information on whether contamination events in the distribution network result in infections, and how often such contamination events may occur.
More detailed information on the volume of tap water drunk by the Norwegian population would be useful, particularly in the immunosuppressed.

Table1. Data gaps in the Risk Assessment on Parasites in Drinking Water (VKM, 2009).

Answers to two of the questions (10 and 1) posed by the Food Safety Authority are of particular relevance to this presentation. These questions are as follows:

10) What general advice would VKM give to the Food Safety Authority regarding the risk of infection with parasites via food and drink?

And

1) How important is drinking water, totally and relatively, as an infection route for cryptosporidiosis and giardiasis in Norway? How might this be expected to alter in the years ahead?

Included in the answer to question 10, VKM stated that it should be clear that both *Giardia* and *Cryptosporidium* occur commonly in Norway, and that not all water supplies are equally protected against contamination.

In the answer to question 1, VKM stated that the risk of new outbreaks was reduced as more and more water treatment works install equipment directed towards ensuring that viable parasites cannot be transferred from the water source to the distribution network (currently 3.5 million of the Norwegian population receive water which has been treated by at least one hygienic barrier effective against parasites). However, predicted climate changes, with increased precipitation and more extreme weather events, may result in higher numbers of parasites reaching water sources, whilst warmer winters may increase the proportion of these parasites that survive over winter.

However, from the statement that 3.5 million of the Norwegian population receive water that has been treated by at least one hygienic barrier against parasites, it can be extrapolated that approximately 1.3 million (approximately 27 %) of the total Norwegian population of 4.8 million receive water which has not been through at least one of these treatments. Perhaps it is this sector of the population, which lives neither in Bergen nor Oslo, which should be concerned about the possibility of a further outbreak of waterborne parasitic infection in Norway?

Small and very small water supplies

In the 'Water treatment and control' session of the 3rd International *Giardia* and *Cryptosporidium* Congress (held in Orvieto, Italy in October 2009), one presentation (Hunter et al, 2009a), provided an overview of a quantitative assessment of risk due to *Cryptosporidium* and *Giardia* in very small water supplies. In this assessment 'small water supplies' were defined as those serving between 50 and 5000 person equivalents (PE), providing 10 to 1,000 m^3 water/day, whilst 'very small water supplies' were defined as those serving less than 50 PE, and providing less than 10 m^3 water/day. The authors had estimated that in Europe between 40 and 50 million persons receive water from a small or very small water supply, or 1 in 10 Europeans. The study found that many small water supplies take their water from unprotected sources, that they are often inadequately maintained, or not maintained at all, and that the infrastructure was often not maintained, and the responsibility for maintaining this infrastructure was not always clear. The authors concluded that the risks from small water supplies are similar in France and UK, and exceed the maximum acceptable daily risk. The mean risk value was affected by a small number of very high probabilities of infection, which, whilst this is unlikely to translate into a high number of infections in older residents is indicative of an elevated risk to non-residents, recent residents, and young children, the latter of which may, in particular, be a serious cause for concern. That the microbiological quality of drinking water from small rural supplies is considerably poorer than that from larger systems (Hunter et al, 2009b), is also borne out by data from England and Wales. Here, only 0.5 % of the total population is reliant on private supplies, but 36 % of drinking water outbreaks detected (not only of parasites) were associated with such supplies (Said et al, 2003).

With this in mind, it would be interesting to investigate how the Norwegian situation relates to the situation described by Hunter et al (2009a) for France and UK. In table 2, the numbers of waterworks in Norway serving between 50 and 5000 people, or over 5000 people are described. There is no overview available of the number of very small waterworks in Norway (serving less than 50 person), but, assuming a population of 4.8 million, simple subtraction demonstrates that approximately 500000 individuals are provided with water by such systems. Whether the water provided by such very small systems is ground water or surface water, and the water treatments used, if any, is unknown. Thus, it can be extrapolated that of the total Norwegian population of approximately 4.8 million, 10 % are served by very small systems with no available overview of water source or treatment, whilst 17 % are served by small systems. Thus, as per the definitions of Hunter et al, (2009a), more than 1 in 4 people in Norway receive drinking water from small or very small water systems.

Number of small water supplies in Norway		
Size of water treatment works (number of people served)	**Number of water treatment works**	**Total number of people served**
Between 50 and 5000	1390	820 400
Over 5000	157	3 444 400
TOTAL	1547	4 264 800

Table 2. Number of small water supplies in Norway. Data in this table kindly provided by Truls Krogh, Department for Water Hygiene, Norwegian Institute of Public Health.

It is also worth noting, that, as reported by Hunter et al, (2009a), larger waterworks in Norway are more likely to have municipal ownership, and hence municipal responsibility for upkeep and provision of water supply. For example, of the 48 waterworks in Norway supplying more than 20000 people with water, none are privately owned, whereas of the 280 waterworks in Norway supply less than 100 people with water, 160 (57 %) are privately owned (data kindly provided by Truls Krogh, Department for Water Hygiene, Norwegian Institute of Public Health).

