Health Stream

INFORMATION AND ANALYSIS FOR WATER AND HEALTH PROFESSIONALS

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In this Issue:

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Avian Influenza: Is There A Risk To Water Supplies?

World-wide concern over the potential for a pandemic outbreak of avian influenza (bird flu) is currently at high levels as isolated human cases of the highly pathogenic strain H5N1 continue to occur in several Asian countries, and birds infected by this virus are reported on the eastern borders of Europe. Waterborne spread of the virus is known to occur between birds, and water-related transmission of the H5N1 strain has been suggested as a possibility in at least two human cases to date. However, a review of current knowledge on the issue suggests that conventionally treated and disinfected drinking water supplies are not likely to pose a risk to consumers, even if source waters harbour infected water birds.

The influenza viruses are lipid enveloped, single-stranded RNA viruses of the family *Orthomyxoviridae.* They are classified into three groups: A, B and C, all of which contain strains that are capable of infecting humans. Human influenza is caused predominantly by a subset of viruses within the type A group. A different subset of type A viruses are known to infect birds. The existence of influenza viruses in birds was recognised over 120 years ago (as 'fowl plague' or 'fowl pest'), and avian influenza occurs in many species of birds all over the world. Different strains of the avian virus have different effects in birds, with some strains causing mild illness with low mortality, while others cause rapidly fatal disease with close to 100% mortality. Mutation of the virus from a mild form to a highly pathogenic form has been observed in some poultry outbreaks.

In contrast to the human influenza virus which replicates primarily in the respiratory tract, the main replication site for avian influenza viruses in birds appears to be the gut. Large numbers of virus particles are excreted in bird faeces, and transmission of the virus is believed to occur mainly by ingestion. Experimentally infected ducks have been reported to shed up to 10^{10} EID_{50} of avian influenza virus particles in a 24 hour period (1). Migratory waterfowl (particularly ducks) appear to be the natural reservoir for the virus, and outbreaks in domestic bird flocks have often been linked to direct or indirect contact with wild waterfowl. Outbreaks have also been traced to contact with infected birds or their faeces at live bird markets. Control of outbreaks requires the slaughter of infected and potentially exposed birds, together with strict quarantine and disinfection procedures. Avian influenza outbreaks have had major economic impacts on commercial poultry operations around the world.

While avian influenza viruses are transmitted readily between birds, they are rarely transmitted from birds to humans. When humans do become infected, the avian virus is not easily transmitted to other people. There is a risk however that an avian virus strain could mutate into a form that is more easily transmissible between humans, or that an avian strain could undergo genetic recombination with a human strain of virus if the same host individual was simultaneously infected with both viruses. Such recombination events between human and animal viruses are believed to be the source of past pandemic strains of human influenza viruses. To date, there is no evidence of effective human-to-human transmission of the avian strain of current interest, H5N1. Evidence from some household outbreaks has suggested transmission may have occurred to family members caring for a sick person, but this involved a much closer degree of contact than is required for transmission of conventional human influenza strains.

The H5N1 strain was first recognised in domestic geese in Guandong province in China during 1996. Outbreaks among poultry at farms and markets occurred the next year in Hong Kong, together with the first known human infections. A total of 18 people were diagnosed with the infection, and six of these died. The virus was then eliminated from Hong Kong by a vigorous campaign of poultry culling.

For the next five years there were no reported instances of H5N1 strain, however in early 2003 this virus strain was apparently reintroduced to Hong Kong by travellers who had recently returned from Fuijan province in China. One of the group had died of severe respiratory disease in China, but no clinical samples had been taken for examination. Two cases of H5N1 infection (one fatal) were diagnosed in those who returned to Hong Kong. Since then the H5N1 strain has been reported in poultry in Cambodia, China, Indonesia, Japan, Kazakstan, Republic of Korea, Lao PDR, Malaysia, Romania, Siberia, Thailand, Turkey, and Vietnam. In addition, the H5N1 strain has been reported in wild birds in several of these countries and in Croatia and Mongolia. In October 2005, the H5N1 virus was detected in a group of mesia finches imported into the UK from Taiwan. The birds were destroyed while still in quarantine, and tests on other birds in the quarantine centre have so far proved negative. There have been no reports of the H5N1 virus in Australia, although there have been five outbreaks of other strains of avian influenza in commercial bird flocks between 1976 and 1997. In each case the virus was successfully eradicated.

A total of 138 confirmed cases of human infection with H5N1 have been reported between 26 December 2003 and 7 December 2005. Cases have occurred in Cambodia, China, Indonesia, Thailand, and Vietnam. There have been 71 deaths among infected people, a 51% mortality rate. The majority of human infections have been attributed to close contact with infected poultry or poultry faeces, however the possibility of water-related transmission has been suggested in two of the cases. A thirty-five year old woman and an unrelated nine year old boy in Vietnam were reported to have developed the disease after swimming in water bodies used for disposal of dead poultry. In Vietnam and other countries in the region, dead birds are often dumped into lakes and rivers to feed fish, or simply as a means of disposing of carcasses. Chicken manure and litter from cages are also used as a cheap protein source for feeding fish. However if the manure comes from birds infected with avian influenza, this practice may introduce a high virus load to lakes and rivers that also serve as drinking water sources.

In both these cases, it is possible that the victims were also exposed to the virus through inhalation of environmental contamination from infected birds. Therefore it is not certain whether they became infected by aspiration or ingestion of the virus while swimming or from another type of exposure. Avian influenza infections in humans are characterised by severe respiratory symptoms, however in one confirmed fatal case a 4 year old boy from Vietnam showed severe diarrhoeal symptoms without significant respiratory involvement. The boy's death was initially diagnosed as being due to acute encephalitis of unknown origin, and the virus was later isolated from stored cerebrospinal fluid and other clinical specimens. The boy's older sister had also died two weeks earlier following a severe diarrhoeal illness, but infection by the H5N1 virus could not be confirmed as no clinical specimens had been taken for testing. These observations raise the possibility that the avian virus may sometimes infect the gastrointestinal tract in humans rather than the respiratory tract.

Avian influenza virus can persist and remain infectious in water for prolonged periods, particularly at low temperatures. It has been suggested that the virus may survive in water and ice in cold climates over winter and infect migratory birds when they return to the water body to breed in springtime. Most experimental work has been conducted using distilled water, however limited comparative work in natural fresh waters has shown comparable results. The time taken for a 1-log reduction in viral titre varied from 21 to 34.5 days at 17ºC, and from 5 to 17 days at 28ºC. These studies used several strains of virus but did not include the H5N1 strain.

Information on the susceptibility of the avian influenza virus to disinfectants comes mainly from the perspective of environmental decontamination following outbreaks in poultry. Thus data for chlorine disinfection pertains to the use of highly concentrated solutions on contaminated surfaces and equipment (eg 2-3% available chlorine for 10-30 minutes). The influenza viruses and all other enveloped viruses are recognised as being highly sensitive to disinfectants and detergents. These viruses require an intact lipid envelope to attach to and infect host cells, and this envelope is readily damaged by chemical agents. Influenza viruses are more susceptible to chlorine disinfection than non-enveloped enteric viruses such as Norovirus, Poliovirus or Hepatitis A virus. Therefore water disinfection processes which are designed to inactivate the more resistant enteric viruses are expected to give a higher degree of inactivation of influenza viruses. The particles of the influenza virus (50 - 120 nm in diameter) are also somewhat larger than the enteric viruses (25 to 40 nm in diameter) and thus they will be removed at least as efficiently by coagulation and filtration processes. The recommended preventive measures to reduce the risk of infection in poultry flocks include the use of potable quality (ie disinfected) water for birds, indicating that conventional levels of chlorination are adequate to inactivate the virus.

Therefore, based on current knowledge, water supplies which receive an adequate level of treatment and disinfection to remove human enteric viruses are not likely to pose any risk of transmission of avian influenza even if infected water birds are present in source waters and reservoirs.

