Health Stream

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Rural And Remote Water Supplies

The Australian Commonwealth Government recently commenced a three year project on rural and remote potable water supplies with the aim of developing a risk assessment framework for prioritising water improvement needs. The project is being undertaken by the Environmental Health Section of the Commonwealth Department of Health and Aged Care, in collaboration with the enHealth Council, and the Bureau of Rural Sciences (BRS).

The project forms part of the Australian National Environmental Health Strategy (NEHS) which was launched in October 1999. The NEHS is based around a set of entitlements and responsibilities, one of the most fundamental being the entitlement to "access to safe and adequate supplies of water" as recognised in United Nations Declaration of Human Rights.

During the development of the Implementation Plan for the NEHS, potable water supplies in rural and remote communities were identified as a priority issue for attention. While it is known that many small community supplies have problems with both the quality and quantity of available potable water, a comprehensive information base is lacking, making it difficult to develop improvement plans and prioritise actions. This project seeks to develop such a database and collect sufficient information to allow relative health risks and community needs to be characterised on a national basis.

The steering committee for the project is composed of a core of key stakeholders from the enHealth Council, Commonwealth Health & Aged Care, the Aboriginal and Torres Strait Islanders Commission, the CRC for Water Quality and Treatment, and the National Health and Medical Research Council. Additional organisations are likely to be become involved in the later stages as the project progresses.

The project comprises three phases:

- A national audit of the current status (quality, availability and access) of rural and remote community potable water supplies; which will inform,
- A comparative health risk assessment of the potable supplies surveyed; followed by the,
- Prioritisation of community water improvement needs, according to the severity of the water quality and access problems, numbers of people affected, health issues, health risks and community input.

In the first phase of the project during 2001, the BRS will conduct a survey of water supplies which serve between 10,000 and 50 people, and fulfill the Australian Bureau of Statistics definition of "rural". Water authorities and others who manage community water supplies will be asked to give a basic description of their system, any current microbial and chemical monitoring programs, and problems with water quality or quantity. Water quality data will also be sought for inclusion into a national database.

The coverage of the compiled data will be assessed and a strategic sampling program will be developed and implemented during the second and third years of the project to fill identified data gaps. Information from previous studies such as the recently completed ATSIC Community Housing and Infrastructure Needs Survey, and data already held by BRS will also be incorporated.

Water quality data and other information relating to the water source, level of protection and type of water treatment will then be used to assess the comparative level of health risk for each water supply. Community consultation on needs and preferences will also be an integral part of the process. The outcomes of the project will serve as the basis for the development of ongoing responses at the federal, state and local level by a range of government departments and agencies.

NZ Standards and Public Health Risk Management Plans

The New Zealand Ministry of Health recently released the Drinking-Water Standards for New Zealand 2000 (DWSNZ 2000). The new Standards will take effect from I January 2001, replacing the previous 1995 version. Although the term standards is commonly used to mean compulsory regulations, the NZ Standards are in fact voluntary, making them similar in nature to the Australian Drinking Water Guidelines.

The DWSNZ 2000 incorporates a number of revisions, including changes in several aspects of microbiological monitoring. *E.coli* has been designated as the sole indicator organism, with the relatively new DST methodology (defined substrate test for the beta-glucuronidase enzyme system) as the referee method for laboratories. Changes have also been made in the statistical methods used to derive monitoring frequencies for supplies of different sizes, resulting in a lower frequency in many cases. Monitoring frequency may be further reduced if specified levels of free available chlorine leaving the treatment plant are continuously monitored. Safeguards against protozoal pathogens are based on documenting the security of groundwater sources, and treatment requirements for surface water and groundwater under the influence of surface water.

In November the Ministry of Health also released a series of draft Public Health Risk Management Plans for water supplies for public comment. The plans are intended to provide water suppliers with guidance on potential sources of public health risk in different components of water supply systems, and the appropriate preventive or remedial measures which should be undertaken to remove or reduce these risks.

Aspects of water supply systems covered by the PHRMPs include; raw water, source abstraction, pre-treatment processes, coagulation /flocculation processes, filtration, disinfection, aesthetic property adjustment, and the reticulation network. The PHRMPs also address the importance of staff training and system monitoring in ensuring safe water supplies.

For each aspect of water supply, several PHRMP modules have been prepared. The modules describe the nature of a particular risk, the reasons why it poses a threat to public health, links to other elements in the water supply system, and a comparative level of risk. In order to apply the plans, water utilities are first required to prepare a flow chart of their water supply detailing the various components. The relevant PHRMPs are then selected for each component of the supply, and the plans are tailored for the characteristics of the individual system. Once the overall structure has been determined, the water utility is to work through the plans to identify:

- Causes of potential risk events
- Preventive measures to avert such events
- Indicators of Performance to determine whether prevention has failed and a risk event has occurred
- Corrective Actions to restore safe and acceptable drinking water
- Contingency Plans to deal with incidents where preventive measures and immediate corrective actions have failed

While the draft PHRMPs are intended to cover the major sources of risk, water utilities should also consider the possibility of events not listed in the plans, and the characteristics of their specific supply system. Existing management practices and operating procedures should then be compared to the theoretical plan derived from the PHRMPs and any missing preventive measures should be noted. The water utility should then develop a priority action list for achieving any missing preventive measures that may be required, taking into account the level of risk and the cost of undertaking prevention.

The Draft PHRMPs are open for public comment until 28th February 2001. When the plans have been finalised, they will be enacted as an amendment to the NZ Health Act. Water utilities will then be required to begin a phased implementation over 5 years, beginning with larger supply systems.

Website: http://www.moh.govt.nz/

US Water Rules

Microbial / DBPs Agreement

An advisory committee comprising US EPA and stakeholder representatives has reached an Agreement-in-Principle on the framework for the Stage 2 Disinfectants/Disinfection Byproducts Rule (D/DBP Rule) and the Long-term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The agreement follows 18 months of negotiation between the EPA and 22 stakeholder organisations. The two rules are scheduled for promulgation in May 2002.

The D/DBP Rule is aimed at lowering levels of disinfection byproducts in drinking water in order to reduce the potential risk of cancers which may be associated with prolonged exposure to high levels of these chemicals. The LT2ESWTR aims at achieving better control of pathogen levels in drinking water and is particularly targeted at *Cryptosporidium*. While the two Rules have separate status, they were negotiated in tandem in recognition that complex risk trade-offs are required to simultaneously achieve both aims [(1)].

The Agreement-in-Principle also includes two recommendations for EPA action in new areas; firstly the development of a program for the analysis and control of public health risks originating from distribution systems, and secondly the development of national water quality criteria for microbial pathogens for stream segments designated as drinking water sources.

