Health Stream

INFORMATION AND ANALYSIS FOR WATER AND HEALTH PROFESSIONALS

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In this Issue:

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Asbestos in Drinking Water

A recent study of gastrointestinal cancers among Norwegian lighthouse keepers has reported an elevated risk of stomach cancer possibly associated with consumption of rainwater collected from asbestos-cement tiled rooftops (1). The findings of the study contrast with many previous studies of asbestos exposure through drinking water, which have failed to find any consistent relationship with elevated cancer risks. However the reported concentrations in collected rainwater in the Norwegian study appear to be up to 10,000 times higher than those reported for conventional drinking water supplies.

The term asbestos is used to describe a group of naturally occurring hydrated fibrous silicates with differing crystalline structures. Serpentine asbestos consists of only one form (chrysotile) while amphibole asbestos includes several forms (actinolite, amosite, anthophylite, crocidolite and tremolite). Chrysotile (commonly known as white asbestos), amosite (brown asbestos) and crocidolite (blue asbestos) have all been used commercially. Chrysotile, incorporated at levels of 10% to 20%, was the form most commonly used in asbestos-cement manufactured products including pipes for water supply and sewerage systems.

Inhalation of asbestos fibres is a proven risk factor for asbestosis (fibrosis of the lung tissue characterised by chronic inflammation and development of scar tissue), mesothelioma (cancer of the cells forming the lining of the chest cavity) and lung cancer. The biological effects of asbestos fibres are dependent on their length, with long fibres being more carcinogenic than short fibres. This is believed

to be due to longer fibres being more resistant to bioclearance mechanisms in the lung. Amphibole fibres are also more persistent in the body than the serpentine type. Workers who were exposed to high levels of airborne asbestos fibres prior to implementation of strict safety regulations would have experienced ingestion exposure to fibres either from deposition in the naso-pharynx or indirectly through ingestion of asbestos particles in mucus transported upwards from the lungs by clearance mechanisms. Studies of occupational cohorts which were highly exposed to chrysotile have not found consistent evidence for increased risks of gastrointestinal cancers. Animal studies of chrysotile asbestos ingestion also failed to demonstrate carcinogenicity. Asbestos is not currently considered to be a human carcinogenic via ingestion (2).

Asbestos may occur in water supplies due to the presence of natural mineral deposits, industrial contamination of water sources or leaching from asbestos-cement pipes. Asbestos may be released into the water as pipes age and deteriorate, particularly when water is “aggressive”. The presence of asbestos fibres in drinking water was first reported in 1973 in the town of Duluth, Minnesota USA. The contamination originated from mine tailings which had been dumped into Lake Superior over the previous 18 year period. This triggered a number of ecological epidemiology studies in the US and Canada over the following decade. These studies compared incidence or mortality rates for various types of cancer in populations with differing levels of asbestos in their water supplies. The asbestos sources included both natural geological deposits and asbestos-cement pipes in water distribution systems.

The studies produced inconsistent results with elevated risks for some cancers observed in some locations but not in others. Some studies also suggested differences in risk patterns between the sexes, while others did not observe such a difference. Due to their ecological nature these studies were not able to assess individual drinking water exposures or the influence of other factors such as smoking or occupational exposures on cancer risks. A higher quality case-control study undertaken in Washington State was able to assess individual water consumption and other variables including smoking. The water supply of interest was derived from the Sultan River, and contained chrysotile asbestos of geological origin at concentrations up to 200 million fibres per litre (in the higher range of levels recorded in drinking water supplies). Over 20% of people in the study had been drinking from this water source for more than 30 years. This study concluded that there was no convincing evidence of increased cancer risks from ingested asbestos.

A survey of 100 representative US water supplies published in 1983 concluded that majority of supplies (95%) contained less than 10 million fibres per litre and more then half (61%) had less than 1 million fibres per litre. Consideration of the relative contribution of asbestos fibres in food and air to the ingested dose suggested that both of these sources would outweigh the contribution of drinking water. By the mid-1980s it had become evident that cancer risks (if any) associated with asbestos in drinking water supplies were likely to be very low (3) and few studies on ingested asbestos have been published since that time. The US EPA established a Maximum Contaminant Level and a Maximum Contaminant Level Goal of 7 million fibres per litre for fibres greater than 10 microns in length, with shorter fibres not being regulated. The World Health Organisation and the Australian Drinking Water Guidelines do not specify a guideline value for asbestos in drinking water due to the lack of convincing evidence that ingested asbestos is a hazard to health.

The incidence of stomach cancer is variable around the world with the highest rates being found in Asia and the Pacific Islands. Known risk factors include smoking, chronic infection with the bacterium *Helicobacter pylori* and consumption of smoked, salted and pickled foods. Genetic factors may also play a role in susceptibility, and the incidence of stomach cancer is about twice as high in men as it is in women. Frequent consumption of fruits and vegetables appears to be protective. Incidence rates for stomach cancer have declined markedly in most developed countries over the last 50 years, most probably due to changes in diet and the advent of domestic refrigeration which resulted in a decrease in consumption of preserved foods.

The recently published Norwegian study examined a cohort of lighthouse keepers who were currently employed on 1 January 1967, or who had been first employed between 1917 and 1966 and left employment or died between 1953 and 1967. From this cohort of 947 men, adequate data was available on 726 men for statistical analysis. Cases of cancer among the group were identified by matching with the national cancer registry. Cancer incidence was observed from 1 January 1960 or the year of first employment in the lighthouse service (whichever occurred last) until their date of death, emigration or the end of the follow up period on 31 December 2002 (up to 42 years of follow up).

The presence of asbestos-contaminated drinking water at lighthouses was determined from a questionnaire survey sent to 81 manned lighthouses in 1983. It was found that 21 lighthouses were supplied with rainwater collected from asbestos-cement tiled rooftops. These roofs had been installed between 1945 and 1950, and were subject to harsh weather conditions leading to erosion of tile material. The asbestos used in the roofing tiles was of the amphibole type, which has a much longer biological persistence than chrysotile. Water samples from 7 water storage cisterns were analysed in 1983 and concentrations of asbestos ranging from 1,800 to 71,000 million fibres per litre were found.

From employment records it was determined that 107 lighthouse keepers had worked at the 21 lighthouses with water collected from asbestos roofs, while 479 had worked at lighthouses with other water sources. For another group of 140 men, the place of work was uncertain and these were classified as having unknown exposure. Significant levels of asbestos were assumed to have been present in the water supplies of the affected lighthouses since 1948. The authors noted that due to incomplete records, they could not be certain that the “unexposed” group had no exposure to asbestos in water supplies during their working life. Cancer incidence in the lighthouse keepers during the follow up period was compared to the expected incidence in the Norwegian male rural population.

A total of 200 cancers (all types except non-melanoma skin cancers) were observed in the cohort during 17,923 person-years compared to 186.1 expected cases (standardised incidence ratio SIR 1.1, 95% CI 0.9-1.2). The SIR for stomach cancer was 1.6 (95% CI 1.0 - 2.3) while that for all gastrointestinal sites was 1.4 (95% CI 1.1-1.8). No other statistically significant differences were seen. When the cohort was split into categories based on asbestos exposure status, the SIR for stomach cancer for the exposed group was 2.5 (95% CI 0.9-5.5), for the unexposed group the SIR was 1.4 (95% CI 0.8 - 2.2), while for the unknown exposure group the SIR was 1.5 (95% CI 0.6-3.3). For total gastrointestinal cancers, the highest SIR was seen in the unknown exposure group (SIR=2.0, 95% CI 1.2-3.1), while lower values were seen in the exposed group (SIR=1.5, 95% CI 0.7-2.8) and the unexposed group (SIR=1.2, 95% CI 0.8-1.7).

When the entire cohort was categorised by duration of possible exposure (less than 20 years versus 20 years or greater working in the lighthouses), increased risks were seen for longer exposure. For stomach cancer among men with less than 20 years possible exposure the SIR was 1.1 (95% CI 0.4-2.5) while for total gastrointestinal cancers it was 0.9 (95% CI 0.4-1.8). For those with 20 years or more possible exposure, the SIR for stomach cancer was 1.7 (95% CI 1.1-2.7), while for gastrointestinal cancers it was 1.6 (95% CI 1.3-2.1).