(1) Influenza viruses can be cultured and assayed by inoculating the virus into fertilised chicken eggs. The EID_{50} or Egg Infective Dose 50% is the dose required to establish infection in 50% of the inoculated eggs.

Cryptosporidium Outbreak In Wales

Over 70,000 people in 40 towns in the north western region of Wales, UK have been told to boil their drinking water due to an outbreak of cryptosporidiosis that is suspected to be waterborne. An increase in the number of cases of cryptosporidiosis in the area was noted by public health officials during late October but initial investigations failed to reveal an obvious source of infection.

As the number of people affected continued to grow, a decision was made to alert local doctors to the outbreak, and on 23 November advice was issued to remind people with severely compromised immune systems to boil tap water before drinking as a precautionary measure (the British Chief Medical Officer advises such groups to always boil tap and bottled water before consumption or making ice for consumption). A boil water notice was issued to the general public on 30 November after a case-control study implicated tap water as a strong risk factor (see below). A total of 203 laboratory-confirmed cases had been identified by 15 December and, according to press reports, several people had been hospitalised with severe gastroenteritis.

The affected towns are supplied from the Llyn Cwellyn reservoir, which is located in the Snowdonia National Park. The reservoir's catchment has a mixture of land uses including some sheep and cattle grazing. The catchment also contains the village of Rhyd-Ddu which discharges treated sewage to the reservoir, and a number of houses with septic tank systems. Water from the reservoir is treated by microstraining, pressurised sand filtration and chlorination before distribution to consumers. The geographic distribution of cases appears to be consistent with this water source as the incidence rate of cryptosporidiosis is about 7-fold higher in areas supplied by the Llyn Cwellyn reservoir than in the remainder of north western Wales.

A case-control study was carried out by public health investigators who interviewed 45 cases and 37 unmatched controls about possible sources of exposure. The results of the investigation showed that people with cryptosporidiosis were 9.5 times more likely to drink tap water than unaffected controls, and a dose-response relationship was also seen with the volume of tap water consumed. According to the water supply company Dwr Cymru (Welsh Water), the water treatment plant has been operating normally with no evidence of problems.

Under the risk assessment framework employed by the UK Drinking Water Inspectorate, the water supply was not considered to be at risk for *Cryptosporidium* contamination, and therefore was not required to carry out continuous monitoring under DWI regulations. However, by chance the equipment needed for continuous monitoring had recently been installed at the treatment plant in preparation for an operational monitoring program to investigate the performance of the treatment process. Dwr Cymru was therefore able to rapidly initiate continuous monitoring for *Cryptosporidium* on 2 November after the company was notified by health authorities of the increasing number of cryptosporidiosis cases in the region. Since then, oocysts have been detected in both raw and treated water from the Llyn Cwellyn reservoir, but the levels in treated water have been below the DWI regulatory standard of 1 oocyst per 10 litres. Supply of drinking water which exceeds this limit may be subject to prosecution under UK regulations.

Genotyping of *Cryptosporidium* oocysts from patients has shown the infections were due to *C. hominis*, a species which is harboured only by humans. Investigations are therefore focusing on sources of human waste in the catchment. The area experienced heavy rains in October, leading to speculation that waste from the sewage treatment plant or from septic tanks may have been washed into the reservoir. Dwr Cymru has stated that the sewage treatment plant was not flooded during the rains, and there is no evidence of problems with the operation of the plant. However as a precautionary measure, effluent from the plant is currently being trucked out of the catchment for disposal at another site. Other sewage plants and septic tanks in the catchment are also being inspected to determine whether they may be the source of contamination.

On 9 December the boil water notice was lifted for 9,000 residents after water from alternative sources was diverted to some towns. However due to the geography of the area and the limited capacity of other water sources, it is not possible to remove the Llyn Cwellyn reservoir from service and still provide an adequate water supply to the remaining affected areas. Residents in these areas have been advised they may need to continue boiling water for drinking until early January. Public health authorities have been criticised for not issuing the boil water notice earlier, however until the results of the case-control study became available, the outbreak investigation team considered the evidence implicating the water supply was considered insufficient to justify action of this nature.

Australian Water Recycling Guidelines

The draft version of the Australian National Guidelines for Water Recycling has been released for public comment by the Natural Resource Management Ministerial Council and the Environment Protection and Heritage Council. The Guidelines provide a generic risk-assessment and management framework that is applicable to all types of water recycling, and also provides specific guidance on uses which were identified as high priority:

- large-scale treated sewage and grey water to be used for:
  – residential garden watering, car washing, toilet flushing and clothes washing
  – irrigation for urban recreational and open space; agriculture and horticulture
  – fire protection and fire fighting systems
  – industrial uses, including cooling water
- grey water treated on-site for use for residential garden watering, car washing, toilet flushing and clothes washing.

The draft Guidelines were accompanied by an Impact Assessment report from an independent economic consulting group which assessed the economic benefits and costs of a coherent national approach to water recycling under the proposed Guidelines.

The draft Guidelines document is divided into six chapters addressing the following aspects:

- an introductory chapter outlining the need for water recycling in Australia, the role of comprehensive national guidelines, and the rationale for adopting a risk management approach.
- a description of the 12-element framework for management of recycled water quality and use, which is modelled on the Framework for Management of Drinking Water Quality in the Australian Drinking Water Guidelines.
- managing health risks in recycled water. Microbial pathogens are the main source of potential health risks from recycled water, and these risks must be reduced to acceptable levels through treatment processes and on-site controls. The draft Guidelines provide detailed information on how information on human exposure and dose-response can be used to calculate the degree of log-reduction for different pathogen classes that is needed for a given water use scenario.
- managing environmental risks in recycled water. In contrast to human health risks, the chemical constituents of recycled water are the most important when considering the potential for adverse environmental impacts. The Guidelines describe how risk assessment may be carried out by grouping the endpoints into the broad categories of air, plants, soils, biota (aquatic and terrestrial), recycled water treatment plans, greywater reuse in-house, groundwater, surface water and infrastructure.
- monitoring. The Guidelines describe the four principle types of monitoring and their application to recycled water schemes. Appropriate and intelligent use of monitoring is a key element of effective risk management.
- consultation and communication. Effective consultation and communication with stakeholders, at the planning stage and during operation, are crucial to successful water recycling schemes. The Guidelines outline factors which influence community attitudes to water recycling, essential features of successful communication strategies, ways to establish partnerships and engage stakeholders, public crisis communication and questions frequently asked by stakeholders.

The draft document also contains several appendices providing information on cases studies, preventive measures to reduce risks, and detailed risk assessment for key environmental hazards.

Following the release of the draft Guidelines, a series of stakeholder meetings were held in state capitals during November and December to explain the Guidelines and invite stakeholder feedback. The public consultation period closes on 13 January 2006. Phase two of guideline development, anticipated to commence in 2006, will focus on stormwater reuse, aquifer storage and recovery as a method of recycling reclaimed water, and potable use of recycled water.

For further details see:
http://www.ephc.gov.au/ephc/water_recycling.html

EU Agrees On Bathing Directive

Negotiations between the European Parliament and the European Council have resulted in a successful agreement on a new Bathing Water Directive for the European Union (1). The new Directive will define four categories of water quality; "excellent", "good", "sufficient" and "poor". The final agreement reflects a compromise over the setting of microbiological standards for the "sufficient" category where the European Parliament had been pushing for a more stringent standard than that favoured by the Council. The "sufficient" category was in itself a compromise element which was introduced because many beaches which are in compliance with the current EU Directive would not qualify for the "good" category under the new regulations. The "sufficient" category will become the new mandatory standard for compliance in the EU. Waters classified as "poor" are considered to have a level of health risk which makes them unsuitable for bathing.

Under the new Directive, monitoring will be required only for *E. coli* and intestinal enterococci, rather than the 19 parameters required under the current regulations. The new water quality categories are shown below:

Category	Excellent	Good	Sufficient
Inland waters			
enterococci	200	400	330 *
E. coli	500	1000	900 *
Coastal waters			
enterococci	100	200	185 *
E. coli	250	500	500 *

* Numbers are the 95th percentile for 100ml water samples except for the "Sufficient" category where the 90th percentile is used.