D/DBP Rule This rule will require a reduction in peak DBP levels through changes in the way that compliance monitoring is carried out for trihalomethanes (THMs) and haloacetic acids (HAAs). Rather than the present arrangement where sampling locations are located at representative sites, the new Rule will target sampling at peak DBP occurrence sites. Requirements for the timing of quarterly samples will also be tightened to require at least one sample date in the peak historical month for DBP levels, and less variation in the number of days between samples.

Water utilities will first be required to carry out a 1year survey of their water supply system in order to identify sampling locations where peak levels of THMs or HAAs occur. The format of the Initial Distribution System Evaluation (IDSE) varies according to the size of the population served by the system, whether it supplies ground or surface water, and the type of disinfectant used (chlorine or chloramine). Systems with historically very low DBP levels (all samples in last 2 years less than 40 micrograms/L THMs and 30 micrograms /L for HAAs) will not be required to carry out the ISDE.

Once peak DBP occurrence sites have been identified, long term compliance will be based on a Locational Running Annual Average (LRAA) calculated for each site. For large surface water systems, quarterly sampling must be carried out at 4 distribution system sites comprising 1 representative average site from among current sampling locations, 1 site with the highest HAA level and 2 sites with the highest THM levels identified from the ISDE.

Requirements for compliance with the new Rule will be phased in gradually over several years following its promulgation, and during the phase in period, compliance with the prevailing Stage 1 D/DBP rule must also be maintained:

- by 3 years after promulgation all systems must comply with a 120 micrograms per L THM /100 micrograms per L HAA locational running average at current monitoring sites. Those which require capital improvements may have a further 2 years to comply.
- by 6 years after promulgation all large and medium systems must comply with an 80 micrograms per L / 60 micrograms per L LRAA at sites selected by the ISDE. For small systems the time period ranges from 7.5 to 8.5 years depending on their concurrent obligations under the LT2ESWTR. Systems which require capital improvements may have a further 2 years to comply.

LT2ESWTR This rule will apply to all surface water supplies and ground water supplies under the direct influence of surface water, except those which are exempted from filtration. Water supplies will be initially classified into categories (termed "bins") in terms of their *Cryptosporidium* risk in source water. Treatment requirements for measures to remove of oocysts in addition to conventional treatment are then specified in terms of the number of logs removal. Conventional treatment is specified as coagulation, flocculation, sedimentation and granular media filtration. Conventional treatment plants which already operate in compliance with the Interim Enhanced Surface Water Treatment Rule are considered to achieve 3 logs removal of *Cryptosporidium*.

For large systems, the bin classification will be based on the results of a 24 month monitoring program for *Cryptosporidium* using 10 litre samples tested by the EPA Method 1622/23 technique[(2)]. Systems which already have equivalent monitoring data using this technique will not be required to carry out a new monitoring program. Those which already provide 2.5 logs of removal in addition to conventional treatment will be exempt from the monitoring requirement. For small systems a limited program of *Cryptosporidium* monitoring triggered by high E.coli levels has been proposed, but has not yet been finalised.

Bin Requirements Table

Bin No.	**Average *Cryptosporidium* Concentration** (a)	**Additional treatment requirements** (b)
1	< 0.075/L	No action
2	0.075/L to < 1.0/L	1.0 log treatment
3	1.0/L ≤ to < 3.0/L	2.0 log treatment (c)
4	≥ 3.0/L	2.5 log treatment (c)

(a) numbers are uncorrected for recovery efficiency
(b) for systems with conventional treatment that are already in full compliance with IESWTR
(c) systems must achieve at least 1-log of the required removal treatment using ozone, chlorine dioxide, UV, membranes, bag/cartridge filters, or in-bank filtration. (1 log = 10-fold, 2 logs = 100-fold etc.)

In recognition of the widely varying characteristics of water supplies and the diversity of methods that may be employed to reduce *Cryptosporidium* numbers in finished water, a high degree of flexibility is permitted in achieving the required level of removal. The Agreement

describes a "Microbial Toolbox" of preventive and remedial measures under the headings of Watershed Control, Alternative Water Sources, Pretreatment, Improved Treatment, and Improved Disinfection. Under each heading, specific measures are listed together with their associated "potential log credit". By selecting the most appropriate and practical combination of measures for each water supply, a water utility can aggregate credits to provide the required level of additional treatment.

In several areas, water utilities have the option of gaining "extra" credit for a given control measure by carrying out system specific studies to demonstrate that its effectiveness is greater than the standard assumed value. In addition, there is provision for utilities to demonstrate the effectiveness of alternative technologies not listed in the Microbial Toolbox. Enhanced performance verified by peer review programs may also be recognised as evidence of effectiveness (eg the Partnership for Safe Water Phase IV).

Following promulgation of the new Rule, and the classification of a water supply system into a "Bin", the utility will have up to 3 years to achieve compliance. An additional 2 years may be granted where capital expenditure is required. The Agreement-in-Principle also recognises that the rate of implementation of the Rule may be limited by the availability of accredited laboratories to carry out *Cryptosporidium* monitoring by the approved method.

It is anticipated that many utilities will choose to add UV treatment to their conventional treatment plants as this technology alone is considered to provide an additional 2.5 logs of removal. However it is acknowledged that while small scale experiments have indicated that UV is highly effective against *Cryptosporidium*, information is presently lacking on its suitability for full scale plants, and on many practical engineering issues. In the interval prior to promulgation of the Rule, the EPA has undertaken to develop standards for compliance of UV treatment systems, dosage tables and appropriate guidance manuals. The EPA will also carry out an estimate of public health effects, and a health risk reduction and cost analysis. The Agreement also includes an undertaking that the EPA Science Advisory Board will be asked to comment on the proposed Rule.

Arsenic Rule

The EPA proposal to reduce the Maximum Contaminant Level (MCL) for arsenic from 50 ppb to 5 ppb (ppb=micrograms/litre) has drawn criticism from many sources including the American Water Works Association (representing US and international water supply professionals) and the Association of State Drinking Water Administrators (representing US drinking water program regulators).

After the public issue of the proposed Rule, the AWWA found that the cost calculation formulae made available by the EPA did not match those described in the Regulatory Impact Assessment. A revised set of formulae were released by the EPA in a Notice of Data Availability, but again according to the AWWA, these did not match the unit cost curves in the RIA. Thus it not possible for other parties to carry out independent verification of the EPA cost calculations.

Numerous aspects of the cost-benefit analysis have also been questioned by the Drinking Water Committee of the EPA's own Scientific Advisory Board (DWC/SAB). The DWC/SAB conducted a 3 day meeting to examine the issues and produced a report to the EPA in September this year. The committee commented that its deliberations were hampered by a lack of detail on the operation of the "decision tree" developed by the EPA to estimate the likely costs of different treatment options for water supplies. Based on the information available to the committee the model did not appear to account for the costs of several important components (eg land acquisition, training and certification of operators, chemical costs), EPA assumptions about the efficiency of arsenic removal treatments in full scale plants are generally unproven, and the presentation of single cost figures does not indicate the degree of uncertainty in the underlying assumptions.