The authors suggest that the results support an increased risk for stomach cancer and perhaps other gastrointestinal cancers associated with ingestion of asbestos in this cohort. However the study did not assess individual exposures such as smoking or diet which may have influenced cancer risks, and the drinking water source or intake were not verified. No information was available on the diet consumed by lighthouse keepers in historical times, but a recent survey indicated that smoked fish and smoked meat were frequently consumed, although growing of vegetables and fruit was also common. The authors suggest that although dietary differences may explain differences in cancer rates between lighthouse keepers and the rest of the rural population, they are unlikely to explain differences within the cohort.

This study was limited by the relatively small sample size, and most of the findings of increased risk were of borderline statistical significance. Balancing this, the follow up period was longer than for previous studies and the coverage of the cancer incidence data was extensive. However the authors conclude that given the very high levels of exposure among this cohort, the limitations of the study and the relatively low observed increases in risk, these findings do not suggest that asbestos in drinking water supplies is a major health problem for the general population.

(1) Cancer of the gastrointestinal tract and exposure to asbestos in drinking water among lighthouse keepers (Norway). Jaerheim K, Ulvestad B, Martinsen JI and Andersen A. Cancer Causes and Control (2005) **16**: 593-598.

(2) Environmental Health Criteria 203 Chrysotile Asbestos. International Program on Chemical Safety. WHO, Geneva 1998. ISBN 92 4 157203 5.

(3) Volume 53 (1983) of the Environmental Health Perspectives journal focused on risks from ingested asbestos.
http://www.ehponline.org/docs/montharch.html

Fluoride And Bone Cancer

Researchers from the Harvard school of Dental Medicine have published the outcomes of a case-control study of osteosarcoma which found a significant association between exposure to fluoride and risks for this rare cancer (1). The newly published paper was not included in the recent review of evidence on the US EPA's fluoride standards conducted by the US National Research Council, although the review committee did assess the PhD thesis from which it was derived (2).

Osteosarcoma is a very uncommon primary malignant tumour of bone. In the US the incidence rate is about 3.3 cases per million children under the age of 15 years. There is evidence that suggests osteosarcoma is associated with skeletal growth, particularly for cases diagnosed during adolescence. Fluoride uptake into bone increases during rapid growth and a number of epidemiological studies have examined possible associations between fluoride exposure and osteosarcoma, with mixed results. Several animal studies have been conducted with one finding an apparent increase in risk only in males, while other studies were negative.

The new case-control study included histologically confirmed cases of osteosarcoma diagnosed between November 1989 and November 1992 at 11 teaching hospitals across the US. Individuals aged 40 years or older were excluded, as were those with a history of radiation therapy or renal dialysis. Matched controls were recruited from patients in the orthopaedic department in the same hospital as the case, who had been seen within 6 months (before or after) the case. Controls were matched by age (+/- 5 years), gender, and distance from hospital.

Information on usual drinking water sources, residential history, use of fluoride supplements and mouth rinses was collected by telephone interview. Where the case was incapacitated or deceased, information was collected from a relative. Information on fluoride levels in public water supplies was collected from water suppliers or relevant state or local authorities, and water samples from private wells were collected and analysed. The fluoride level in bottled water was assumed to be 0.1 ppm based on levels in leading brands. For those who reported bottled water as their drinking water source at home, it was assumed that some tap water would also be consumed in food and outside the home. Fluoride exposure levels in this group were assumed to be the mean of bottled and tap water values.

The data collected from case and controls did not include estimates of the volume of each type of water consumed. An adjustment for the relative exposure from all three drinking water sources in different geographic areas was made by standardising against CDC recommendations for optimum fluoride levels. For example in warmer climates the fluoride level was divided by 0.7 to correspond with the CDC recommended fluoride level of 0.7 ppm. In colder climates the fluoride level was divided by 1.2 to correspond with the CDC recommended level of 1.2 ppm. This procedure provided a weighting for the (presumed) increased consumption of water in warmer areas.

Only the results for cases under 20 year of age were presented in the paper. To examine the association between osteosarcoma and fluoride exposure at specific ages, separate conditional logistic regression

models were fitted for each exposure age up to the age of diagnosis for each case and the same age for the matched controls. The genders were analysed separately.

Of 157 cases diagnosed before 20 years of age, 103 (60 male, 43 female) were included in the analysis together with 215 matched controls. The median age at diagnosis was 14 years. Median family income was significantly lower for cases than controls, and a significantly greater proportion of controls drank bottled water.

Exposure to fluoride at or above the target level among males was associated with an increased risk of developing osteosarcoma compared to the lowest fluoride exposure group. This association was most apparent between ages 4 and 12 with a peak at 6 to 8 years of age. The odds ratio was found to be 4.07 at 7 years for the high exposure group (95% CI 1.43-11.56). After adjusting for potential confounders a similar result was found with an adjusted odds ratio for males of 5.46 (95% CI 1.50-19.90) at age 7 years. In females, no association was found between fluoride in drinking water and osteosarcoma at any age of exposure.

Sensitivity analyses using different assumptions for the fluoride content of bottled water (0.1 to 0.5 ppm) or omitting the adjustment for climate-specific fluoride targets had little impact on the results. A subgroup analysis in males who reported never using fluoride supplements (n=33) produced similar results.

These results suggest that exposure to fluoride is associated with an increased risk of osteosarcoma in young males with the most sensitive exposure period being around 6 to 8 years of age. However there does not seem to be a significant increase in risk for females. In discussing the findings the authors note that odds ratio estimates for the intermediate exposure category (30-99% of target fluoride level) were generally similar to the highest exposure category (99% or more of target fluoride levels), rather than showing a clear dose-response effect. This may have been due to exposure misclassification as it has been reported that target levels for fluoridation are not maintained in many water supplies.

Fluoride exposure in this study was assessed in terms of a semi-quantitative estimate for drinking water sources plus ever/never use of fluoride supplements (rinses, tablets, drops, school programs). It appears that use of fluoride-containing toothpaste was not considered in the analysis. Estimates of average fluoride intakes in the US indicate that for a 6-12 year old child intake from fluoride supplements is 0.0250 mg/kg body weight /day, while intake from non-water sources (including toothpaste) is 0.0219 mg/kg/day (2). Intake from water (assuming a fluoride concentration of 1 ppm) is 0.0178 mg/kg/day. It is perhaps surprising therefore that the odds ratios in the subgroup with no use of fluoride supplements were similar to those for the total group given that their total fluoride intake would be lower than those who used fluoride supplements.

The case-control paper was accompanied by a letter to the journal editor advising caution when interpreting the findings of the paper. The letter from a senior member of the research group that conducted the study, points out that a second case-control study subsequently conducted in the same group of hospitals has failed to replicate the results. A second set of osteosarcoma cases was recruited between 1993 and 2000 from new incident cases, and similar exposure assessment methods were used. Preliminary finding from the overall analysis of the second set of cases do not appear to replicate the overall findings from the first part of the study. In addition, many of the cases and controls recruited in the second time period agreed to provide bone specimens. The preliminary analysis of the fluoride content of the bone specimens suggests that fluoride level within the bone is not associated with excess risk of osteosarcoma. It is recommended that conclusions should not be drawn until publication of the second study which will also examine whether age-specific exposure effects on risk are evident.

(1) Age-specific fluoride exposure in drinking water and osteosarcoma (United States). Bassin EB, Wypij D, Davis RB and Mittleman MA. (2006) Cancer Causes and Control, **17**(421-8).
(2) The outcomes of the NRC review were reported in Health Stream Issue 41.
(3) Caution needed in fluoride and osteosarcoma study. Douglass CW and Joshipura K. (2006) Cancer Causes and Control, **17**(481-482).

Waterborne Outbreaks in England and Wales 1992-2003

A review of waterborne outbreaks occurring in England and Wales during the period 1992 to 2003 has highlighted the elevated risk associated with private water supplies (1). It was estimated that the rate of waterborne illness in people served by private water supplies could be as much as 35-fold higher than the rate in those receiving water from public water systems. The report also showed that more cases of gastroenteritis arose from swimming pool outbreaks during the study period than from outbreaks in private water supplies.