The classification of bathing waters will be based on consideration of three years of monitoring data. Where water quality is consistently falls into the "good" or "excellent" categories, monitoring frequencies may be reduced. For beaches where water quality is classified as "sufficient", member states are required to develop plans to identify and assess pollution sources, and indicative timelines to implement measures to improve water quality. All bathing waters will be required to at least meet the "sufficient" category by the end of the 2015 bathing season. It is estimated that bathing in water of this category carries with it a 7% to 8% risk of developing gastrointestinal or respiratory illness per bathing event, based on the dose-response relationship derived from British epidemiological studies. These studies have been used by the World Health Organisation to derive its Guidelines for Recreational Water Quality, upon which the new EU Directive is largely based. The mandatory compliance level under the current EU Directive equates to a risk of illness of about 12% to 15% per bathing event.

The new Directive is expected to be adopted by both the European parliament and the European Council early in 2006 and will come into force two years later. In addition to the new water quality classifications the Directive contains provisions for better and more timely communication with the public, including prompt posting of water testing results on the internet. Other measures include involvement of beach users in the development of management plans for bathing sites, and the adoption of uniform advisory signage.

During development of the Directive, some member states expressed doubts over the strength of the epidemiological evidence relating water quality to health risks. As a result of this, the European Commission has undertaken to carry out further epidemiological studies in collaboration with member states to strengthen the evidence base. There will be a particular focus on bathing in freshwaters, as the current body of evidence is very limited. The outcomes of these new studies as well as other scientific and analytical evidence will be reviewed and reported to the European Parliament by 2008. The review will specifically evaluate evidence relating to viral pathogens, which are believed to be the most important group of pathogens for bathing-related illness. The Bathing Water Directive itself will be reviewed by 2020 and it is anticipated that a decision may be made at this time to phase out the "sufficient" category.

(1) See Health Stream Issue 39 for a report on the development of the Bathing Water Directive.

Cocaine Rivers Make Headlines

Studies of cocaine levels in European rivers have revealed that levels of drug use in the community may be much higher than estimated by police authorities. In a paper published in the journal BMC Environmental Health in August this year, Italian scientists reported the detection of cocaine in samples from the River Po in northern Italy and several urban wastewater treatment plants around the country.

Four water samples from the River Po were collected on different days, with each sample being a composite of 5 x 500 ml volumes collected 30 minutes apart. Composite samples were also collected from influent wastewater at treatment plants in four medium-sized towns in different areas of Italy (total volume 2 litres, collected every 20 minutes over 24 hours). The samples were analysed for cocaine and its major urinary metabolite benzoyl-ecgonine (BE). All samples were positive for both cocaine and BE. Average levels in river water were 1.2 ng/L for cocaine and 25 ng/L for BE. In wastewater, levels of cocaine ranged from 42 to 120ng/L, and BE from 390 to 750 ng/L. Levels of cocaine use in the community were estimated from the concentration of BE, assuming that a single dose was 100 mg. The results suggested cocaine use at the level of 2 to 7 doses per 1,000 persons/day or 9 to 27 doses per 1,000 persons/day if only young adults were considered (15-34 year age group). These estimates are about 80 times higher than official figures.

The findings prompted international media coverage and led to the commissioning of a similar study in London by a British newspaper. The Italian research team sampled the river at two locations downstream of major sewage treatment plants in London and found levels of BE similar to those in the Italian study. Comparison with official UK figures suggested cocaine use in London was at least 15 times higher than previously estimated. The researchers have suggested that monitoring of drug levels in wastewater may be a more accurate way of estimating trends in use than the current method of anonymous questionnaire surveys.

News Items

WSAA Continuous Improvement Tool

The Water Services Association of Australia is developing an assessment tool to allow water utilities to measure their progress in implementing the Framework for Management of Drinking Water Quality contained in the Australian Drinking Water Guidelines. The Tool is intended to provide operators with a “roadmap” of good practices with sufficient detail to allow them to design a robust system which will not fail when inevitable challenges to the water supply system occur. The Tool assesses water quality management from catchment to tap, and contains some 200 measures linked to the Framework by a comprehensive scoring system. The high level output from the Tool is designed to provide Boards and senior executives with information on the strengths and weaknesses of their organisation in implementing good drinking water quality management. Pilot trials of the Tool will be undertaken by three WSAA members in early 2006. For more information, contact Peter Donlon: peter.donlon@wsaa.asn.au

Cobalt Clue To Fallon Cancer Cluster?

Researchers from the University of Arizona have raised the possibility that the cluster of childhood leukemia cases in the town of Fallon may be related to airborne exposure to a mixture of cobalt and tungsten. A comparison of airborne particulates in five Nevada towns showed that Fallon had higher levels of both tungsten and cobalt compared to other towns. Earlier studies had focused on exposure to arsenic and tungsten in drinking water supplies but found no relationship between water-related exposures and leukemia risk (see Health Stream Issue 29). A subsequent study by the US EPA found no evidence of elevated levels of other cancers in long term residents of the town despite the presence of arsenic at 100 ppb in drinking water. While tungsten is considered to have low toxicity and cobalt is an essential trace element, the combination of cobalt and tungsten carbide together has been declared to be a probable human carcinogen by the International Agency for Research on Cancer. Researchers have suggested that the likely source of airborne metals is a “hard metal” processing plant in Fallon.

Wet Feet Are A Trigger For Colds

The name "common cold" reflects a traditional belief that minor infections of the upper respiratory tract can be triggered by exposure to cold environments and by getting wet under such conditions. However during the 1950s and 1960s a number of experimental studies failed show any increase in infection rates when people were inoculated with the cold virus and exposed to cold conditions. Orthodox medical opinion therefore dismissed any link between being cold and developing "a cold" and attributed higher rates of upper respiratory infection in cold weather to other factors, such as closer contact between people due to remaining indoors or being crowded into buses and trains during such weather. British researchers have now performed a new study which suggests the traditional viewpoint is based on fact.

The study was carried out at Cardiff University, where 180 students were randomly assigned either to sit with their bare feet in cold water (10ºC) for 20 minutes, or to keep their feet dry and warm. Randomisation was stratified based on the number of self-reported colds suffered in the previous year to ensure that both groups were similar in terms of any predisposition or resistance to colds. Subjects were asked to score cold symptoms (runny or blocked nose, sore throat, sneezing, cough) immediately before and after the procedure, and twice a day for 5 days afterwards. A statistically significant difference was observed between the two groups, with 14.4% of those in the cold feet group reporting cold symptoms, compared to 5.6% in the control group.

Chilling of the feet causes constriction of blood vessels in the nose, and it has been hypothesised that this may temporarily impair defence mechanisms against infection. The authors of the new study suggest that the increased rate of symptoms in subjects exposed to cold conditions may be due to worsening of existing sub-clinical viral infections to the point where symptoms are experienced, rather than the occurrence of new infections. This would explain why previous studies which deliberately inoculated subjects with the virus failed to detect an effect of exposure to cold conditions.

WHO Conference On Water Hardness

The possible health and nutrition benefits of hard water consumption will be addressed in the symposium on ***Health Aspects of Calcium and Magnesium in Drinking Water*** produced by the NSF International, WHO Collaborating Centre and International Life Sciences Institute. The subject is of potential relevance to Public Water Systems, Desalination, Home Water Softening and other home treatment, Bottled Water and Beverages. The Symposium will be in Baltimore. MD. USA on April 24-26. Posters and Registration and Sponsors are invited. For more details see: www.CaMgWater.org

This conference follows a review of '*Nutrient minerals in drinking-water and the potential health consequences of consumption of demineralized and remineralized and altered mineral content drinking-water'* carried out as part of the rolling revision of the WHO Guidelines for Drinking-water Quality. Draft documents produced from this review suggest that WHO is considering adoption of guideline values for minimum calcium and magnesium levels in drinking water, based on perceived health benefits.