The committee also concurred with submissions from the water industry that disposal of arsenic-

containing waste to sewers or streams would often not be possible either due to toxicity or other characteristics such as TDS load. Disposal mechanisms will therefore add significantly to the costs of compliance.

The DWC/SAB expressed the opinion that the EPA had misinterpreted some of the conclusions of the National Research Council's (NRC) arsenic report. In this report the NRC carried out an assessment to determine whether the available human data were adequate to provide the basis for risk modelling. The EPA has accepted this exercise as an actual risk assessment, rather than exploring alternative methods of assessing risk. Overall the DWC/SAB suggested that in the light of large uncertainties both in costs and health benefits, a phased reduction in the arsenic MCL under the Rule would be preferable. This would provide the opportunity to verify cost assumptions and improve estimates of the health benefits. The EPA is required to issue the final arsenic regulation by June 22, 2001.

(1) See Health Stream Issue 14 for a discussion of the estimated benefits and costs of the Stage 1 D/DBP rule and the IESWTR.
Health Stream Issue 16 discusses differences between US EPA and Centers for Disease Control estimates of waterborne cryptosporidiosis (one of the main drivers of the IESWTR) .
(2) EPA Methods 1622 and 1623 are described in Health Stream Issue 14 p7.

Walkerton Update

The boil water advisory for the Canadian town of Walkerton was lifted on 5 December, more than 6 months after it was imposed because of a waterborne disease outbreak. The outbreak, predominantly caused by *E.coli* O157 and *Campylobacter*, resulted in 7 deaths and widespread illness, and led to the establishment of a judicial inquiry by the Ontario government [(1)].

An epidemiological report, released by the Bruce-Grey-Owen Sound Health Unit on 10 October, confirmed the most likely cause of the outbreak as contamination of one of three wells serving the town by runoff from a cattle farm following heavy rainfall and flooding in mid-May.

Testing of livestock at 13 farms within a 4km radius of the wells showed the presence of *Campylobacter* at nine farms, and both *E.coli* and *Campylobacter* at two farms. Molecular finger-printing of the bacteria showed those at the farm closest to Well No. 5 were identical to the isolates in the majority of human infections during the outbreak. This well was closed when the outbreak was detected. The flooding in May is believed to have overwhelmed the water disinfection system with an increased pathogen load and high turbidity, however low level contamination probably occurred at least one month earlier as some people who became ill in April had the same *E.coli* genotype.

Investigation of the hydrological characteristics of the wells supplying the town have shown that all three may be subject to surface water influence. According to a report by consultants engaged by the Ontario Ministry of the Environment, pools of surface water can be observed to infiltrate into the ground and a nearby natural spring reverses its flow whenever the pump at Well No. 5 is activated. These clear indications of surface water infiltration and a long history of turbidity increases and faecal indicator bacteria in the well resulted in the recommendation that the well be plugged and abandoned, as it cannot be made secure from contamination. Several other wells which have not been used for some years have also been plugged to improve the security of the groundwater supply.

Wells No. 6 and 7 were found to have a lesser degree of surface water influence, and have been retained as the town's water supply. However a hollow-fibre ultrafiltration system and improved chlorination equipment have been installed to ensure that water treatment is adequate to deal with potential contamination events. A control system of on-line monitoring, alarms and automatic shutdown has been installed, and a wellhead protection program will also be undertaken to provide a higher degree of security. In the longer term, the feasibility of providing an alternative water supply (by pipeline from another source, or from a new well field), or alternative treatment for the current supply will be explored.

Prior to the lifting of the boil water notice, a extensive decontamination program was carried out on the Walkerton water supply system at an estimated cost of CA$11 million. This included:

- the elimination of potential cross connections from 39 private wells and 474 private cisterns (many residents use rainwater cisterns as a source of soft water as the Walkerton municipal supply is hard)
- flushing of water mains, storage standpipes, and dead ends
- swabbing of 41km of mains, and 31 km of 400mm to 100mm pipes at least 4 times
- replacement of 5km of 100mm cast iron mains which had extensive mineral encrustation and could not be effectively swabbed
- hyperchlorination and flushing of pipes in 1816 individual buildings

More than 5,000 water samples were tested to confirm the effectiveness of the decontamination program. The program was audited by the Ontario Ministry of the Environment which concluded that restoration work had brought the Walkerton supply into compliance with the Ontario Drinking Water Standards. On receiving this advice and the results of independent monitoring tests, the Bruce-Grey-Owen Sound Health Unit recommended the lifting of the boil water notice, and this was supported by the Chief Medical Officer of Health for Ontario.

The Walkerton Inquiry(2) began hearing evidence on 16 October and is expected to continue for several months. A number of witnesses have testified that the town's chlorination equipment was unreliable or improperly operated, and that records were falsified prior to inspections by Ministry of the Environment officials. The Walkerton Public Utilities General Manager, who reportedly denied problems with the water supply when directly questioned by local health officials at the time of the outbreak, is expected to give evidence in late December.

(1) Refer to Health Stream Issues 18 and 19 for earlier reports on the Walkerton outbreak.
(2) www.walkertoninquiry.com

UK Fluoride Report

A team of researchers from the University of York recently delivered a major report on the human health effects of drinking water fluoridation to the British government. The report reviewed evidence on five questions:

Objective 1: What are the effects of fluoridation of drinking water supplies on the incidence of caries?

Objective 2: If water fluoridation is shown to have beneficial effects, what is the effect over and above that offered by the use of alternative interventions and strategies?

Objective 3: Does water fluoridation result in a reduction of caries across social groups and between geographical locations, bringing equity?

Objective 4: Does water fluoridation have negative effects?

Objective 5: Are there differences in the effects of natural and artificial water fluoridation?

A total of 3231 references and submissions were considered and assessed against predetermined relevance criteria. The criteria were fulfilled by 732 references. These references were then examined to determine whether they fitted inclusion criteria relevant to positive effects (dental caries prevention) or negative effects (dental fluorosis, osteoporosis, cancer etc). The quality and validity of each of the 214 included studies was then rated on a points scale for specific design features and a three level scale for susceptibility to bias. The review found that research in this area was only of low to moderate quality, with few studies achieving high scores for validity and freedom from potential bias.

The overall findings of the review were:

Objective 1: (26 studies) The evidence suggests that fluoridation reduces caries prevalence whether this is measured by the proportion of children who are caries-free or by changes in the average number of decayed /missing/ filled teeth (DMFT). Due to the limited quality of the studies it is difficult to ascertain the exact degree of benefit, however it was estimated that for 1 additional person to remain caries-free, six people would needed to receive fluoridated water.

Objective 2: (9 studies) The evidence suggests the fluoridation continues to confer benefits despite increased exposure to fluoride through other routes (eg toothpaste).