Information on outbreaks was compiled from reports made to the Communicable Disease Surveillance Centre. Reporting of outbreaks is not mandatory in the UK but is facilitated by liaison with a network of local and regional health professionals and agencies. For each outbreak the strength of association with water sources was assessed using a previously developed classification system which incorporates both microbiological and epidemiological evidence to produce a ranking of "strong", "probable" or "possible" association with water.

A total of 89 waterborne outbreaks were identified in England and Wales from 1992 to 2003 (inclusive). The sources of outbreaks and number of cases of gastroenteritis are summarised below:

Water	Outbreaks		Cases	
Source	Number	%	Number	%
Public	24	27	2850	66
Private	25	28	549	13
Swimming pools	35	35	762	18
Rivers	3	3.4	126	3
Fountains	2	2.5		
Total	89	100	4321	

The average annual incidence of cases of gastroenteritis from recognised outbreaks was 53 cases per million population for public water supplies (based on estimates from 1997 census figures of 51,112,600 people served by such supplies). For private drinking water supplies the incidence was 1830 cases per million population (based on an estimate of 300,000 people served by private supplies). This calculation is derived from the number of residents in households served by private water supplies and does not include people who may have short term exposure to private supplies through visiting campsites, hotels, hospitals and other similar facilities. No deaths were attributed to any of the waterborne outbreaks in the 12 year period.

Gastrointestinal pathogens were identified in 62 of the 89 outbreaks (70%). In public water supplies *Cryptosporidium* was by far the most common cause of outbreaks (accounting for 21 of 24 outbreaks). One outbreak in a public supply was attributed to *Campylobacter*, one to *Astrovirus* and one had no pathogen identified. In private water supplies, *Campylobacter* was the most commonly identified pathogen (11 of 25 outbreaks), followed by *Cryptosporidium* (6), *E. coli* VTEC 0157 (3), and *Giardia* (1). Two outbreaks in private supplies were caused by a mixture of *Campylobacter* and *Cryptosporidium*, and in two outbreaks no pathogen was identified. The number of outbreaks in public water supplies has declined since the mid-1990s, with a particularly marked fall since 2000 when regulations relating to *Cryptosporidium* risk management and monitoring were introduced.

Cryptosporidium accounted for the majority of swimming pool outbreaks (32 of 35), with a further two mixed outbreaks of *Cryptosporidium* and *Giardia*, and one of *Giardia. Cryptosporidium* was also implicated in 3 of 5 outbreaks from "other" sources (rivers and fountains), along with one mixed *Cryptosporidium* and *Giardia* outbreak, and one attributed to *Norovirus.* Genotyping information was available for 12 *Cryptosporidium* outbreaks. Of these, outbreaks in 2 public supplies, 1 private supply and 3 swimming pools were attributed to *C. hominis* (which is restricted largely to human hosts). One outbreak in a public supply, 1 in a private supply and 2 in swimming pools were attributed to *C. parvum* (from livestock and humans). One outbreak had a mixture of both *Cryptosporidium* species.

Outbreaks in public water supplies showed peaks in spring and late autumn, while private supplies had a single annual peak in spring and a gradual decline over summer. Not unexpectedly, swimming pool

outbreaks were most likely to occur in late summer/autumn. Previous UK studies of cryptosporidiosis (including non-water sources and non-outbreak cases) have also shown spring and autumn peaks. Springtime peaks may be related to infections in young animals during lambing and calving, and runoff of manure slurry into drinking water sources. The late summer/autumn peak may be attributable to summer travel and subsequent return of infected cases to the UK.

When assessing the strength of evidence linking the outbreaks to water, half of the outbreaks in public supplies were classified in the "strong" category, whereas only one third of private supply outbreaks and one quarter of swimming pool outbreaks fell into this category. Direct microbiological evidence of water contamination was found in only one third of outbreaks. This is likely to reflect the transient nature of many water contamination events, and the time delay between the event, the development and diagnosis of cases of illness, and recognition of the outbreak. The authors note the importance of gathering relevant analytical or descriptive epidemiological evidence to assist in correctly identifying the sources of outbreaks.

Common themes were found to underlie many of the outbreaks identified in this report. These include inadequate levels of water treatment, transient treatment failures, overwhelming of treatment processes by gross contamination of water sources, and use of swimming pools by people already experiencing gastrointestinal symptoms. The report confirms the continuing need to improve the management of private water supplies and swimming pools to reduce the risk of disease outbreaks. Although the total case numbers reported here are not large in relation to the size of the UK population, the true number of people affected by waterborne outbreaks may be considerably larger as many people with gastroenteritis do not seek medical attention even during well publicised outbreaks.

(1) Outbreaks of waterborne infectious intestinal disease in England and Wales, 1992-2004. Smith A, Reacher M, Smerdon W *et al*. (2006) Epidemiology and Infection. doi: 10.1017/S0950268806006406, Published online 11 May 2006

US Groundwater Study

Researchers in the US have commenced a large epidemiological study of microbial disease risks from groundwater. The study has been funded by the Environmental Protection Agency as part of a research program to estimate the incidence of waterborne disease in the US. This program was undertaken at the request of the US Congress after passage of the Safe Drinking Water Amendments in 1996. Previous work in this program included the Water Evaluation Trial in Davenport Iowa which assessed gastrointestinal illness risks from conventionally treated surface water drawn from a poor quality source (the Mississippi River) (1).

The groundwater study is being conducted in 14 communities in the state of Wisconsin which have been chosen from among 40 towns that volunteered to take part. Some of the participating towns currently use groundwater without disinfection for their municipal water supplies, with chlorine treatment being applied only occasionally to disinfect sections of the distribution system following repair work on water mains. The remainder of the towns use chlorinated groundwater. All of the participating communities have sand/gravel or sandstone aquifers which make them potentially vulnerable to microbial contamination. The study is being led by Dr Mark Borchardt of the Marshfield Clinic Research Foundation in Wisconsin, and carried out by a team of researchers from the Foundation and Washington State University.

The Water and Health Trial for Enteric Risks (WAHTER) study will use a randomised design to assess the effect of adding UV disinfection of drinking water on the rates of gastroenteritis in the participating communities. In contrast to the WET study and a previous study of a similar nature conducted in Australia, the WAHTER study will randomise entire towns to receive or not receive centrally installed UV treatment rather than randomising individual households to receive real or sham water treatment devices. This strategy has the advantage that all tap water consumed by participants in the town will have the same type of central treatment whether they are at home, work or school.

A crossover design will be used so that the seven towns initially assigned to receive UV treatment during the first half of the study will have the UV removed for the second half, while the non-UV towns will then receive UV treatment for their water supplies. As the rate of gastroenteritis is higher in children than in adults, the study will focus primarily on assessing the health of children between 6 months and 13 years of age. Families will record information on gastroenteric illness during four 12-week intervals over one year. The study will also collect stool specimens from children with gastroenteritis and analyse them for a wide range of pathogens. A water testing program will examine samples from a subset of households and from the wellheads for each community. The water testing program will be specifically aimed at detection of viral pathogens using a quantitative real-time PCR method.

A total of 673 households with at least one child in this age group have been recruited and enrolled into the study, and the first 12 week observation period has already been completed. The total number of participants is 1786, with data being collected for 1150 children in the eligible age group and 636 adults (participation by adults is voluntary).

Groundwater sources supply over 30% of the US population that is served by public community water systems, and it has been estimated that about 40 million Americans obtain their drinking water from private wells. Almost 95% of rural populations rely on groundwater for drinking and domestic use. Use of undisinfected groundwater is common practice for groundwater systems in the US and many other parts of the world. Groundwater is often perceived as having little or no risk of microbial pathogens but in reality many groundwater sources are vulnerable to contamination. Between 1991 and 2000 groundwater systems accounted for more than two-thirds of drinking water-related outbreaks recorded in the US.

(1) See Health Stream Issue 31 (article) and Issue 38 (literature summary) for details of the WET study.

Circulation Report – Issue 42 June 2006

Circulation for the print version of this issue is 3008 copies, with readers in 63 countries.
In addition, 1251 readers are registered for email notification of new issues.