Examination of the relationship between the size of waterworks and the water treatments in place, table 3, demonstrates that of the very small water supplies (due to the information available, for this situation described as serving less than 100 people, rather than less than 50 PE, as per Hunter et al (2009a)) in Norway, less than 2 % have treatments effective against parasites (chlorination is not considered to be an effective barrier against *Cryptosporidium* or *Giardia*), whereas of the small waterworks (here defined as serving between 100 and 5000 people), at least 15 % do not have treatment effective against parasites. Indeed, even among the larger waterworks (serving over 5000 people) it can be calculated that at least 30 % (based on number of people) do not have treatments in place that are considered to be effective barriers against parasites.

Treatments in water supplies in Norway related to water supply size					
Size of waterworks (number of people served)	Ozonation/ biofilter	Membrane filtration	Coagul-ation/ filtration	UV	Chlorin-ation
<100	0	500	700	7 700	1 000
100-299	300	4 600	7 000	43 600	5 700
300-999	0	23 900	22 300	144 500	15 300
1 000-4 999	13 800	58 700	83 000	307 900	126 200
5 000-19 999	0	53 300	309 500	403 200	405 100
≥ 20 000	0	0	957 100	609 200	2 372 700
TOTAL	**14 200**	**141 000**	**1 379 600**	**1 516 100**	**2 925 900**

Table 3. Treatments in water supplies in Norway related to water supply size. Data in this table kindly provided by Truls Krogh, Department for Water Hygiene, Norwegian Institute of Public Health.The rows cannot be summed horizontally, as several waterworks include more than one treatment regime.

The logistics of waterborne outbreaks of parasitic infection occurring and being detected associated with large water systems and small water systems

In order for an outbreak of waterborne parasitic infection to occur, ALL the following factors must be in place:

1) There must be a source of contamination in the water supply catchment (or, in the case of post-treatment contamination in the distribution network, then this source must be sited where contamination of the distribution network is possible).
2) Sufficient quantities of viable parasites of a species/genotype infectious to humans must enter the supply.
3) Sufficient quantities of these parasites must remain in infectious form (not removed or inactivated) following any treatment.
4) These parasites must be ingested in sufficient quantities by members of the consumer population who are vulnerable to infection.

For an outbreak of waterborne parasitic infection to be identified, sufficient numbers of the infected population must report to their health care providers, the aetiologic parasite must be identified, and an epidemiological association must be made between those infected and the contaminated water supply. Detection of the parasite within the water supply provides further weight, as does the identification of treatment inadequacies and a credible potential source of contamination.

Most large waterworks in Norway, not only have protected catchments (such that the risk of contamination in the water catchment is reduced), but are also more likely to have water treatments in place that are capable of removing and/or inactivating parasites. Indeed, some of the larger waterworks have also chosen to have analyses of their source water performed and have some information on the possible parasite load in their source water. Nevertheless, the possibility of post-treatment contamination should not be neglected, and it should be recognised that extreme weather events may not only impact on the quantities of parasites in the source water, but may also affect the water treatment regime due to elevated turbidities.

However, in small or very small water supplies, catchments are less likely to be protected, the water treatments in place are less likely to be adequate at removing or inactivating parasites, and there is less likely to be any monitoring of the water supply. Additionally, there are more likely to be infrastructure and maintenance weaknesses. Nevertheless, populations served by such supplies may have developed some immunity if they are constantly exposed to a trickle of parasites, although this will not be the case for non-residents, recent residents, and young children.

A further important point is that waterborne outbreaks of parasitic infection associated with small or very small water supplies may be less likely to be identified by the health authorities due to the low number of primary cases.

Conclusion

Although the waterborne outbreak of giardiasis in Bergen in 2004 was the main impetus for focussing the attention of the authorities and the Norwegian population on the potential for transmission of parasites via the water supply, it was an unusual situation, in which the simultaneous occurrence of a chain of different factors resulted in large numbers of *Giardia* cysts infectious to humans entered the water distribution network. It seems unlikely that such a situation will arise in a major city or town in Norway again.

The risk assessment performed by VKM suggests that, despite more and more waterworks installing treatments effective against parasites, a considerable proportion of the population still receives water that has not received a treatment that is effective against parasites. Closer examination of the distribution of water works and their treatments suggests that small water systems and very small water systems may be particularly vulnerable to both contamination by parasites and also the parasites not being effectively removed or inactivated by treatment systems. As these water systems are common in Norway, serving one person in four of the population, then parasites in water should probably continue to be of concern both to the Norwegian population and to the relevant authorities. Cost benefit analyses regarding interventions aimed at improving rural community water supplies in developed countries indicate that investments in drinking water provision from such supplies in the developed world are highly cost beneficial and that it is not good economic sense to ignore the problems associated with such supplies (Hunter et al, 2009b).

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