Objective 3: (15 studies) Research was limited and of particularly poor quality, but there was some evidence that fluoridation reduced health inequalities in relation to DMFT in 5-12 year olds. However no difference was seen in caries-free prevalence in 5 year olds. The reviewers urged caution in interpreting these results.

Objective 4:
Dental Fluorosis (88 studies) This was the most widely studied negative effect of fluoridation, but studies were mainly of low quality and susceptible to bias. Nevertheless a dose-response relationship with water fluoridation was evident. It was estimated that at 1.0 ppm about 12.5% of people may have fluorosis of aesthetic concern.
Bone fracture and bone development problems (29 studies) This was the next most frequently studied adverse effect after dental fluorosis. For hip fractures there was sufficient evidence to carry out a meta-analysis which showed no association of fractures with fluoridation. For other fractures the evidence was less abundant but again no effect was evident.
Cancer (26 studies) There was no association between fluoridation and the incidence of all cancers, nor with osteosarcoma and other bone/joint cancers. No association was seen in 2 studies of thyroid cancer.
Other possible negative effects (33 studies) a diverse range of potential adverse effects has been studied, but most research has been of poor quality. There is insufficient evidence to draw conclusions.

Objective 5: Very few studies have compared the effects naturally and artificially fluoridated waters. From the little evidence available, no major differences in effect were apparent.

In its discussion the review team commented on the methodological limitations and poor quality of much of the research on the effects of water fluoridation, and the consequent difficulties in interpretation of the results.

Vancouver Turbidity Study

A Canadian research group has released a report describing a relationship between drinking water quality and measures of community gastro-enteritis in Vancouver. The report has not been subject to formal independent peer review as is the normal procedure for publication in high quality scientific journals, although the authors circulated draft versions for comments by other scientists. Not all reviewers supported the methodology nor the interpretation of the results.

The Greater Vancouver Regional District has a population of about two million, and is served by an unfiltered chlorinated water supply. This supply is drawn from three catchments which are closed to public access and farming. Although it is not mentioned in the report, substantial logging activity has been permitted in the catchments, producing deforested areas and sediment runoff during heavy rainfall. Turbidity peaks up to 19 NTU were recorded during the study period.

The study used a complex statistical modelling analysis to look for correlations between water quality parameters (mainly turbidity) and three measures of gastroenteritis (hospital admission data, physician billing data, and paediatric hospital emergency room visit data) from 1992 to 1998. The analysis was conducted separately for the three water supply areas and zones with mixed supply were excluded.

It was estimated that variations in drinking water turbidity were associated with 1.6% of all gastroenteritis-related physician visits, 0.6% of gastroenteritis-related hospital admissions and 1.6% of gastroenteritis-related paediatric hospital emergency room visits over the 6 year period.

Comment The methodology is similar to that of previous studies in the Philadelphia water supply, however here the measured changes in turbidity are much greater. In the previous studies serious doubts about the data quality and methodology were raised by an EPA peer review (See Health Stream Issues 8 and 9).

Website: http://www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/vancouver_dwq.htm

News Items

Bottled water contamination incidents
The New York health department has been criticised for delaying notification to the Mayor's Office of several cases of bottled water contamination. In early September several people reported illness after drinking two different brands of bottled water. The health department began an investigation and notified local police and the FBI, but did not contact city officials who were unaware of the incidents until questioned by the media several days later. It was reported that several of the cases involved ammonia contamination.

Two brands of British mineral water were recalled on 22 November when tests showed the presence of faecal indicator organisms in samples taken in October and November. The recall affected supplies for office water coolers as well as bottled water in a range of containers. The natural mineral water comes from bores in a chalk aquifer in the Chiltern Hills, which is believed to have become contaminated after heavy rainfall.

Campylobacter outbreak
A suspected waterborne outbreak of *Campylo-bacter* has occurred in a housing estate in Wales. The estate is situated on elevated ground and supplied from a gravity feed tank fed by a pump from the main municipal supply. Fifteen people became ill between 17 and 24 September, with Campylobacter infection confirmed in all but one case. There was no common exposures from food sources, however routine water samples taken from the water storage tank on 18 September were positive for total and faecal coliforms. Samples taken on and prior to 15 September were clear. The water supply system was chlorinated and flushed, and tests will be carried out to check the physical integrity of the tank.

Cryptosporidium takes wing
Researcher Dr Thaddeus Graczyk has demonstrated transmission of *Cryptosporidium parvum* by flies feeding on calf faeces. The experiment involved trapping wild filth flies from a barn containing *Cryptosporidium* infected calves, and a control study with uninfected calves. Oocysts on the surface of the flies were removed and used to infect mice. The results suggested that flies could carry oocysts for at least three weeks, and infectivity was retained. Similar results were reported with flies raised on cattle faeces in the laboratory. Dr Graczyk has previously shown that *C. parvum* oocysts retain infectivity during passage through the digestive tract of birds (although they cannot grow in these hosts) and can be accumulated by oysters.
Comment This finding is not unexpected - indeed the "5 Fs" (food, fingers, faeces, flies and fomites) have long been recognised as the main vectors of infectious gastrointestinal disease.

US Marines health study
The US Marine Corps is to undertake a study of an estimated 16,500 military families who may have been exposed to chemically contaminated drinking water at Camp Lejeune in North Carolina. The chemicals tetrachloroethylene and trichloroethylene were first discovered in the groundwater supply to the camp in 1982, and the wells were capped in 1985. The contamination is believed to have come from a dry cleaning business. It is suspected that the chemicals may be associated with increased risks of childhood cancers and birth defects.

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From the Literature

Arsenic
Risk of internal cancers from arsenic in drinking water.
Morales KH, Ryan L, Kuo TL, Wu MM, Chen CJ. Environ Health Perspect (2000) **108**:655-61.

The US EPA is currently under congressional mandate to revise the current standard for arsenic in drinking water of 50 micrograms/L. This paper presents a risk assessment for internal cancers from exposure to arsenic in drinking water based on reanalysis of previously published data from Taiwanese studies. Risks for bladder, liver and lung cancers are examined using several statistical approaches.

The results show that the exposure-response assessments are dependent on the model applied and whether a comparison population is used. A

wide range of risk predictions were obtained, and the authors conclude that the overall results indicate the current US standard of 50 micrograms/L is not adequate in protecting against cancer risks.

Comment The limitation of the ecological studies conducted in Taiwan are well documented (ie no assessment of individual arsenic exposure, no control for high rates of smoking as a potential confounding cause of cancer, high arsenic intake from food, poor nutritional status leading to possible lack of comparability with western populations). The authors of this paper found that the observed data could be fitted equally well to any of several statistical models although the EPA chose to use only one in its recent NODA on arsenic. It should also be noted that the models applied here are not necessarily based on plausible biological mechanisms.