Australia	2360	Germany	34	Malaysia	21	Saint Lucia	1
Algeria	1	Greece	5	Mexico	1	Singapore	6
Argentina	1	Hong Kong	27	Morocco	5	Slovenia	3
Austria	3	Hungary	1	Myanmar	1	South Africa	9
Belgium	2	India	22	Nepal	5	Sri Lanka	3
Brazil	2	Indonesia	6	Netherlands	14	Sweden	1
Cambodia	5	Iran	1	New Zealand	25	Switzerland	6
Canada	61	Ireland	1	Nigeria	4	Thailand	10
Chile	9	Israel	11	Norway	3	Togo	1
Chinese Taipei	18	Italy	3	Oman	1	UAE	2
Czech Republic	1	Ivory Coast	1	Pakistan	1	UK	65
Cyprus	1	Japan	66	Palestine	3	USA	106
Denmark	2	Jordan	2	Papua New Guinea	5	Yugoslavia	1
Egypt	6	Lebanon	1	Philippines	16	Zambia	1
Finland	1	Lesotho	1	P.R. China	1	Zimbabwe	1
France	28	Luxembourg	1	Russia	2		

News Items

UK Issues Spa Pool Guidance

The Health Protection Agency in the UK has issued a guidance document on management of spa pools aimed at reducing risks of infection by *Legionella* and other pathogens. The document has been produced primarily for managers of commercial spas but also contains information relevant for those who design, manufacture, install and display spas baths, and for home owners. The microbiological risks covered include *Legionella species, Pseudomonas aeruginosa, Mycobacterium avium* and other mycobacterial species, *Naegleria fowleri, Acathamoeba* and enteric pathogens. Brief guidance is also given on non-microbiological aspects such as drowning, physical, chemical and electrical hazards. It is estimated that about 15,000 spas are installed in British homes each year. The new guidelines are not mandatory but are considered to provide an outline of good practice for spa owners and managers. The guidance document can be downloaded from: www.hpa.org.uk

US EPA Loses Case On Stormwater Pollution

The U.S. District Court for the Central District of California recently ruled against the US EPA in a court case brought by the environmental lobby groups the Natural Resources Defense Council and the Waterkeeper Alliance. The case related to sections of the Clean Water Act which require the EPA to "identify categories of sources discharging toxic or nonconventional pollutants for which effluent limitation guidelines (ELFs) and new source performance standards (NSPSs) have yet been published" and to "establish a schedule for promulgation of effluent guidelines" for such sources. According to the plaintiffs, in 2002 the EPA proposed effluent limitation guidelines and new source performance standards for stormwater discharges from the construction and development industry. However following public comment on these proposals the EPA decided not to proceed with national uniform standards for these pollution sources. The EPA argued that it had discretionary power under the Act to remove some pollution source categories from consideration, but the court agreed with the plaintiffs that the Clean Water Act imposed a non-discretionary duty on the EPA to promulgate ELFs and NSPSs for all categories of sources listed in a plan published in accordance with the relevant section of the Clean Water Act.

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

Intake of arsenic from water, food composites and excretion through urine, hair from a studied population in West Bengal, India.
Uchino T, Roychowdhury T, Ando M and Tokunaga H. (2006) Food & Chemical Toxicology, **44**(4); 455-61.

Distribution of urinary selenium and arsenic among pregnant women exposed to arsenic in drinking water.
Christian WJ, Hopenhayn C, Centeno JA and Todorov T. (2006) Environmental Research, **100**(1); 115-22.

Arsenic-contaminated water and extent of acute childhood malnutrition (wasting) in rural Bangladesh.
Minamoto K, Mascie-Taylor CG, Moji K, Karim E and Rahman M. (2005) Environmental Sciences, **12**(5); 283-92.

Assessing the measurement precision of various arsenic forms and arsenic exposure in the National Human Exposure Assessment Survey (NHEXAS).
Pellizzari ED and Clayton CA. (2006) Environmental Health Perspectives, **114**(2); 220-7.

Bromate: concern for developmental neurotoxicity?
Crofton KM. (2006) Toxicology, **221**(2-3); 212-6.

Impact of tetrachloroethylene-contaminated drinking water on the risk of breast cancer: using a dose model to assess exposure in a case-control study.
Vieira V, Aschengrau A and Ozonoff D. (2005) Environmental Health: A Global Access Science Source, **4**(1); 3.

Combining drinking water treatment and hand washing for diarrhoea prevention, a cluster randomised controlled trial.
Luby SP, Agboatwalla M, Painter J et al. (2006) Tropical Medicine & International Health, **11**(4); 479-89.

Drinking water in Michigan: source, quality, and contaminants.
Nathan VR. (2006) Journal of Water & Health, **4** Suppl 1(67-73).

Arsenic

Does arsenic exposure increase the risk for diabetes mellitus?

Chiu, H.F., Chang, C.C., Tsai, S.S. and Yang, C.Y. (2006) Journal of Occupational & Environmental Medicine, **48**(1); 63-7.

Blackfoot disease (BFD) is a peripheral vascular disease and is endemic along the southwestern coast of Taiwan. This disease begins with numbness or coldness of one or more extremities and intermittent claudication and may ultimately progress to gangrene and spontaneous amputation. BFD has been associated with consumption of drinking water containing high levels of arsenic from artesian wells in endemic areas. Some epidemiological studies in BFD endemic areas have reported a dose-response relationship between arsenic in drinking water and prevalence and mortality of diabetes mellitus (DM). In the early 1960s a tap water supply system was implemented in BFD endemic areas on the southwest coast of Taiwan to replace the arsenic-contaminated groundwater and by 1975 nearly all of the affected areas were supplied with municipal water. This study examined whether mortality rates from DM among residents living in BFD endemic areas had changed with the improvement in the drinking water supply system and the elimination of exposure to arsenic.

The study area included four townships on the southwest coast of Taiwan. The current tap water supply for the study area came from the Tzeng-Wen reservoir with an arsenic concentration of less than 0.01 ppm. Information was obtained from the Bureau of Vital Statistics of the Taiwan Provincial Department of Health for the years 1971-2000 on the number of DM deaths. Standardised mortality ratios (SMRs) for DM were calculated - the ratio of the number of DM deaths occurring in the study area to the number of expected deaths given standard rates in each sex and age group.

There were 816 DM deaths in the BFD-endemic area between 1971 and 2000. The means of the 3-year SMRs for DM in the study area were found to be considerably higher than for Taiwan as a whole for both males and females. In females a trend of decreasing mortality rates after the improvement in the drinking water supply system was found with the SMRs decreasing by an average of 1.53 per year from 1971 to 2000 (*P* less than 0.01). There was no significant association found in males.

The findings here might suggest that women are more susceptible to arsenic exposure than men. It may also be possible that women may have consumed more local water than men and therefore the change in water supply had more impact on women. Other possibilities are that men are exposed to more other risk factors related to DM (such as higher body mass index and higher triglyceride concentrations) than are women in the BFD endemic area. Therefore the SMRs for DM in males may not have changed as much as in women after high arsenic consumption ceased.

Comment Changes in mortality rates for diabetes mellitus may not necessarily reflect changes in incidence over time, as mortality also depends on the availability and effectiveness of treatment. This was an ecological study with no information on any changes in other risk factors that may have affected mortality from diabetes mellitus.

Bottled Water

Microbiological evaluation of bottled non-carbonated ("still") water from domestic brands in Greece

Venieri, D., Vantarakis, A., Komninou, G. and Papapetropoulou, M. (2006) International Journal of Food Microbiology, **107**(1); 68-72.

The consumption of bottled water in Greece over the past decade has increased immensely. Bottled water has been marketed as pure and safe for human consumption, and also as ideal for infants and immunocompromised individuals wishing to avoid exposure to pathogens. Concerns have been raised about the microbial quality of bottled water and standards have been set to protect the public from waterborne disease. The microbiological quality of bottled waters is defined by the Greek legislation along with the European Community (EC) Directive of 1980 which states that total coliforms, *Escherichia*

coli, *Enterococcus* spp. and *Pseudomonas aeruginosa* should not be detectable in 250 ml of any bottled water. The upper acceptable limit the EC sets for heterotrophic plate count (HPC) is 100 colony forming units (cfu)/ml for bottled mineral water.