Huge Chemical Spill In China

An explosion at a Chinese petro-chemical factory on 13 November has resulted in hundreds of tonnes of toxic chemicals being released into the Songhua River. The pollutants included large quantities of benzene, aniline, nitrobenzene and xylol. The Chinese government did not acknowledge the environmental disaster until 23 November when the pollution slick reached the city of Harbin, a city of 3.8 million situated 380 km downstream from the factory. Water supplies to the city were turned off for 5 days as the 80 km long slick passed down the river. Smaller towns further downstream followed the same procedure as the pollution passed by them. It has been reported that local authorities initially denied that any pollution of the river had occurred as a result of the explosion. The incident has strained relations between China and Russia as the Songhua River is a tributary of the Amur River which marks the border between the two countries. The slick began to enter the Amur River on 16 December and is expected to reach the Russian city of Khabarovsk (population 1.5 million) by 22 December.

From the Literature

Web-bonus articles

Summaries of these additional articles are available in the web page version of Health Stream and are included in the searchable archive at:
www.waterquality.crc.org.au/pubs

Rural health alert: Helicobacter pylori in well water
Reavis, C. (2005) Journal of the American Academy of Nurse Practitioners, **17**(7); 283-9.

The Walkerton Health Study
Richards, A. (2005) Canadian Nurse, **101**(5); 16-21.

The effective use of fluorides in public health
Jones, S., Burt, B.A., Petersen, P.E. and Lennon, M.A. (2005) Bulletin of the World Health Organization, **83**(9); 670-6.

Workgroup report: Drinking-water nitrate and health--recent findings and research needs
Ward, M.H., deKok, T.M., Levallois, P., Brender, J., Gulis, G., Nolan, B.T., VanDerslice, J. and International Society for Environmental, E. (2005) Environmental Health Perspectives, **113**; 1607-14.

Does the provision of cooled filtered water in secondary school cafeterias increase water drinking and decrease the purchase of soft drinks?
Loughridge, J.L. and Barratt, J. (2005) Journal of Human Nutrition & Dietetics, **18**(4); 281-6.

Inactivation of *Escherichia coli* and coliform bacteria in traditional brass and earthenware water storage vessels
Tandon, P., Chhibber, S. and Reed, R.H. (2005) Antonie van Leeuwenhoek, **88**(1); 35-48.

Private water wells in Minnesota: recommended tests for contaminants
Convery, M.P. (2005) Minnesota Medicine, **88**(5); 46-8.

The characterization of waterborne-disease outbreaks
Poullis, D.A., Attwell, R.W. and Powell, S.C. (2005) Reviews on Environmental Health, **20**(2); 141-9.

The 1991 cholera epidemic in Peru: not a case of precaution gone awry
Tickner, J. and Gouveia-Vigeant, T. (2005) Risk Analysis, **25**(3); 495-502.

E coli O157

***Escherichia coli* O157:H7 in drinking water from private water supplies in the Netherlands**
Schets, F.M., During, M., Italiaander, R., Heijnen, L., Rutjes, S.A., van der Zwaluw, W.K. and de Roda Husman, A.M. (2005) Water Research, **39**(18); 4485-93.

Escherichia coli O157:H7 is a known cause of human disease and has become increasingly recognised as a health problem. Clinical manifestations can range from asymptomatic excretion to mild non-bloody diarrhoea to hemorrhagic colitis, and to severe complications such as haemolytic uremic syndrome (HUS) with acute renal failure sometimes resulting in death. Those at particular risk of HUS are children under 5 years, pregnant women and the elderly.

The main reservoir of *E. coli* O157 is ruminants, particularly cattle. Water supplies can be potentially contaminated with *E. coli* O157 when farmed or wild animals graze in water catchment areas. The microbiological quality of drinking water from private water supplies in the Netherlands was tested to examine compliance with Dutch drinking water legislation (with respect to faecal indicators identical to the European Drinking Water Directive 98/83/EG) and the presence of total coliforms, *E. coli* and enterococci were studied as well as the occurrence of *E. coli* O157.

Samples of drinking water from the consumer’s tap were taken from 144 private water supplies located at camp-sites, offices, hospitals and breweries throughout the Netherlands during the summers of 2002 and 2003. All supplies tested were from groundwater sources. Standard membrane filtration methods were used to enumerate faecal indicators. A specific enrichment method was used to determine the presence of *E. coli* O157.

There were 147 samples analysed. Most of the samples (86.4%) did not contain intestinal enterococci, total coliform bacteria, *E. coli* or *E. coli* O157. However 10.9% of drinking water samples contained one or more of the faecal indicators total coliforms, *E. coli* and intestinal enterococci and therefore did not comply with Dutch legislation requiring the absence of faecal indicators, in 100ml samples. For 50% of the positive water supplies no water treatment was normally used by the householders. There were 4 private water supplies (2.7%) in which *E. coli* O157:H7 was detected, the water from these supplies otherwise met microbiological water quality standards (ie negative for total coliforms and *E. coli* in 100ml sample).

All of the *E. coli* O157 strains were isolated from private water supplies on camp-sites in agricultural areas with average to large densities of dairy herds and other grazing animals. Pulsed field gel electrophoresis analysis of bacterial isolates indicated that they were similar to strains previously isolated from cattle in the Netherlands. No testing was performed on animal herds for the current study.

The usefulness of water quality testing of these private water supplies is confirmed by this study. It was found that routine monitoring of standard 100ml sample volumes with standard membrane filtration methods for total coliforms and *E. coli* that is required by European drinking water legislation may not elucidate the presence of *E. coli* O157. When pathogens such as *E. coli* O157 are found in drinking water there may be resulting health consequences, however a risk assessment needs to be undertaken as the monitoring of both faecal indicator parameters and pathogens does not predict the health effects of microbiologically contaminated drinking water on a population.

<u>Comment</u> *The authors note that differences in sample volume (100ml for standard E. coli versus 100ml and 1000 ml for E. coli O15) and test methods (membrane filtration + plating for the standard E. coli test versus membrane filtration + enrichment culture + immunomagnetic separation + plating for E. coli O157) may account for discrepancies in the results. There was only one sample where a confirmed E. coli O157 was detected in a 100ml volume. The rate of positive detections varied on different growth media.*

<u>Fluoride</u>

Bioavailability of fluoride in drinking water: a human experimental study
Maguire, A., Zohouri, F.V., Mathers, J.C., Steen, I.N., Hindmarch, P.N. and Moynihan, P.J. (2005) Journal of Dental Research, **84**(11); 989-93.

The systemic absorption of fluoride from drinking water may be influenced by the type of fluoride compound in the water and by the water hardness. This human experimental double-blind cross-over trial was conducted to compare the bioavailability of fluoride in natural and artificially fluoridated drinking water and in soft and hard drinking water. The study was prompted by a recent UK review of water fluoridation which noted a lack of comparative data on natural and artificial fluoridation.

The study group comprised 20 healthy adults between 20 and 35 years of age. Subjects were given fluoride–free toothpaste and asked to avoid any significant fluoride products one week before and during the whole six weeks of the study. They were also asked not to consume tea and beer or eat seafood during the washout and experimental periods and they were given low-fluoride bottled water for drinking and cooking.

During the six week experimental period, subjects underwent 5 experimental sessions, with different water consumed on each session and an interval of about a week between sessions. The test water were: artificially fluoridated soft tap water, artificially fluoridated hard tap water, naturally fluoridated soft bottled water, naturally fluoridated hard tap water and reference water which was Water for Irrigation BP (British Pharmacopoeia) with sodium fluoride added. A 5-ml blood sample was taken from each subject at baseline after an overnight fast. After ingestion of 500 ml of test or reference water, a further 11 blood samples were taken at regular intervals over the next 8 hrs. During each session subjects consumed a specified low-F drink, meal and snack at specific times.

Calculations of the area under the plasma fluoride concentration vs time curve (AUC) from 0 to 3 hours and 0 to 8 hours were made. Also maximum plasma F concentrations (c_{max}) and lag time to maximum F concentration (T_{max}) were calculated for each subject for each session.