Arsenic in drinking water and bladder cancer: Comparison between studies based on cancer registry and death certificates.
Guo HR, Tseng YC. Environ Geochem Health (2000) **22** p83-91.

A study was conducted in Taiwan examining the associations between arsenic in drinking water and bladder cancer. The National Cancer Registry was used to identify diagnosed cases of bladder cancer from 1980 to 1987, and death certificates were used to identify fatalities attributed to bladder cancer from 1971 to 1991.

Data from the National Cancer Registry Program included 243 townships for which arsenic levels in drinking water were measured. From the death certificates, 140 villages in 10 townships in southwest Taiwan were included. Arsenic levels in drinking water were determined from a nationwide survey of wells published in 1977.

The results of data analysis from the cancer registry and from the death certificates were consistent. Population exposures to arsenic of levels above 0.64 mg/L (640 ppb) in drinking water were significantly associated with increased incidence and mortality of bladder cancer in men and women. Exposures to water arsenic levels lower than 0.64 mg/L were not significantly associated with incidence of bladder cancer.

Chronic arsenic exposure and risk of infant mortality in two areas of Chile.
Hopenhayn-Rich C, Browning SR, Hertz-Picciotto I, Ferreccio C, Peralta C, Gibb H. Environ Health Perspect (2000) **108** p667-73.

This study compared rates of stillbirth and infant mortality over time in two areas in Chile. An area with historically high water arsenic levels (Antofagasta) was compared with an area of low arsenic concentrations in the drinking water (Valparaiso). The study period spanned 47 years from 1950 to 1996 and included a sharp increase in drinking water arsenic levels in Antofagasta in 1958 (when a new water source was connected), and a subsequent decrease in arsenic levels beginning in 1970 (when an arsenic removal plant was added to water treatment). A retrospective ecological design was used with data on vital statistics and environmental measurement of arsenic levels for the study period.

There was a general decrease in infant and late foetal mortality rates in Chile during the study period, and rates in both study areas also declined. However despite the overall decline in rates there was a relative elevation in late foetal, neonatal and postnatal mortality rates in Antofagasta coinciding with the period of highest arsenic concentration in drinking water. Poisson regression analysis showed elevated rate ratios for high arsenic exposure in association with late foetal mortality (RR = 1.72, CI 1.54-1.93) with neonatal mortality (RR = 1.53, CI 1.40-1.66) and postneonatal mortality (RR = 1.26, CI 1.18-1.34).

At the beginning of the study period average arsenic levels in Antofagasta drinking water were 90 micrograms/L (90ppb), and when the new water supply was introduced arsenic levels rose to 860 micrograms/L. After commissioning of the arsenic removal plant in 1970, arsenic levels fell to about 110 micrograms/L and continued to gradually decrease, reaching 40 micrograms/L by 1988. Levels of arsenic in Valparaiso water were not measured prior to 1990 when a level below the detection limit (20 micrograms/L) was

recorded, but are believed to have been consistently low. A recent survey showed levels to be less than 5 micrograms/L.

Overall the study suggests that exposure to high levels of inorganic arsenic from the drinking water supply may be associated with an increase in risk of infant mortality. The greatest risk maybe for late foetal mortality. The associations were still found after adjustment for geographic location and calendar time. Since the late 1970s, fetal, neonatal and postneonatal mortality rates have been similar in both towns.

Comment *The authors note that the study may have been affected by unmeasured confounding factors such as other environmental exposures which may have differed between the two towns (Valparaiso is in an agricultural area while Antofagasta is a centre for mining and smelting industries), although it seems unlikely that changes in other exposures would have coincided with changes in arsenic levels. Reporting of births and/or deaths may also have been incomplete especially in the early part of the study period. The peak arsenic levels in Antofagasta water were much higher than current regulatory levels in developed nations.*

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Chemical contamination

Ammonium perchlorate contamination of Colorado River drinking water is associated with abnormal thyroid function in newborns in Arizona.

Brechner RJ, Parkhurst GD, Humble WO, Brown MB, Herman WH. J Occup Environ Med (2000) **42**(8) p777-782.

This ecological study examined the possible effect of ammonium perchlorate contamination of drinking water on newborn thyroid function. Perchlorate affects thyroid function by acting as a competitive inhibitor of iodide transport in the thyroid. If iodine intake is normal or low, perchlorate can inhibit iodide accumulation causing goiter and hypothyroidism.

A comparison was made between Thyroid Stimulating Hormone (TSH) levels in newborn infants in two Nevada towns; one with 6ppb perchlorate in drinking water, and one with an uncontaminated supply. Median TSH levels were lower in the town with contaminated water although no specific adverse effect is presently known to be associated with this condition. A previous study did not show any relationship between perchlorate in drinking water and diagnosed rates of congenital hypothyroidism.

♦

Cryptosporidium

Contaminated drinking water in one town manifesting as an outbreak of cryptosporidiosis in another.

McAnulty JM, Keene WE, Leland D, Hoesly F, Hinds B, Stevens G, et al. Epidemiol Infect (2000) **125** p79-86.

During the first 4 months of 1992 an increase was observed in the number of cases of *Cryptosporidium* reported to the local health department in the town of Medford, Jackson County, southern Oregon. An initial investigation revealed no common exposures to swimming pools, farm animals, day care centres etc, however all but one patient reported drinking Medford municipal water in the 2 weeks before symptom onset.

On 1 May, *Cryptosporidium* oocysts were detected at low levels in Medford Water Commission samples taken in April and an advisory to boil water was issued. While a large proportion of the population boiled their water, others used bottled water or filled containers from nearby towns including Ashland and Talent. The outbreak became worse and within a week more cases were reported including a clusters from a Medford long-term-care facility (LTCF) and following a wedding in Talent, as well as unrelated cases throughout the county.

An unmatched case-control study was conducted among employees of the LTCF to determine the cause of the outbreak. Illness was found to be strongly associated with drinking water that had been trucked to the facility from the town of Talent. A matched case-control study was conducted to determine the risk factors associated with community acquired cryptosporidiosis. It was found that 46% of cases reported drinking

Talent water in the two weeks before symptom onset, compared to 6% of controls.

A retrospective cohort study of wedding attendees was conducted and all reception attendees were interviewed. It was found that everyone drank Talent water at the reception or within the previous 24 hours. Diarrhoea lasting at least 3 days was most common among attendees who lived outside Jackson County, less common among persons who lived elsewhere in Jackson County, and no illness was reported among Talent residents. A telephone survey was conducted in mid-May among residents of Medford and Talent to determine prevalence of cryptosporidiosis-like illness. Among Medford residents those who reported drinking Talent water in the previous 10 days were no more likely to report illness than those who did not drink Talent water.