This study evaluated the microbiological quality of 1527 bottled water samples available in the Greek market from 10 manufacturing companies from 1995 to 2003 and assessed compliance with Greek water regulations. All water samples were tested for the presence and enumeration of total coliforms, *E. coli*, *Enterococcus* spp. and *P. aeruginosa* using the membrane filter technique and aerobic bacteria were counted as HPC at 22°C and 37°C.

E. coli isolates were detected in low numbers in 16 (1%) of the 1527 samples and none of them were typed as 0157 strain. *P. aeruginosa* was the most frequently isolated regulated microorganism during the study period, being present in 90 (5.9%) of 1527 samples. Greek legislation states the limits for heterotrophic plate count in bottle water are 20 and 100 cfu/ml after incubation at 37°C and 22°C respectively. Of the 1527 water samples tested 87.9% had HPC of 100 cfu/ml or less at 22°C and 85.6% had HPC of 20 cfu/ml or less at 37°C. However the microbiological analysis did not take place within 12 hours after bottling as specified by Greek water regulations.

Species of *Pseudomonas* other than *P. aeruginosa* were isolated from 9.9% of samples including *P. stutzeri*, *P. testoalcaligenes*, *P. putida*, *P. maltophilia*, *P. diminuto*, *P. fluorescens* and *P. vesicularis*. *Aeromonas hydrophila* was also isolated as well as *Citrobacter freundii*, *Flavobacterium breve*, *Pasteurella* spp., *Providencia alcalifaciens* and *Enterococcus cloacae*. Overall there was a reduction of total coliforms, *E. coli* and enterococci from 1995 to 2003. In total 13.95% of bottled water samples were noncompliant with regulations.

The Greek bottled water industry has improved over the years with the overall reduction of contaminated samples. Manufacturing companies at present have applied Hazard Analysis and Critical Control Point (HACCP) systems as well as ISO (International Organization for Standardization) guidelines in order to have strict manufacturing standards, to control the production process and to ensure the quality of the final product. In general bottled water in Greece meets high quality standards.

Cancer

The association between drinking water source and colorectal cancer incidence in Jiashan County of China: a prospective cohort study

Chen, K., Yu, W., Ma, X., Yao, K. and Jiang, Q. (2005) European Journal of Public Health, **15**(6); 652-6.

The incidence of colorectal cancer (CRC) has recently increased, especially in the developing world. In China the incidence is relatively low apart from in the eastern part of China where there a higher incidence is reported. The highest incidence has been found in Jiashan County in Zhejiang Province, and some epidemiological studies have suggested an association with polluted drinking water. This prospective cohort study was conducted assessing person-years of exposure directly on the relative risks of CRC for different sources of drinking water.

Screening for existing cases of CRC was conducted from 1 May 1989 to 30 April 1990 among 75,842 residents aged 30 years and over in 10 small towns in Jiashan County. At the same time, a face-to-face questionnaire was completed which included information on drinking water source and smoking history and other potentially related factors for colorectal cancer. There were 64,115 residents included in the study and these were classified into five cohorts according to drinking water source (municipal, river, ditch, well or mixed). Cohort members were followed up for CRC incidence until 1 January 2002. For each cohort member, person-years were calculated from the 1 of May 1990 to the end-point. The end-point was classified as the date of diagnosis of CRC, the death date from other causes or 1 January 2001, which ever came first. To estimate the strength of association between the drinking water exposure and CRC, relative risks (RRs) were calculated. Poisson regression was used

to calculate crude and adjusted RRs with adjustment for potential confounding factors.

The majority of people (62.18%) used river water, followed by municipal groundwater (11.23%), well water (10.02%), ditch water (9.72%), and mixed water sources (6.85%). The incidence densities for colon cancer, rectal cancer and the total CRC in the whole cohort were found to be 15.72, 19.84 and 35.56 per 100,000 inhabitants respectively. When people were grouped by water type, the lowest incidence of CRC per 100,000 people was found in the municipal groundwater group (29.61), followed by river water (32.67), ditch water (33.45), mixed water (40.87) and well water (58.67). The incidences of rectal cancer and CRC for well water were significantly higher than for municipal water.

After adjusting for confounding variables, the risks for well water were significantly higher than those for municipal groundwater for colon cancer, rectal cancer and CRC with relative risks of 1.741 (95% CI 1.001-3.029), 2.228 (95% CI 1.432-3.466) and 2.022 (95% CI 1.432-2.854) respectively.

The authors note that well water may become polluted from surface runoff, and that well water also generally contains higher levels of a variety of minerals than surface waters, including some which may be carcinogenic. Jishan County is an agricultural district and fertilizers and persistent pesticides may be present in high concentrations in well water. It is important therefore to control water pollution especially in well water in this district and improve the safety of drinking water sources.

Chemicals

Trichloroethylene-contaminated drinking water and congenital heart defects: a critical analysis of the literature

Watson, R.E., Jacobson, C.F., Williams, A.L., Howard, W.B. and DeSesso, J.M. (2006) Reproductive Toxicology, **21**(2); 117-47.

Trichloroethylene (TCE) is a halogenated hydrocarbon organic solvent primarily used as a metal degreasing agent and is produced as an intermediate in the production of fluorochemicals and polyvinyl chloride (PVC). TCE is volatile and evaporates rapidly when released into the environment. However it occurs as a contaminant in some groundwater supples where it has limited contact with the air and can remain for years. There have been several epidemiological studies conducted and some have linked TCE to health problems including cancer, spontaneous abortions and congenital heart defects (CHDs). However, the results of these studies have been inconsistent. This review paper examines the current epidemiological data on TCE contaminated water and the relationship to CHD, and information gained from animal studies of TCE. CHDs are the most common type of birth defect, and are present in nearly 1% of births.

Published information from epidemiological studies was available from several locations where pregnant women may have been exposure to TCE or related substances predominantly through contaminated groundwater. These locations include: Tucson, AZ; Northern NJ; Woburn, MA; Milwaukee, WI; Santa Clara, CA; San Francisco, CA; Baltimore, MD/Washington, DC area as well as regions of Finland and France. Sixteen studies were reviewed, including 5 which assessed TCE alone, and 11 which examined organic solvents possibly including TCE.

In interpreting the epidemiological data, two major problems were evident. Firstly, the extreme difficulty in quantifying TCE exposure of pregnant women during the first trimester when organogenesis is taking place and the developing heart is most susceptible to environmental impacts. Information on the amount of tap water drunk by the women and the concentration of TCE in the drinking water is needed to quantify exposure. The second major problem is that the majority of the epidemiological studies examined solvents in general and it is not known what the proportion of TCE was in the mixtures of organic solvents. The validity of the data from all of these studies relies on the quality of the parental interview or on how rigorously CHDs were detected and reported in birth defects registries. The limitations of the five studies that specifically examined TCE exposure meant that they are insufficient to support the hypothesis that TCE

contributes to CHD. Studies of mixed solvents with unknown TCE content cannot contribute useful information. Overall the epidemiological studies do not provide any convincing evidence that TCE exposure during pregnancy is associated with increased CHD in offspring.

A number of experimental animal models have been used to assess whether exposure to TCE can adversely impact normal heart development. When extrapolating results of experimental animal exposure studies to humans caution is needed due to significant differences in how rodents and human metabolise TCE. TCE induces peroxisomal proliferation and mutagenicity in rodent hepatocytes while neither of these adverse effects is seen in TCE-treated human hepatocytes. Also, many of the animal studies have been conducted at doses far exceeding what would be expected from environmental exposure and can not be extrapolated to low dose effects on human health. Overall the animal studies do not support an association between TCE and CHDs. Those animal studies which have suggested a relationship specifically between TCE and CHDs were flawed in their design and/or statistical analyses. None of the data from animal studies was adequate or appropriate to extrapolate to the potential risks associated with developmental TCE exposures in humans.