Mean AUC over 0 to 3 hours was 973, 1058, 1167, 1217 and 1017 ng F.min.mL^{-1} and over 0 to 8 hours was 1330, 1440, 1679, 1566 and 1328 ng F.min.mL^{-1} for naturally fluoridated soft, naturally fluoridated hard, artificially fluoridated soft, artificially fluoridated hard and reference waters, respectively with no statistically significant differences found between waters for AUC. There were also no statistically significant differences for c_{max} and T_{max} between waters. There was a large variation in fluoride absorption both within and between subjects. The estimated standard deviation of the between subject random errors for three hour AUC was 166 ng F.min.mL^{-1} and the estimated standard deviation of the within-subject random errors was 470 ng F.min.mL^{-1} . For eight hour AUC the figures were 207 and 655 ng F.min.mL^{-1} respectively.

The results showed that any differences between waters are small compared with the large within subject and between subject variations in F absorption after ingestion of drinking water. This study provides more understanding of F pharmacokinetics and bioavailability of naturally fluoridated compared with artificially fluoridated water and hard compared with soft water. These preliminary results suggest there are no significant differences in the rate of fluoride absorption or mean plasma concentrations over time regardless of whether drinking water is hard or soft, or whether it is naturally or artificially fluoridated.

Indicators

Transport of chemical and microbial compounds from known wastewater discharges: potential for use as indicators of human fecal contamination
Glassmeyer, S.T., Furlong, E.T., Kolpin, D.W., Cahill, J.D., Zaugg, S.D., Werner, S.L., Meyer, M.T. and Kryak, D.D. (2005) Environmental Science & Technology, **39**(14); 5157-69.

In order to protect public health, the quality of drinking and recreational water is monitored to ensure pathogens are not present. Indicator organisms are monitored in water supplies because of the large number of potential pathogens that may be present. Direct analysis is often impractical as some pathogenic organisms cannot be cultured. Indicator species should be present when pathogens are present and in sufficient concentrations to make them easy to detect. Indicators are selected that are more environmentally stable and are more resistant to disinfectants than the pathogens they trace so they are easy to detect and identify.

In the U.S. currently, the total coliform test is used for screening drinking water samples for potential pathogen contamination. Recreational waters are now screened in the U.S. by monitoring *E. coli* and enterococci. These indicator bacteria have been useful in protecting human health but they also have their limitations and disadvantages. The traditional biological assays require 18-48 hours for microorganisms to grow and to be enumerated. In the time it takes for a result to be obtained, individuals can consume or come in contact with the contaminated water. Many microbial indictors lack specificity and it is not possible to discriminate between human or animal sources or to even establish whether the presence of indicators is a result of faecal contamination.

The applicability of using chemical indictors of human faecal contamination to identify human sewage contamination in water is a relatively new area of research. The advantage of chemical tests over current microbial tests is the shorter time required for sample preparation and analysis. Also, chemical indicators offer the potential of being able to distinguish between human and animal sources. This study was conducted to evaluate the usefulness of a range of organic chemical compounds as specific indications of human faecal contamination.

Ten wastewater treatment plants across the United States were studied. One upstream, one effluent and two downstream water samples from each WWTP were collected. Two remote sites were also sampled (reference locations), these having minimal direct impact from human wastewater. The persistence of a chemically diverse range of emerging contaminants in streams was determined. There were 110 chemical analytes investigated in this study. Of these, 78 were found in at least one sample. The number of compounds found per sample ranged from three in a reference location to 50 in a WWTP effluent sample. The total analyte load varied from 0.018 microg/L at a reference location to 97.7 microg/L in a WWTP effluent sample. Most of the compound concentrations were in the range of 0.01 -1.0 microg/L, however in some samples individual concentrations were in the range of 5-38 microg/L.

The two microbial indicators *E. coli* and enterococci were found in more than 90% of the samples. In contrast to the chemical analytes, *E. coli* and enterococci were found in both collected reference samples. This shows the lack of specificity of the microbial indicators for identifying only human faecal contamination.

The results suggest that chemicals may be useful as indicators of human faecal contamination. For the majority of the chemicals present in the samples, concentrations generally followed the expected trend where they were either nonexistent or at trace levels in the upstream samples and in maximum concentrations in the WWTP effluent samples with a decline by the downstream samples. There were 35 chemicals in particular that could be useful indicators. The wastewater compounds ethyl citrate, galaxolide and tonalide go through distinct changes in concentrations between upstream, WWTP effluent and downstream sites and this could make them good indicator candidates. Compounds that are only used by humans such as the pharmaceuticals carbamazepine and diphenhydramine and even caffeine may also be potentially good indicators. Of the faecal sterols, coprostanol which has a human source showed the most changes in concentrations between the sample sites and had the greatest potential as an indicator of human faecal material. No compounds should be ruled in or out until an epidemiological study has compared its presence or concentration to the incidence of illness such as gastroenteritis caused by water contact.

Lead

Reducing lead exposure from drinking water: recent history and current status

Maas, R.P., Patch, S.C., Morgan, D.M. and Pandolfo, T.J. (2005) Public Health Reports, **120**(3); 316-21.

In the United States lead exposure from drinking water has been recognised as a substantial (14% to 20% of total) contributor to a child's overall lead exposure. Over the past two decades efforts have been made to significantly reduce tap water lead exposure in the US including banning lead solder, reducing the corrosivity of public water supplies and removing lead from brass faucets and water meters. During this same period, medical and epidemiological studies have shown that even very low-level lead exposure can cause substantial and permanent IQ and learning difficulties in young children. The health effects from low-level but widespread lead exposure such as through drinking water may be disproportionately large. A study in 2003 indicated that the relationship between blood lead levels (BLL) and IQ deficits is not linear and the first small elevation of BLL in young children may cause most of the neurological damage with higher levels of exposure causing disproportionately less additional IQ reduction.

The city of New York has offered free tap water testing to all residents since early 1995 and provided a good case study opportunity. Since this time about 20,000 residents have had their water tested. The city is supplied with finished water of fairly stable chemical composition coming from only a few raw water sources. For each resident from 1992 to the present, first-draw and one-minute flush lead concentrations have been measured and the data stored along with information on the age, location and size of the building, the composition of plumbing system materials and other water quality variables such as pH and concentration of orthophosphate. From late 1992 and continuing through mid-1993, New York City began adding ortho-phosphoric acid to it tap water on an experimental and irregular basis as a corrosion inhibitor. In 1993, the city added it continuously to effectively the entire water distribution system. From 1992 to 1994, median first-draw lead concentrations decreased by 42%. Levels increased slightly in 1995 then from 1996 through 2003 median levels were constant at around 1.5 µg/l which is a decrease of 62% relative to 1992 levels. This corrosion reduction program has therefore been quite consistently effective.

It seems that the most influential and cost-effective measure to further reducing lead exposure from drinking water may be to encourage and make it possible for households to test their water for lead. By using a two-sample test to determine whether a household has a tap water lead problem and whether exposure can be avoided by flushing the tap for a specified length of time, exposure of children to residential tap water lead can be practically eliminated.

It is advisable for other cities to undertake corrosion control measures as New York has done to reduce their tap water lead levels. There are however an estimated 50 million North American households which have individual or private water supplies that have seen little if any reduction in tap water lead levels.

<u>Manganese</u>

Neurotoxicity of inhaled manganese: Public health danger in the shower?

Elsner, R.J. and Spangler, J.G. (2005) Medical Hypotheses, **65**(3); 607-16, 2005.

Manganese (Mn) is an essential trace element, but at higher doses it is neurotoxic. There have been concerns raised regarding the possible role of Mn in neurological diseases, and its regulation in the environment and in drinking water. There has never been an evaluation of the potential route of central nervous system (CNS) deposition of Mn from inhalation of aerosols while showering with water contaminated with Mn. A literature review was undertaken to quantify on the basis of the best available evidence, the potential human CNS exposure to Mn from showering.