Plant records were reviewed from the two water filtration treatment plants supplying Talent, and raw and treated water samples were analysed for *Cryptosporidium.* Turbidity levels at one of the treatment plants were greater than 1 NTU on 32 out of 61 days in April and May. This plant was the major supply to the town and much of its influent water comprised sewage discharge from an upstream plant and agricultural runoff. No *Cryptosporidium* oocysts were detected in treated or untreated water at the plant in May. During the outbreak period Medford was supplied by chlorinated unfiltered water from a spring.

The evidence indicates that most if not all of the later cases in this outbreak stemmed from the consumption of Talent water. Consumption of Medford water may have accounted for some cases. Person-to-person spread of the illness may have accounted for many of the remaining cases. Talent residents were less likely to report clinical illness than were other people who drank Talent water. The most probable explanation for this is immunity among Talent residents. This investigation highlights the need for thorough investigation of outbreaks, and suggests that when water contamination is identified visitors may be at increased risk compared to residents.

A serological survey of college students for antibody to *Cryptosporidium* before and after the introduction of a new water filtration plant.

Frost FJ, Muller T, Calderon RL, Craun GF. Epidemiol Infect (2000) **125**(1) p87-92.

In a large city in the northeastern United States in April 1997, drinking water treatment practices were changed from chlorination only to filtration and chlorination of surface water. To determine whether water filtration reduces the risk of waterborne *Cryptosporidium* transmission, college students were tested for serological responses before and after water filtration.

A serological survey was conducted in March 1997, one month prior to filtration and again in September, 5 months after filtration commenced. Blood was collected from students from a local commuter college serving the city and surrounding communities. Students also completed a questionnaire. Sera were analysed by immunoblot to measure IgG serological responses to 15/17-kDa and 27-kDa *Cryptosporidium* antigens.

In the first survey 107 students were screened and 225 were tested in the second. For the 15/17-kDa antigen, 19% of students had a detectable response in the first survey and 24% had a detectable response in the second survey (*P=0.63,* not significant). For the 27-kDa antigen, 27% of people had a detectable response in the first survey and 41% in the second (*P=0.02,* significant increase). A detectable response was defined as more than 10% of the intensity of a positive control sample.

Changes in serological responses (either increasing or decreasing) were not found to be associated with gender, travel, or exposure to pets, diapers or a household child in day care, and not drinking tap water or drinking bottled water. Relative to the positive control, swimming in a lake, stream or pool predicted a significant 18% increase in the intensity of the response to the 27-kDa marker. Consumption of untreated water from a lake or stream predicted a significant 32% increase in intensity of response to the 15/17-kDa marker. Participants in the second survey had a significant 14% more intense response to the

15/17-kDa marker and a significant 16% increase for the 27-kDa marker.

The overall results of the study suggest levels of *Cryptosporidium* infections did not decline markedly with water filtration. However the two surveys were not conducted at the same time of year and there may have been a seasonal changes in the risk of *Cryptosporidium* infection from one survey to the other.

Comments This study did not include follow up of individuals, and only 15% of participants in the second study also participated in the first study. Thus changes in individuals could be analysed only in a minority of cases. No information was reported on illness in participants in this study, but previous research has shown increases in Cryptosporidium antibody responses often occur in the absence of illness.

♦

DBP Exposure Assessment

Household exposures to drinking water disinfection by-products: whole blood trihalomethane levels.

Backer LC, Ashley DL, Bonin MA, Cardinali FL, Kieszak SM, Wooten JV. J Expo Anal Environ Epidemiol (2000) **10**(4) p321-326.

When examining the association between exposure to disinfection by-products such as trihalomethanes (THMs) and potential adverse health effects, all forms of exposure must be considered not just water consumption. This study examined individual exposure to THMs through other routes of exposure such as dermal absorption and inhalation. Whole blood levels of THMs in individuals exposed through household activities such as drinking and showering, or bathing in tap water were considered.

Thirty-one adult volunteers from Atlanta, Georgia participated. Volunteers agreed to participate in one of three activities: showering of 10 min with tap water, immersing themselves for 10 min in a bathtub filled with tap water, or drinking 1L of water during a 10 min time period. Water samples were collected during the bathing and showering sections, and water temperature was measured. Participants also provided 10 ml blood samples, one immediately before the exposure, one 10 min after exposure ended and one 30 min (for shower and bath exposure) or 1 hour following the end of exposure (for ingestion).

The highest median levels of THMs in blood samples were found in those who had 10 min showers and the lowest median levels in those who drank 1L of water in 10 mins. The highest blood levels of each THM were found in samples collected 10 min after exposure ended. The second blood samples (taken 30 or 60 mins later) showed a significant decrease in THM levels but where still higher than baseline levels. There were significantly greater increases in blood THM levels from showering or bathing than the increases from drinking 1L of water.

This study confirms previous research showing that the dermal and inhalation routes are likely to make a significant contribution to total THM exposure.

Comment A similar situation is likely to be true for some other DBPs depending on their volatility (relevant for inhalation) and lipophilic character (relevant for dermal absorption).

♦

DBPs and Cancer

Case-control study of colon and rectal cancers and chlorination by-products in treated water.

King WD, Marrett LD, Woolcott CG. Cancer Epidemiol Biomarkers Prev (2000) **9** 813-818.

To assess the relationship between chlorination by-products and colon and rectal cancers, a case-control study was conducted in southern Ontario, Canada. Cases were residents 30-74 years of age, who had a diagnosed primary cancer of the colon or rectum between September 1992 and May 1994 and were identified from the Ontario Cancer Registry. Eligible controls were selected randomly from a database of residential listings.

Participants were given a questionnaire to gather information on demographics, other potential risk factors, and information about primary exposures of interest. Volume of tap water consumed was calculated using reported daily consumption of water and beverages or foods made with water. A

database characterised each water supply in the study area according to source, chlorination status, and level of trihalomethanes (THMs) by geographical area and time. Individual exposure was calculated by linking residents and water source information to the relevant treatment plant data by time and geographical area. Only subjects with more than 30 years of known residential water history were included.

The final analysis included 767 colon cases, 661 rectal cases and 1545 controls. Among males, long-term exposure (over 35 years) to a THM level above 75 micrograms/L was associated with a doubled colon cancer risk (OR, 2.10, 95% CI, 1.21-3.66). The highest quartile of cumulative THM-years exposure was associated with an OR of 1.74 (95% CI, 1.25-2.43). Among females the risk of colon cancer was not positively associated with exposure to THMs. Inverse associations were found for those exposed to a THM level of more than 50 micrograms/L for 20-30 years and the highest quartile of THM-years. For rectal cancer no associations were found for either sex.

Subjects who had at least 30 years of exposure within a single level of exposure (with respect to ground versus chlorinated surface water or THM level in three categories) were analysed. Among males, use of chlorinated surface water for at least 30 years was associated with a 49% increased risk of colon cancer relative to those served by ground water. Colon cancer risk also increased with THM concentration. Among females water source was not associated with colon cancer risk. A reduced risk of colon cancer was observed for females exposed to THM concentrations between 25 and 75 µg/litre but not for those exposed to higher THM concentrations. No associations were found for rectal cancer risk for either sex.