An evaluation of in vivo and in vitro studies which examined the possible biological mechanism of TCE in the heart was also conducted. All CHDs reported after exposure to TCE were grouped by the underlying morphogenetic processes responsible for the defects to see if TCE may disrupt any particular developmental process. There was no shift in the expected distribution of different defect categories. This finding indicates an absence of a specific mechanism, which decrease the probability that TCE causes CHD. To finally evaluate the data, Hill's guidelines of causation were applied to all epidemiological and mammalian animal studies. These guidelines dictate that as more guidelines are met, the likelihood of a causal association increases. There are six requirements that must be mostly met in order to state confidently that an agent is the cause of a given effect. One study fulfilled three guidelines and the majority of studies only supported one. Therefore overall the body of data does not support the hypothesis that TCE is a causal factor in CHDs.

Disinfection Byproducts

Chlorination disinfection by-products in drinking water and the risk of adult leukemia in Canada.
Kasim, K., Levallois, P., Johnson, K.C., Abdous, B., Auger, P. and C.C.R.E.R. Group (2006) American Journal of Epidemiology, **163**(2); 116-26.

A population based case-control study was undertaken to examine the relationship between adult leukemia and levels of exposure to chlorination disinfection by-products, specifically total trihalomethanes and bromodichloromethane in treated municipal drinking water. There is some evidence that consumption of chlorinated surface water is associated with an increased risk of some types of cancers including colon, bladder, kidney, pancreas and possibly brain. The results of the few studies investigating disinfection by-products and adult leukemia have been inconclusive.

Data from the Canadian National Enhanced Cancer Surveillance System (NECSS) was used to conduct this study. The NECSS collected data between 1994 and 1997 on individual risk factors from a sample of 20,755 Canadians recently diagnosed with one of 19 types of cancer. Eight Canadian provinces were included. There were 1,068 cases aged 20-74 years who completed and returned a questionnaire and 5,039 population controls with age and sex distributions similar to cancer cases. The questionnaire included questions about age, gender, ethnicity, educational level, family income, height, weight, residential and job histories, active and passive smoking, alcohol use, source of drinking water, occupation, physical activity, dietary history and occupational exposure to specific carcinogens.

Subjects were asked about the first and last year of residence for each Canadian residence where they had lived for at least 1 year. Information was also collected about the main source of drinking water at the residence. Trihalomethane monitoring data was assembled by NECSS from a variety of sources to create a water quality database. An individual's

exposure was assigned by linking a subject's residence and water source history to the trihalomethane data by time and geographic area. Therefore each subject had for each year of residence in the study period, indicators of exposures of interest including source of water supply, chlorination status and trihalomethane levels. Only exposures occurring over the 40-year period preceding the subject's interview were considered. The analysis was restricted to subjects with 30 or more years of known water history during the 40-year targeted period.

There were 686 cases and 3,420 controls included in the analysis. Of the cases, 161 were acute myelocytic leukemia (AMC) cases, 23 were acute lymphocytic leukemia (ALL) cases, 91 were chronic myelocytic leukemia (CML) cases, 323 were chronic lymphocytic leukemia (CLL) cases and 48 were hairy cell leukemia (HCL) cases. In a comparison with subjects never exposed to chlorinated surface water over the 40-year period studied, a non-significant increase in the risk of CML was observed with increasing years of exposure, with an adjusted odds ratio of 2.20 (95% CI: 0.93 - 5.23) among subjects reporting exposure to chlorinated surface water for 36 or more years. No other obvious associations were found for all leukemias combined as well as other leukemia subtypes with duration of exposure to chlorinated surface water, although the risk was found to decrease by increasing exposure years for most of the leukemia subtypes.

Increasing years of exposure to total trihalomethane (TTHM) levels of more than 20 or more than 40 microgram/litre and to bromodichloromethane levels above 5 microgram/litre were associated with increased risks of CML although statistical significance was reached only for the longest exposures. For the highest exposure duration the adjusted odds ratio for CML was 1.72 (95% CI: 1.01 - 3.08) for a TTHM level of greater than 40 microgram/litre for more than 31 years, and 1.63 (95% CI: 1.00 - 3.10) for a bromodichloromethane level of greater than 5 microgram/litre for more than 24 years. In contrast it was found that the risks of all leukemias combined, CLL, and HCL decreased with increasing years of exposure to TTHMs and bromodichloromethane. The adjusted odds ratio associated with the highest exposure duration to total trihalomethanes of more than 40 µg/litre was 0.60 (95% CI 0.41 - 0.87) for CLL.

The authors comment that it is possible that the risk of adult leukemia varies according to exposure to different types of chlorinated disinfection by-products. TTHMs and bromodichloromethane may be particularly important in the etiology of chronic myelocytic leukemia however the possible protective effect of chlorination disinfection by-products on chronic lymphocytic leukemia is not clear. Further larger studies with long-term exposure measures are needed to confirm the findings here.

Comment This study found weak associations in both harmful and protective directions between different types of leukemia and long term DBP exposures. Few of the odds ratios reached statistical significance and significant trends for protective effects were more common than for harmful effects. The authors noted some weaknesses in the study including a low participation rate of cases (only 53.5% of potentially eligible cases were included in the analysis) and an unexpectedly high prevalence of nonsmokers in the ALL group which may suggest selection bias. The observed associations may have been due to random error or selection bias, rather than a real effect of DBP exposure. Exposure to benzene is currently the only known risk factor for leukemia.

Metals

Lead and copper in drinking water fountains--information for physicians

Cech, I., Smolensky, M.H., Afshar, M., Broyles, G., Barczyk, M., Burau, K. and Emery, R. (2006) Southern Medical Journal, **99**(2); 137-42.

Both lead and copper are potentially toxic metals, although copper is also an essential nutrient. Lead was widely used in the past and even at trace concentrations can cause a variety of undesirable health effects, especially in younger children and pregnant women. Lead can cause foetal abnormalities and its toxic effects include anaemia, mental retardation, neuropathology and physical organ damage. The United States Environmental

Protection Agency (USEPA) estimates that about 20% of human exposure to lead is attributable to drinking water sources. Copper has been widely used in place of lead in household plumbing systems and fixtures. In excessive concentrations it is also toxic. It can cause health problems ranging from gastrointestinal and respiratory irritation to liver, kidney and brain tissue injury. Drinking water does not normally contain significant amounts of lead or copper when it leaves the municipal treatment plants however as water travels within the distribution system, lead and copper may leach into the treated water via contact with corroded lead pipes, lead solder or copper pipes. This study investigated water from drinking fountains of large public access facilities located in the city of Houston, Harris County, Texas for the levels of lead and copper.

In February 2005, water samples from 40 drinking water fountains located in five public access buildings in southwest Houston were tested for concentrations of total lead, total copper, total coliform bacteria and *E. coli.* All samples were collected as first draw at the beginning of the work week. Traces of copper were found in the drinking water of all 40 fountains sampled. Traces of lead were found in 15 (37.5%) of the fountains. The concentrations of total lead ranged from nondetectable to as much as 210 microgram/L. The mean and the standard deviation were 16 ± 48 microgram/L. Concentrations of total copper ranged from 2 microgram/L to as much as 5,043 microgram/L with the mean and standard deviation being 650 ± 958 microgram/L. In two of the buildings, concentrations in some fountains exceeded the USEPA action level for lead by up to 12-fold and for copper by up to 3.9-fold. One water fountain in the basement of a building tested positive for total coliform bacteria and *E. coli*. Buildings that were 30 to 40 years old had higher lead concentrations and buildings that were either newer or older had lower concentrations. The concentration of total lead was significantly correlated with the concentration of total copper (r=0.69, P less than 0.03).

In the February of the year before the present study, sampling of municipal tap water was conducted throughout Houston/Harris County, Texas. Samples of tap water from public access buildings were collected all on the same day excluding water fountains. Concentrations of lead in these samples were all below the limit of detection (0.1 microgram/L) and the mean concentration of total copper was 87 microgram/L ± 110 microgram/L. A comparison was made of these samples with the fountain samples. The exceptionally high concentrations of both metals in several of the drinking water fountains seems to suggest a secondary local contamination source which is probably due to corrosion in the fixtures and plumbing directly at these fountains.

Drinking water fountains were found to be an unexpected source of lead and copper intake. The study findings highlight the need for proper maintenance of water supply equipment, and testing of water quality to assure the public is not exposed to metal and bacterial contaminants.