Medline was systematically searched in September 2002 and again in September 2004. Some other databases were also searched and a Google internet search was also undertaken. Included in the evaluation were animal experimental investigations, human epidemiological studies and consensus and governmental reports.

Animal and human data has shown that pregnant women and individuals with iron deficiency anaemia are at increased risk for excessive Mn absorption. Neonates are at particularly vulnerable to the effects of Mn. Those with impaired biliary excretion such as people with liver disease and alcoholics may accumulate excessive manganese. The elderly population may also be at risk because of iron deficiency and liver abnormalities. Mn toxicity is called Manganism and it is a neurological disorder similar to Parkinson’s disease. At earlier stages of Mn toxicity subtle neuropsychiatric effects are seen such as headache, decreased libido, abnormal hand-eye coordination, decreased reaction time and tremor. Of most concern, particularly in children, is that the neurological effects may be permanent.

Manganese is poorly absorbed through the digestive tract, and most reports of human toxicity concern inhalation exposure to manganese-containing dusts. The inhalation route of exposure has been found to be much more efficient at delivering Mn to the brain. A study in rats using inhalational exposure to an aqueous solution of radioactively labelled $MnCl_2$ demonstrated that most manganese absorption took place through the olfactory membrane in the nose rather than through the lungs. Other research has shown that Mn (and other substances) can be absorbed readily into the olfactory neurones, then travel through these nerves into the brain tissue bypassing the “blood-brain barrier” which normally regulates the entry of chemicals into brain tissue.

In this paper the model derived from the rat study was used to estimate human exposure to excessive manganese levels in water during showering. Several factors were considered when extrapolating to human shower exposure including the difference in olfactory mucosa surface of human and rats, with less inhaled air reaching the olfactory surfaces in humans. The higher metabolic and respiratory rates in children than adults had to be considered. It was assumed that most US residents take one 10 min shower daily. The human model used exposure to aerosolised solutions of Mn if water supplies contain between 0.1 and 0.5 mg/L. It was calculated that children after three years of exposure to 0.5 mg/l of Mn in the water supply would have theoretically received a dose nearly equivalent to that shown to cause olfactory deposition in rats. It was also found in adults that showering with water supplies containing 0.5, 0.4 and 0.3 mg/l of Mn at 6, 8 and 10 years, respectively would in theory receive nearly equivalent doses to that of the rats. During 10 years of showering in Mn-contaminated water, models for both children and adults show higher doses of aerosolised Mn (3-fold and 1.5 fold greater respectively) than doses reported to cause Mn brain deposition in rats.

When setting drinking water standard, regulatory agencies have not considered this possible pathway for respired manganese. In the US there are a potential 8.7 million people exposed to Mn levels that this model suggests might cause brain accumulation. The authors suggest that in view of the modelling performed here, regulatory agencies may have to reconsider the existing Mn drinking water standards.

Comment *The calculations in this paper attempt to equate short term exposure to high concentrations of* $MnCl_2$ *in rats (90 min exposure to 277 mg/L) to chronic exposure to low concentrations in humans (years of exposure at 10 min per day to 0.1 mg/L). The validity of this calculation is doubtful, and it also appears to assume that Mn is accumulated in the body and never excreted. The rat study was designed to differentiate between nasal and lung sites of absorption, and the levels of Mn detected in rat brain after olfactory membrane absorption were not necessarily toxic. Exposure in the rats was by means of a fine aerosol with average droplet size of 2.5 microns, which does not reflect the wide range of droplet sizes inhaled during showering. There are also considerable differences in the metabolism of manganese in humans and rats, and significant olfactory absorption by humans has not yet been demonstrated.*

Outbreaks

Infectious disease outbreaks related to drinking water in Canada, 1974-2001.

Schuster, C.J., Ellis, A.G., Robertson, W.J., Charron, D.F., Aramini, J.J., Marshall, B.J. and Medeiros, D.T. (2005) Canadian Journal of Public Health, **94**(4); 254-58.

Information on waterborne outbreaks in Canada from 1974-2001 was analysed with the objective of identifying apparent trends, reviewing the current status of monitoring and reporting, and to gain a better understanding of the impact of drinking water quality on public health and disease burden.

Data on outbreaks was obtained from two main sources: Health Canada's summary reports and the Quebec health reports. This was supplemented by an extensive literature review. Outbreaks were categorised as being definitely, probably or possibly waterborne in nature. The data was also categorized by water supply type: public (municipal), semi-public (privately owned systems providing drinking water to the visiting general public), and private (systems providing drinking water to the individuals owning the system and their guests). Data was also gathered on the water system or the location of the outbreak. Information on the agent responsible for the outbreak was collected from original documentation.

There were 288 outbreaks of disease linked to a drinking water source in the final data set. Nearly half of the outbreaks were reported in semi-public systems (138 outbreaks), 99 were in public water systems and 51 were in private systems. Over one third of the outbreaks were categorised as definitely waterborne. Of these outbreaks most were in public systems. The highest number of outbreaks annually was during the period 1989 to 1996.

For 134 of the outbreaks, the pathogen responsible was not known. Of the remaining outbreaks, the most common causative agent was *Giardia lamblia* (51 outbreaks) followed by *Campylobacter* (24 outbreaks) and *Cryptosporidium*, hepatitis A, Norwalk-like viruses and *Salmonella* (each responsible for 10 or more outbreaks). There was more than one pathogen involved in four of the outbreaks. Most semi-private and private systems did not document a particular pathogen as the source of the outbreak.

There were 223 outbreaks which documented a single contributing factor or circumstance. More than three contributing factors were documented in 9 of the outbreaks. Reasons most frequently stated as contributing to the occurrence of the outbreak included issues with the water treatment process and the need for more stringent or enhanced treatment techniques.

The majority of all outbreaks occurred in spring (between March and May) and summer (between June and August). Spring was the season where meteorological conditions or specific weather events were most often implicated. Several public system outbreaks in summer were attributed at least in part to weather events.

This study found a seasonal distribution of waterborne disease outbreaks in Canada with a peak in spring/summer. Severe weather, close proximity to animal populations, treatment system malfunctions, poor maintenance and treatment practices were all associated with drinking water supply outbreaks. This study found the quality of existing information associated with waterborne disease outbreaks is not adequate, with basic information often missing. The current data could be improved if a nationally standardised surveillance system was implemented and epidemiological training was provided to improve the quality of outbreak investigation information. There is also a need for trend identification and policy development to prevent future outbreaks.

Norovirus outbreaks from drinking water.
Manunula, L., Miettinen, I.T. and von Bonsdorff, C.-H. (2005) Emerging Infectious Diseases, **11**(11); 1716-21.

As a part of an improved and intensified outbreak surveillance system commencing in 1997 in Finland, testing for viruses was included in the investigation of suspected waterborne outbreaks. The importance of viruses in waterborne outbreaks has only been recognised relatively recently, after techniques were developed to detect Noroviruses (formally called Norwalk-like viruses). These viruses commonly cause gastroenteritis in all age groups in the community, and they may be transmitted by multiple routes. Noroviruses cannot be grown in culture, and it was only after molecular detection techniques were established in the 1990s that it became possible to detect them in water supplies. This article describes an improved procedure to identify waterborne viral outbreaks.

There were a total of 41 waterborne outbreaks registered in Finland from 1998 to 2003. Of these outbreaks, 28 were investigated for viruses. Patients' stool samples and water samples were available for analysis in 24 of these outbreaks. For 3 of the outbreaks only water was available and in 1 outbreak only a patient sample was available.

Patients' stool samples were analysed by electron microscopy and reverse transcription-polymerase chain reaction (RT-PCR) for noroviruses and astroviruses and were screened by electron microscopy for other enteric viruses. If the test results were positive for a virus, a water sample was analysed. The virus concentration method used positively charged filters from 1L samples. Water samples were mostly only analysed for noroviruses.