Overall, an excess risk of colon cancer among males was found for long-term exposure to chlorination by-products. No association was found for risk of colon cancer and exposure in females. Also, no associations were found for rectal cancer in males and females.

Comment *The subjects included in the analysis represented 45% of colon cancers and 43% of rectal cancers identified by the Cancer Registry. These participation rates are relatively low and result from prior deaths of cases, illness preventing participation, lack of consent from treating doctors or cases, and inability to trace current residences. The finding of increased risks for colon cancer only in males is unexpected. This may be a chance finding, or a genuine effect of chlorination byproducts, or the effect of an unmeasured confounder which is more frequent in males than in females.*

♦

DBPs and pregnancy outcomes

Drinking water chlorination and delivery outcome-a registry-based study in Sweden.
Kallen BA, Robert E. Reprod Toxicol (2000) **14**(4) p303-9.

This study considered drinking water chlorination and delivery outcomes using a Swedish birth registry. Exposure data was based on municipality and published reports on drinking water treatment and composition. Data for the years 1985, 1989 and 1994 for each municipality drinking water plant was collected. Three groups were identified: those with no disinfection, disinfection with chlorine dioxide only and disinfection with sodium hypochlorite only. Birth outcome data from 1985 to 1994 were obtained from the Swedish Medical Birth Registry.

Odds ratios (ORs) were calculated for various birth outcomes. The results were stratified to account for maternal age, parity, smoking and other factors. In the areas with sodium hypochlorite water disinfection, significantly increased ORs were found for short gestational duration, birth weight below 2500g, short body length, and very small head circumference. The ORs for the birth outcomes studied in the areas with chlorine dioxide disinfection were not statistically significant. ORs were calculated for a number of relatively serious congenital malformations. The OR for hydrocephaly was significantly increased in areas that used chlorine dioxide disinfection but not in areas with sodium hypochlorite disinfection. This association was mainly explained however by variable diagnosis and/or recording of hydrocephaly. There was no association found between childhood cancer,

infant mortality, low Apgar score, neonatal jaundice, or neonatal hypothyroidism and the chlorination method.

This study found no association between chlorine dioxide disinfected drinking water and the variables studied. For sodium hypochlorite the results suggest there may be a weak effect of water disinfection method but not enough to increase serious outcomes. However the authors note that exposure status of pregnant women was assumed from their residential address at time of delivery, and no information was available on water consumption. There was no information on levels of disinfection byproducts in the water supplies. The results may also have been affected by systematic variation in measurement and recording between different hospitals.

Association between chlorination of drinking water and adverse pregnancy outcome in Taiwan.
Yang CY, Cheng BH, Tsai SS, Wu TN, Lin MC, Lin KC. Environ Health Perspect (2000) **108**(8) p765-768.

This study was undertaken to examine the relationship between the use of chlorinated drinking water and adverse birth outcomes in Taiwan. The study population consisted of 14 municipalities with chlorinated water (CHM). These were municipalities where more than 90% of the municipal population was served by chlorinated water. There were also 14 municipalities with unchlorinated water (NCHM). These were municipalities where less than 5% of the population was served by chlorinated water. Municipalities were assigned an urbanisation level and each NCHM was matched with a CHM with the same urbanisation level.

Data on pregnancy outcomes was collected from the registry of births in Taiwan. The final study population consisted of 18,025 first-parity singleton live births for the period 1 January 1994 to the 31 December 1996 with complete information on maternal age, education, gestational age, birth weight, and sex of the baby. There was no significant difference in mean birth weight between CHMs and NCHMs. The CHMs had a significantly higher rate of preterm delivery than the NCHMs (OR 1.34, 95% CI, 1.15-1.56). The strength of the study is limited as there was no assessment of actual drinking water consumption or DBP levels, and no information on whether women moved residence during pregnancy. There was also no information on nutrition, smoking or occupational exposures which may affect pregnancy outcomes.

Chlorination of drinking water and sex ratio at birth in Taiwan.
Yang CY, Cheng H, Tsai SS, Wu TN, Hsu TY, Lin KC. J Toxicol Environ Health. Part A (2000) **60**(7) p471-476.

The aim of this study was to determine whether chlorination of drinking water is associated with abnormal sex ratios at birth in Taiwan. Certain occupational exposures and environmental exposures to air pollutants have been reportedly associated with abnormal sex ratios. 156 municipalities from the total of 361 municipalities in Taiwan were classified as chlorinating municipalities (CHM) because more than 90% of their population was served by chlorinated drinking water. Fifteen municipalities were classed as nonchlorinating municipalities (NCHM) with less than 5% of the population served by chlorinated water. Each NCHM was matched with a CHM with the same urbanisation index. The annual number of male and female births was obtained for the years 1994-1996 in the study municipalities.

The mean sex ratios of births in CHMs and NCHMs for 1994-1996 were 108.2 and 109.4 respectively. There was no significant difference between all yearly and 3 yearly total values for the two groups, and therefore no evidence that chlorinated drinking water was associated with abnormal sex ratios in Taiwan.

Relationship between Stillbirth and Specific Chlorination By-Products in Public Water Supplies.
King WD, Dodds L, Allen AC. Environ Health Perspect (2000) **108**(9) p883-6.
A retrospective cohort study was conducted to evaluate the relationship between the level of total

trihalomethanes (THM) and specific THMs in public water supplies and risk of stillbirth. A cohort of 49,756 singleton births between 1988 and 1995 with known gestational age was assembled from a perinatal database in the Canadian province of Nova Scotia. The Nova Scotia Department of Environment provided exposure information on THMs for the public water facilities throughout Nova Scotia. Individual exposures were estimated by linking mother's residence to the geographical area served by each water facility. The data set was restricted to those municipalities where greater than 90% of households were served by surface water sources via public water utilities.

Relative risks (RRs) and 95% confidence intervals (CI) were estimated for the relationship between stillbirth and total THM, chloroform and bromodichloromethane and adjusted for potential confounders (smoking and maternal age). For total THM the RR rose with increasing levels of exposure and reached statistical significance for levels above 100 micrograms/L relative to the lowest category of less than 50 micrograms/L. A 5% increase in risk was found with each 10 micrograms/L increase in total THM. Similar results were found for chloroform. A dose-response pattern was found for bromo-dichloromethane exposure, with a doubling of risk in the highest exposure category. A 29% increase in risk with each 10 micrograms/L of bromodichloromethane was found.

Relative risk estimates of the effect for individual THMs were calculated and adjusted for the other by-product, maternal smoking, and maternal age. Chloroform was not associated with increased risk however bromodichloromethane was associated with a 26% increase in risk per 10 micrograms/L (RR = 1.26; CI 1.05-1.49).