Comment Although some of the levels lead and copper found in this study were very high, they may not pose the same degree of health risk as a household supply since it is unlikely that the same person would drink the first flush water from a particular public water fountain every day for a prolonged period. For copper, very high levels are likely to cause nausea and vomiting which would have the effect of reducing the amount absorbed.

Protozoa

Emerging opportunistic protozoa and intestinal pathogenic protozoal infestation profile in children in western Nepal.

Easow, J.M., Mukhopadhyay, C., Wilson, G., Guha, S., Jalan, B.Y. and Shivananda, P.G. (2005) Nepal Medical College Journal, **7**(2); 134-7.

In many tropical and subtropical countries, intestinal pathogenic protozoa infestation continues to be a public health concern. In Nepal the annual incidence of intestinal pathogenic protozoa is increasing, with *Entamoeba histolytica* being the most commonly isolated protozoa. Children are particularly prone to these infections in Nepal because of the low socio-economic background and lack of basic sanitary

training. This hospital based retrospective study was conducted over 5 years in the Manipal Teaching Hospital in Pokhara in the western part of Nepal. The intestinal protozoal profile in preschool and school children visiting the hospital with gastrointestinal illness was investigated.

Stool samples were collected from 1790 children visiting the hospital as well as from 100 healthy children in the community with no gastrointestinal illness. There were 354 (19.7%) samples that were positive, with 192 (54.2%) of these having protozoal cycts, trophozoites or oocysts and 162 having helminiths. A significantly higher (*P* less than 0.05) isolation rate of protozoa was found in school-going children (12.2%) than in preschool children (8.9%). The most commonly isolated protozoan parasites was *Giardia lamblia* (73.4%) followed by *E. histolytica* (24.4%). However, in healthy children in the community the infestation rate was 16.0% with isolation of *E. histolytica* being significantly (*P* less than 0.05) higher than that of *G. lamblia*. The isolation rates of *E. histolytica* and *G. lamblia* were significantly higher in summer – monsoon (June-September) and in spring (March-May) than in autumn (October-November) and winter (December – February). The "newer" emerging diarrhoeal pathogens like *Cyclospora cayetanensis* and *Cryptosporidium* sp. were isolated only from immunocompromised (HIV infected) children under 2 years of age.

It is possible that school-going and preschool children but not breast-fed children had acquired the protozoal infestation from the untreated water from their schools and houses. It has previously been documented in Nepal that drinking water can be contaminated with sewage due to the close running of water pipes and sewage lines. There was a lower protozoal isolation rate (12.2%) among school-going children visiting the study hospital with gastrointestinal illness as compared to those from various other Nepalese cities in other published studies. This may be due to better sanitary conditions, water supply and health education in the population in recent years. The isolation of *E. histolytica* and *G. Lamblia* among healthy children from the community suggests that there still a need for improvement in water supply and health education at the basic community level.

Public Perception

Public perceptions of drinking water: a postal survey of residents with private water supplies
Jones, A.Q., Dewey, C.E., Dore, K., Majowicz, S.E., McEwen, S.A., David, W.T., Eric, M., Carr, D.J. and Henson, S.J. (2006) BMC Public Health, **6**(94.

Over four million Canadians receive their drinking water from private water supplies, predominantly from groundwater wells. Canadian private water supplies may pose a threat to public health as the condition of the private water supply is the responsibility of the owners with no regulatory oversight. This study was undertaken to investigate the public perceptions of water from private water supplies in the City of Hamilton, Ontario (Canada). This knowledge will enable public health professionals to better target public education and outreach activities and also address the needs and concerns of residents in their areas. In the City of Hamilton there are approximately 500,000 people with about 20% of households served by private water supplies.

A cross-sectional postal survey was conducted in May 2004 of residents in the City of Hamilton with homes located outside the municipal water supply area. Residences were selected randomly for a pilot study and for the main study. There were 502 questionnaires mailed out, with 246 questionnaires completed and returned. Approximately 71% of responding households supplied by private water wells, 16% by water cisterns and 13% by both. Water directly from the private water supply (ie untreated) was the most common source of drinking water in the home for 33.5% of respondents. Bottled water and treated water from the private supply were the most common source of drinking water in the home for 35% and 31% of respondents respectively. Many households used multiple treatment devices, with water softeners being the most common type.

Most respondents rated the taste, smell, colour, clarity and safety of the water from their private

supply as being either "very good" or "good". There were 27% and 33.8% of respondents who were "very sure" or "sure" that water from their private supply was safe for consumption, respectively. However, 80% of respondents stated they were "very concerned" or "concerned" about the overall safety of the water from their private supply. Bacterial contamination ranked as the most common cause for concern, followed closely by chemicals (such as pesticides or fertilisers) and metals (such as lead). Among those who used some form of water treatment or drank bottled water, a reduction in bacterial exposure was cited as the most important factor in this choice, although reduction of chemicals and improved aesthetic properties also ranked highly.

Among the 79% of households who reported having one or more tests done on their private water supply, the most commonly performed test (88%) was for detection of *E.coli* and coliforms. However 20% of households who reported testing did not know what type of test had been performed. Inconvenience was the main reason cited for never testing water.

Respondents commonly wanted more information about their private water supplies; in particular on where they could have their water tested, how often it should be tested and what testing should be performed. The majority (85%) said they would be "very likely" or "likely" to read a flyer or brochure mailed to their homes. Overall, respondents thought their water supply was of high quality however the majority still had concerns about water from their private supplies and many used bottled water and/or treatment devices. As water testing was performed infrequently, waterborne pathogens could pose an undetected public health risk. The authors recommend increased surveillance testing of these private supplies be conducted and investigation of the association with adverse health outcomes in this population. Increased public education is needed about the importance of regular water testing and the testing process needs to be made more convenient. By understanding what the public's perceptions, concerns and needs are, better public health programs can be designed and implemented.

Recreational Water

Spa, springs and safety

Sukthana, Y., Lekkla, A., Sutthikornchai, C., Wanapongse, P., Vejjajiva, A. and Bovornkitti, S. (2005) Southeast Asian Journal of Tropical Medicine & Public Health, **36** Suppl 4(10-16).

Natural mineral water has been used for bathing and health reasons for thousands of years. Thailand is famous for health spas and natural hot springs which are used by locals and tourists. However as well as health benefits there may be adverse health effects associated with bathing in these spas and springs due to exposure to harmful contaminants. This cross-sectional study examined water samples from 71 sites of natural hot springs, adjoining main-made bathing facilities, hot spring ponds and pools from 12 provinces in northern, central, eastern and southern Thailand for hazardous pollutants in the water.

At each water collection point, the temperature and the pH of the water were recorded. Five hundred ml of water was collected as well as sediments, algae mat and scrapings of biofilm on rock surfaces for detection of *Legionella* and free-living amoebae (*Naegleria* and *Acanthamoeba*). The radon concentration in the water was also determined.

The water temperature from the 71 sites varied from, 28°C to 65°C and the pH varied from 6 to 8. In the northern region 5 of 15 samples had radon levels exceeding the concentration of 11,000 Bq/cubic m which is recommended for safe drinking by the US Environmental Protection Agency. There were no radon concentrations that exceeded the safety level for natural hot springs of 40,000 Bq/cubic m. High radon concentrations found in Mae Hong Son and Chiang Rai Provinces in the north may be related to the type of rock underneath the hot spring sites. Those who use natural hot springs in these areas regularly may inhale radon emissions which could be a threat to their health.

Testing for opportunistic pathogens showed 63.4% of samples were positive for *Legionella*, 24.6% and 13.1% were positive for *Naegleria* and *Acanthamoeba* respectively. The serogroups of

Legionella pneumophila found were 1,3,5,6,7,10 and 14. *Legionella* spp can cause legionnaire's disease (a form of pneumonia) and Pontiac fever (an influenza-like illness). Specific risk factors include frequency of spa use and length of time spent in or around spas. *Naegleria fowleri* is present in fresh water and soil and can reproduce successfully at water temperatures up to 46°C. *N. fowleri* primarily causes amoebic meningoencephalitis with infection acquired by exposure to polluted water in ponds, swimming pools and artificial lakes. *Acanthamoeba* cysts are resistant to extremes of temperature, disinfectants and desiccation. The human pathogenic species of *Acanthamoeba* cause two distinct clinical infections affecting the brain and the cornea.