Noroviruses caused 18 of the outbreaks, including 3 very large outbreaks involving 5500, 2500 and 2000 cases respectively. One outbreak was caused by rotavirus and no viruses were found for 9 outbreaks. Most of the norovirus contaminants occurred in groundwater systems and of these 8 occurred in public communal systems and 7 in private ground water wells. Half of the waterborne epidemics occurred in summer and norovirus outbreaks were the most common in late winter to spring. Summer outbreaks were mainly caused by bacterial pathogens. Inadequate disinfection of surface water, or use of undisinfected groundwater were considered to be responsible for most viral outbreaks.

Further characterisation of noroviruses from 16 outbreaks was undertaken by sequence analysis of amplicons from which the genotype was also deduced. Most of the outbreaks were found to be caused by a single norovirus strain/genotype. In 10 of the outbreaks norovirus was also found in the water samples, and in all but 1 of these outbreaks the same norovirus genotype was found in the water sample and in the patient samples. Coliforms were detected in water in only 9 of these 16 outbreaks, and the authors suggest that this may be explained by the longer persistence of infectious viruses compared to enteric bacteria.

The finding that noroviruses are frequent causes of waterborne outbreaks in Finland has given authorities an increased knowledge of the viral risks. As a result of this, laboratory techniques have been enhanced and the capacity for analysing environmental samples, especially water samples had increased. It is suggested that legislative measures for viral monitoring should be considered as part of a microbial risk assessment in drinking water production.

Pathogens

Concentrations of pathogens and indicators in animal feces in the Sydney watershed
Cox, P., Griffith, M., Angles, M., Deere, D. and Ferguson, C. (2005) Applied and Environmental Microbiology, **71**(10); 5929-34.

A study was conducted to provide a cross-sectional estimate of the intensity of shedding of pathogenic and indicator microorganisms in animal faeces in the drinking water watersheds of Sydney, Australia. Estimating the pathogen source loads is an important step in the modelling of pathogen origin, fate and transport in watersheds. Pathogens from animal faeces may enter waterways through direct deposition or by overland runoff containing faecal material.

Four watersheds within the Sydney Catchment Authority were studied. These watersheds have mixed land use with significant agricultural activities mixed with urban and rural residential areas. The main agricultural land uses are sheep and cattle grazing. Samples of animal faeces were collected from each watershed during April and May 2002. Samples collected came from a range of domestic animals including: cattle, calves, sheep, pigs, dogs, horses, poultry and cats. Native and feral animal faecal samples were also collected in May and June 2002. Faecal samples were analysed for pathogenic protozoa (*Cryptosporidium* and *Giardia*), enteric viruses (adenovirus, enterovirus and reovirus), and indicator organisms (faecal coliforms and C*lostridium perfringens* spores).

The concentrations of *C. perfringens* spores, *Cryptosporidium* and *Giardia* and enteric viruses were all higher in the faeces of domestic animals than in the faeces of wildlife animals. *C. perfringens* was isolated mostly from domestic animal faeces and was rarely found in wildlife faeces. *C. perfringens* may be a useful indicator of faecal inputs from agricultural and urban development in watersheds. Faecal coliforms were isolated from the majority of the faecal samples from domestic and wildlife animals and mostly in high concentrations. The levels of faecal coliforms found were substantially higher than the pathogen levels found. Using faecal coliforms as surrogates for pathogen loads could therefore lead to an overestimation of the risk. Reoviruses were the most often isolated viruses. These viruses are ubiquitous and infect and range of vertebrates.

Future studies are required in this watershed to investigate the seasonal and other temporal effects on pathogen input loads especially from domestic animals. Even though potential human pathogens were isolated in this study area, there have been no outbreaks of waterborne disease in the population that is served by this watershed.

Perchlorate

Long-term environmental exposure to perchlorate through drinking water and thyroid function during pregnancy and the neonatal period.
Tellez, R.T., Chacon, P.M., Abarca, C.R., Blount, B.C., Van Landingham, C.B., Crump, K.S. and Gibbs, J.P. (2005) Thyroid, **15**(9); 963-75.

Recently concern has been raised about the possibility of environmental perchlorate in drinking water inducing a relative iodine deficiency during pregnancy, especially if women have a low iodine intake. Such a deficiency may result in adverse neurodevelopmental effects in the foetus. A longitudinal epidemiologic study was conducted to assess the possible impact of perchlorate in drinking water at concentrations of 100-120 µg/L on maternal thyroid function during pregnancy, neonatal thyroid function and developmental status at birth, and breast milk iodide and perchlorate levels during lactation. It is hypothesised that long-term exposure to perchlorate in drinking water will cause a situation similar to iodine deficiency and therefore cause increases in thyrotropin (TSH) and thyroglobulin (Tg) levels and decreased levels of free thyroxine (FT_4) in either the mother during early stages of gestation or the neonate at birth, or cause growth retardation in the foetus

The study was conducted between November 2002 and April 2004 in three coastal cities in northern Chile where saltpeter, which contains perchlorate, has been mined for over 200 years. The three cities studied were Taltal with 114 µg/L, Chanaral with 6 µg/L, and Antofagasta with 0.5 µg/L perchlorate in their public drinking water supplies. Women were enrolled in the study when first presenting for prenatal care. Women were excluded if they were beyond 24 weeks gestation, had lived in their respective cities less than 6 months, or were taking thyroid medications or medication containing iodine during the 3 months before starting the study.

During the first prenatal study visit subjects answered a questionnaire on socioeconomic and cultural information and provided a sample of home tap water. During the post-partum study visit, a breast milk sample was collected when possible. During both visits, maternal serum and urine samples were taken and analysed. Levels of TSH, free FT_4 and triiodothyronine (T_3) were measured using chemiluminescence. Tg was analysed by radioimmune separation and antibodies to thyroid peroxidase (TPO) were analysed using hemagluttination. Urine iodine determinations were made using oxidation with ammonium persulfate. A physical examination of maternal thyroid was conducted during both study visits. Tap water samples were analysed for perchlorate. There were also 63 serum samples and 297 urine samples analysed for perchlorate. All breast milk samples were analysed for perchlorate and for iodine. For all hospital births, neonatal weight, length and head circumference were measured and gestational age at birth was estimated.

To determine if nitrate, selenium, iodine, lithium and arsenic were present in mineral deposits in the study region, some of the home tap water samples from each of the three cities were analysed for these substances. These substances have been linked to thyroid dysfunction and might confound the results. Postpartum serum samples from 40 nonsmokers were analysed for thiocyanate to ensure the local diet was not high in cyanogens.

No increases in Tg or TSH and no decreases in FT_4 were found among women during early pregnancy, late pregnancy or neonates at birth in relation to perchlorate in drinking water. The birth weight, length and head circumference of neonates were similar among the three cities and were similar to the distribution reported in the National Health and Nutrition Examination Survey in the U.S (NHANES III) in the early 1990s. Therefore perchlorate levels in drinking water found here did not cause changes in neonatal thyroid function or foetal growth retardation. The levels of arsenic, lithium, nitrate and iodine were not sufficiently high to cause concern about confounding.

The mean urinary iodine level of the entire cohort was 269 µg/L which is intermediate between that of pregnant women in the U.S. NHANES I in the early 1970s and NHANES III, and also consistent with current World Health Organization (WHO) recommendations. It has been hypothesised that perchlorate from the environment might cause a decrease in breast milk iodine concentrations however this was not the case with no decrease in iodine levels found in cities with detectable perchlorate. Maternal urinary perchlorate excretion in Antofagasta and Chanaral were higher than expected if drinking water was the only source of perchlorate, indicating that a significant additional dietary source of perchlorate is present.

Risk Assessment

Detection and risk assessment of adenoviruses in swimming pool water

van Heerden, J., Ehlers, M.M. and Grabow, W.O. (2005) Journal of Applied Microbiology, **99**(5); 1256-64.

Nonenteric human adenovirus (HAds) has been associated with swimming pool outbreaks of eye infections (pharyngo-conjunctivitis). Many of these outbreaks were related to poor disinfection of the pool water. This study was conducted to routinely investigate selected swimming pools to assess the prevalence and potential risk of infection from HAds when HAds is detected in swimming pool water. Two indoor swimming pools (swimming pool A and B) and one outdoor swimming pool (swimming pool C) were assessed.