In Thailand the spa and health business is growing rapidly and increasing in economic importance. This study has highlighted the potential for health risks associated with spa use. Better awareness and implementation of measures to reduce infection risks are needed to maintain this growing industry.

Salmonella

Salmonella Mississippi infections in Tasmania: the role of native Australian animals and untreated drinking water.

Ashbolt, R. and Kirk, M.D. (2006) Epidemiology and Infection, (published on-line 4 May 2006).
doi: 10.1017/S0950268806006224

Salmonella Mississippi is an uncommon serotype in many parts of the world, including mainland Australia. However on the island state of Tasmania this serotype accounts for a large proportion of all notified cases of *Salmonella*, although the overall rate of *Salmonella* diagnosis in Tasmania is less than the Australian average rate. A case-control study was conducted from October 2001 to December 2002 to investigate the routes of transmission of *S.* Mississippi in Tasmania.

Eligible cases of *S.* Mississippi with a recent history of diarrhoea were identified from the notifiable disease register at the Tasmanian Department of Health and Human Services. Eligible controls were recruited from an earlier population survey where subjects were randomly selected using true random digit dialling. Telephone interviews were conducted with subjects (or their parent or guardian if under 15 years of age) by trained interviewers using a standardised questionnaire. Cases were questioned about exposures 7 days prior to the onset of diarrhoea while controls were questioned about exposures in the 7 days prior to interview. Data was collected on possible sources of exposure including: foods consumed, drinking water sources, exposure to animals, recent travel, personal behaviours and demographic information. Untreated water exposure was assessed for the home and outside the home.

There were 89 cases of *S.* Mississippi infection during the study period, with 59 of these enrolled in the study along with 219 controls. No statistically significant associations were found for exposure to farm animals, pet species or specific foods. Cases were more likely than controls to report exposure to environments where Australian native animals may be found. Hand-to-mouth behaviour such as biting or chewing fingers, thumbs or fingernails (and for children less than 5, using a dummy/pacifier) either every day or frequently was reported more often by cases than controls (OR=5.9). The effect estimate was found to be higher for adults and children aged more than 5 years (OR=6.2) compared with children aged less than 5 years (OR=3.0).

Exposure to untreated drinking water at home and when visiting outside the home were both significantly associated with illness, as was the combined variable. Most of the exposure to untreated drinking water was from exposure to water collected in rainwater tanks. Risk estimates were found to be significant for exposure to rainwater tanks (*P* less than 0.001) for both away from home exposure and any rainwater tank exposure. The greatest risk estimate in relation to water was found for exposure to untreated drinking water away from home (adjusted OR=8.06, 95% CI 3.10 - 20.96). This may be because of a lower level of immunity in populations not frequently exposed to *S.* Mississippi. Very high risks were also found for exposure to the native quoll (a small carnivorous mammal) (adjusted OR=11.32 95% CI 2.34 - 54.56) and to native birds (adjusted OR 8.21 95% CI 3.34 - 20.10).

This study showed that indirect exposure to a variety of native mammals, reptiles and birds may pose a risk of infection with *S.* Mississippi in Tasmania. Exposure to untreated drinking water (principally from rainwater collection tanks) is also a strong predictor of infection. It is possible that the native animals are a reservoir of *S.* Mississippi and contaminate land and water environments. Infections rates can be decreased by treatment of water supplies, in particular private rainwater collection systems and by advising people to wash their hands after being outdoors and before eating.

Comment The authors note that the S. Mississippi serotype has not been associated with foodborne transmission in Australia, unlike most other Salmonella serotypes. The rarity of S. Mississippi cases in mainland Australian states despite a high rate of food exports from Tasmania is also consistent with a different mode of spread.

Water Disinfection

Reducing diarrhoea in Guatemalan children: randomized controlled trial of flocculant-disinfectant for drinking-water
Chiller, T.M., Mendoza, C.E., Lopez, M.B., Alvarez, M., Hoekstra, R.M., Keswick, B.H. and Luby, S.P. (2006) Bulletin of the World Health Organization, **84**(1); 28-35.

Diarrhoeal disease is the cause of an estimated 2 million deaths in children each year. Most of these children live in developing countries and are under 5 years of age. Many of these deaths are attributed to using unsafe drinking water. A randomised controlled intervention trial was conducted to examine the effect of an in-home water treatment technology using a flocculant-disinfectant on the longitudinal prevalence of diarrhoea in an area where drinking water is heavily contaminated.

The study was undertaken in rural Guatemala. There were 12 Kachiquel Mayan villages included which were divided into 42 neighbourhoods, or clusters. To be eligible to participate households had to have at least one child younger than 1 year and to have not participated in prior studies. Households were grouped into neighbourhoods with an average of 12 households in each. The intervention group used the flocculant disinfectant which combined precipitation, coagulation and flocculation with chlorination and removed suspended organic matter, bacteria, viruses, parasites and heavy metals. After decanting the water looked considerably clearer and was left with a free chlorine residual of 2 ppm in treated water.

Field workers trained participants to use the flocculant disinfectant and provided them with the equipment necessary to do so. The control group were participants who continued their usual water collection, treatment and storage practices. Two groups of field personnel were used in the study. The first group were 13 local women who were trained as field educators who visited households 1-2 times per week. The second group were field technicians who visited the households weekly and conducted a baseline survey of each household using a questionnaire which collected data on water use. Technicians collected weekly information on whether each household member had had diarrhoea since their last visit. Information was also collected on breastfeeding and the consumption of food and water during the preceding week for children who were less than 2 years old. The field technicians provided intervention households with the sachets of flocculant-disinfectant during their weekly visits. Visits were conducted for 13 weeks from 4 November 2002 through 31 January 2003.

Field technicians collected samples of drinking water stored by the household at baseline to determine chlorine concentration. They also collected samples from stored drinking water during the intervention at weekly visits so the total chlorine concentration and free chlorine concentration could be determined. Additional water samples were collected during unannounced visits, in weeks 3, 6 and 10 after the intervention to determine the chlorine concentration. At baseline and during an unannounced visit in week 3 samples from household water sources and water storage containers were collected to measure *Escherichia coli* and total coliform counts.

Longitudinal prevalence of diarrhoea was calculated as the number of person-days of diarrhoea divided by the total number of person-days of observation. The prevalence of diarrhoea was compared using the Wilcoxon rank-sum test. The incidence of episodes of persistent diarrhoea (more than 13 consecutive days of diarrhoea) was also evaluated.

There were 514 households who completed the whole 13 week study. A total of 98% of drinking water sources were contaminated with *E. coli* at the beginning of the study. All infants were found to have been routinely given drinking water even if they were breastfed. There were 1702 people in households using the flocculant-disinfectant and 1699 people in control households for which weekly data on diarrhoea prevalence was collected. There was a 40% reduction in the longitudinal prevalence of diarrhoea among people living in the households using the flocculant-disinfectant compared with people from the control households (0.9% vs 1.5%, *P* less than 0.001). A 39% reduction in diarrhoea was found among infants from intervention households who were reported to have been breastfed (3.7% vs 6.1%, *P*=0.002) compared with breastfed infant in control households. Also, children under 5 years in intervention households had a significant reduction in the longitudinal prevalence of diarrhoea (2.4% vs 3.9%, *P*=0.002). The greatest reduction in prevalence was found in participants aged 15 years and older in intervention households: 72% lower than controls (0.1% vs 0.4%, *P*=0.006). Children who were less than 1 year old and children who were less than 5 years old had fewer episodes of persistent diarrhoea in the intervention households than did controls. Measurements of free chlorine concentrations showed that intervention households were using the flocculant-disinfectant and *E.coli* measurements also confirmed this.

This study shows that in-home use of flocculant-disinfectant to treat contaminated drinking water can reduce diarrhoea among all age groups and most importantly reduce diarrhoea disease in children under 1 year of age are most at risk of mortality. If this intervention was widely implemented than a reduction in mortality would be expected.

<u>Comment</u> The high rate of disinfectant use seen in this study may not have been maintained in normal circumstances when householders were no longer being frequent visited by the researchers.

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