Adenoviruses were concentrated and extracted from swimming pool water samples. Concentration of viruses from 11 grab samples of swimming pool water was undertaken using a silicon dioxide-method. The HAd DNA once extracted was amplified using a nested PCR method. An exposure assessment was then undertaken. There were 93 water samples analysed from the three swimming pools which had water treated and disinfected to generally accepted specifications. Swimming pool managers supplied information about the pool volume, chlorine levels, pH and number of bathers per pool.

Swimming pool managers reported residual free chlorine levels of 1-2 mg/L in the pools investigated. In the laboratory free and total residual chlorine levels of 2-10 mg/L in swimming pool A were found. HAds were detected in four of the 26 samples from the indoor swimming pool; A, from 8 of the 38 samples from indoor pool B and from 3 of the 28 samples from outdoor pool C. An exponential risk assessment model was used to calculate the daily risk of infection. The daily risk of infection for swimming pool A was 2.61×10^{-3}, for swimming pool B it was 3.69×10^{-3} and for swimming pool C, 1.92×10^{-3}, assuming a daily consumption of 30 ml of swimming pool water.

Even though the swimming pool water conformed to specifications for treatment, disinfection and indicator organism, HAds were still detected in the water. There do not seem to be any recommendations for tolerable risks for HAd infection for recreational water such as swimming pools, only for freshwater environments. It is however generally expected that swimming pool water be of similar quality to drinking water. In drinking water the recommended acceptable risk for infections constituted by pathogens is one infection per 10,000 consumers per year (US EPA). This risk was exceeded for the swimming pool water.

The prevalence of HAds found in the swimming pool water analysed may lead to waterborne outbreaks such as pharyngo-conjunctivitis and possibly to gastroenteritis. It therefore is important to formulate specifications for swimming pools to which they must comply to ensure that the risk of infection is acceptable for bathers using the facilities.

Comment *The authors note that the detection method would detect both infectious and non-infectious viruses. To compensate for this they assumed that only half the virus particles were infectious, however the accuracy of this assumption is not known. WHO is currently revising its Guidelines for Recreational Water (Swimming pools and Spas) and the target risk levels for these waters are not yet known. The suggested acceptable levels of risk defined for swimming in coastal and freshwaters are in the range of 1% to 5% per swimming event for gastrointestinal illness and 0.3% to 1.9% per swimming event for acute febrile respiratory illness (such as that caused by respiratory adenoviruses). It is doubtful whether the public or regulatory authorities would expect swimming pool water to have the same level of microbiological safety as drinking water, as stated by the authors.*

Water Disinfection

Household based treatment of drinking water with flocculant-disinfectant for preventing diarrhoea in areas with turbid source water in rural western Kenya: cluster randomised controlled trial.

Crump, J.A., Otieno, P.O., Slutsker, L., Keswick, B.H., Rosen, D.H., Hoekstra, R.M., Vulule, J.M. and Luby, S.P. (2005) BMJ, **331**(7515); 478.

It is estimated that there are 2.2 million deaths a year caused by diarrhoeal diseases worldwide. The importance of household based water treatment to reduce diarrhoeal disease in low income countries which lack access to clean water is increasingly being recognised.

A study was undertaken in rural western Kenya where source waters are both heavily faecally contaminated and very turbid. The study was conducted over 20 weeks. It was hypothesised that children less than 2 years of age living in family compounds (restricted plots containing several houses of family members) that received a new flocculant-disinfectant would have less episodes of diarrhoea than children in compounds using sodium hypochlorite (a widely used household based disinfectant). The use of both of these interventions was compared with the usual water handling practices to assess the effect of water treatment on diarrhoea among household residents of all ages and to assess the relative suitability of the two interventions for treating highly turbid water.

There were 605 family compounds identified from 49 villages near Lake Victoria in Siaya and Bondo Districts in western Kenya with at least one child aged less than 2 years. Family compounds were randomly assigned to either flocculant-disinfectant (201 families), sodium hypochlorite (203 families) or a control group (201 families). Flocculant-disinfectant is a new technology using single use sachets which work quickly on small volumes of water by aggregating and facilitating the removal of suspended organic matter, bacteria, viruses, parasites and heavy metals in treated water. One packet contains enough calcium hypochlorite to leave a residual chlorine concentration of 3.5 mg/L in 10L of demineralised water. The sodium hypochlorite treatment used 1 % sodium hypochlorite manufactured commercially. The control group continued their usual water collection, treatment and storage practices. These practices included turbidity mitigation by setting and decanting, cloth filtration and treatment with alum to modestly reduce turbidity.

Field workers visited participants weekly and used a questionnaire to record the presence or absence of diarrhoea and any deaths during the seven days since the last visit. A questionnaire was also used to assess the mothers' knowledge of and attitudes towards the interventions during the 5th and 15th week of the study. Field workers collected samples of stored drinking water during the baselines survey and during unannounced visits every four weeks to measure free chlorine concentrations and turbidity as well as samples of source water to measure turbidity. The concentration of *Escherichia coli* was measured during the baseline survey and the 10th week of the study from stored drinking water and from source water.

When children under 2 years old were compared with those in the control group, the absolute difference in prevalence of diarrhoea was 25% less for the flocculant-disinfectant users (95% CI -40 to -5) and 17% less in those using the sodium hypochlorite (-34 to 4). When all age groups were compared with the control group, the absolute difference in prevalence was reduced by 19% in the flocculant-disinfectant users (-34 to -2) and by 26% in those using the sodium hypochlorite (-39 to -9). It was found that there were significantly less deaths in the intervention groups than in the control group (relative risk of death 0.58, P=0.036). *E. coli* concentrations less than 1 CFU/100 ml were found in 14% of water samples from the control group compared with 82% in the flocculant-disinfectant users and 78% in the sodium hypochlorite users. The mean turbidity was found to be 8 NTU in the flocculant-disinfectant users compared with 55 NTU in the other two groups.

This study showed that flocculant-disinfectant was well suited to areas with highly contaminated and turbid water and provided a significant health benefit by reducing the risk of diarrhoea particularly among infants and children.

Water Quality

Microbial contamination of dental unit water systems

Forde, A., O'Reilly, P., Fitzgerald, G., O'Mullane, D., Burke, F.M. and O'Sullivan, M. (2005) Journal of the Irish Dental Association, **51**(3); 115-8.

This study was conducted to determine the microbial levels of dental unit water systems (DUWS) used in dental practices. There has been concern raised regarding the development of biofilms which may serve as a source of bacterial contamination of the water used during dental treatment. A cross-sectional study was conducted as part of a pan-European project on the microbial qualitative and quantitative aspects of DUWS. Samples from 30 general dental practices from three points of the DUWS were collected. There were 30 water-line (WL), 30 aerated water (AW) and 23 water-line biofilm (BF) samples assessed.

Microbial loads were found to range from 100 to 104 cfu/ml, and were found to exceed the acceptable European standard (100 cfu/ml) for potable water in 87 % of cases. The isolates found most probably belonged to families of aquatic and soil bacteria. There were no associations between the age of the unit, water source and chemistry and presence or absence of anti-retraction devices and microbial loads. There were no opportunistic or true pathogens detected. Yeasts were found in AW samples from three private practices, however these were not the opportunistic pathogen *Candida albicans*.

Even though none of the microorganisms identified were pathogenic or potentially so, the presence of high bacterial counts indicated that in most cases the water was not of EU potable standard. Dental practitioners need to be well-informed about microbial contamination and biofilm formation of their dental unit waterlines. Evidence-based guidelines and reliable control regimes for microbial contamination of DUWS are needed.

Comment *This paper does not provide details on all the pathogen tests undertaken, but notes that E. coli, Pseudomonas aeruginosa and Legionella pneumophila were not detected. Non-pathogenic Mycobacteria were found in six units.*

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