The data were then reanalysed after dividing stillbirths into unexplained and asphyxia-related deaths. No significant associations were found between DBPs and unexplained stillbirths. For asphyxia-related stillbirths and total THM exposure, relative risks increased with increasing levels of exposure to 4.6 for total THM levels above 100 micrograms/L. For chloroform an RR estimate of 3.6 was found for those exposed to levels above 100 micrograms/L. For bromo-dichloromethane, RRs were also elevated but the dose-response trend was not consistent.

Overall the results suggest that specific chlorination by-products need to be considered in relation to the risk of stillbirth, especially bromodichloromethane and potentially other brominated DBPs. Further research is need to confirm the stronger associations and dose-response relationship of stillbirths due to asphyxia-related causes of death

♦

Hepatitis A

Prevalence of antibody to hepatitis A virus in drinking water workers and wastewater workers in Texas from 1996 to 1997.

Weldon M, VanEgdom MJ, Hendricks KA, Regner G, Bell BP, Sehulster LM. J Occupat Environ Med (2000) **42**(8) p821-826.

A cross-sectional study was undertaken to determine whether wastewater workers in Texas had a higher prevalence of antibodies to hepatitis A (anti-HAV) than drinking water workers. A total of 89 drinking water workers and 359 wastewater workers agreed to participate in the study. This represented between 65% and 85% of those who attended workplace meetings explaining the study. A questionnaire was given to participants to collect information on possible risk factors for hepatitis A. Serum specimens were collected from all participants and tested for the presence of antibody to HAV.

A total of 21 (23.6%) of the drinking water workers were anti-HAV positive and 102 (28.4%) of the wastewater workers were positive. After adjustment for age, education and ethnicity the odds ratio for association between anti-HAV positivity and employment in the wastewater industry was 2.0 (95% CI 1.0 to 3.8, just significant). The independent factors significantly associated with anti-HAV positivity among wastewater workers were never eating in a designated lunchroom (ie eating in vehicle or worksite), employment in the industry for 8 years or more, never wearing face protection, and

having skin contact with sewage at least once a day. About half of the wastewater workers reported having skin contact with sewage at least once a day and nearly half reported getting sewage in their mouth at least once a month. A large proportion of workers did not observe recommended health and safety practices.

This study found a higher prevalence of anti-HAV among wastewater water workers in Texas than among drinking water workers and results are consistent with previous studies in other countries. However few people with positive results could recall suffering hepatitis symptoms. By undertaking simple health and safety measures wastewater workers can reduce their risk of anti-HAV positivity. Using face protection and eating in a designated lunchroom both reduced risks. Vaccination against hepatitis A is available.

♦

Nitrate

Blue babies and nitrate-contaminated well water [clinical conference].

Knobeloch L, Salna B, Hogan A, Postle J, Anderson H. Environ Health Perspect (2000) **108**(7) p675-8.

This paper looks at two recent US cases of blue baby syndrome, a potentially fatal condition that occurs when haemoglobin in an infant's red blood cells is oxidised to methaemoglobin. Methaemoglobin is unable to transport oxygen and the infant develops a blue-grey skin colour. If levels of methaemoglobin reach greater than 50%, a coma or death can result if the condition is not treated. The use of nitrate contaminated drinking water to prepare infant formula is a risk factor for infant methaemoglobinaemia.

The first case was noticed during June 1998 when a 6-month old white male was brought to a village clinic for immunisations in the Columbia County, Wisconsin. The infant had grey skin around his mouth and nose and had been vomiting after feedings. The infant's family had recently moved to a new home, which was served by a private water supply. The infants formula was made with water from the family's well. Laboratory analysis of the well water found a nitrate-N concentrations of 22.9 mg/L. The family was advised to use bottled water for the formula. The infant was examined 12 days after starting on bottled water and was found to be healthy and had normal methaemoglobin levels.

The second case was during April 1999 when a 3-week white female was admitted to emergency in Grant County, Wisconsin. The infant had turned blue and was having difficulties breathing. The infant had been fed formula diluted with bottled water until the bottled water ran out, and water from the farm where the infant's family lived was used to prepare formula. Water samples collected from the farm well were found to have a nitrate-N concentration of 27.4 mg/L. The infant was successfully treated and discharged 17 days later.

The authors note that continuing education is needed to ensure community awareness of the potential hazard that nitrate contaminated water poses to infants.

♦

Magnesium and Calcium

Magnesium and calcium in drinking water and death from acute myocardial infarction in women.

Rubenowitz E, Axelsson G, Rylander R. Epidemiology (1999) **10**(1) p31-6.

This case-control study investigated the significance of magnesium and calcium in drinking water in relation to mortality and morbidity from acute myocardial infarction (AMI, heart attack). The study involved 18 Swedish municipalities. Cases were defined as men and women in the study area who suffered AMI during the period October 1994 to June 1996, and at the time of AMI were from 50-74 years of age. One age- and gender-matched control was selected for each case from the population register.

Telephone interviews were conducted with surviving cases and the corresponding controls. A food frequency questionnaire was administered. Magnesium and calcium content in the drinking water at the last residence for each subject was measured. Water samples from tap water from households representing all of the 79 waterworks were collected. Water samples were also taken

from water filters and private wells. Subjects were classified by quartiles of water magnesium or calcium levels.

The incidence of AMI was not significantly different in areas with higher magnesium levels (more than 8.3 mg/L), but the survival rate were significantly higher. The reduction in deaths appeared to occur mainly in deaths outside hospital. The odds ratio (OR) for the risk of dying from AMI in relation to magnesium in drinking water was 0.64 (95% CI = 0.42-0.97) for the highest quartile compared with the other three quartiles. The OR was lower for women than men. High calcium levels were associated with a lower total incidence of AMI in women but not in men (range of calcium quartiles not stated).

When ORs were recalculated on the basis of estimated individual magnesium and calcium intake from water instead of the concentration in water, the protective effects appeared stronger. However intake from food and beverages had little effect on odds ratios, even though intake from these sources was greater than from water.

Comment *This study reinforces the observations of several ecological studies that rates of death from ischaemic heart disease are lower in areas with high magnesium levels in drinking water. The results presented here suggest that magnesium may reduce the risk of death immediately after AMI, so that the victim has an increased chance of receiving medical treatment.*

♦

Sulphate

Assessing the acute gastrointestinal effects of ingesting naturally occurring, high levels of sulfate in drinking water.
Backer LC. Crit Rev Clin Lab Sci (2000) **37**(4) p389-400.

There are concerns over the health effects associated with ingesting water with high levels of sulphate, prompted by human case reports of severe diarrhoea in infants, and some animal studies. This paper reviews the available literature on sulphate ingestion. The author notes that the data from most case reports and studies is of poor quality and it is not possible to identify exposure levels likely to lead to adverse effects. A well conducted blinded volunteer study found no significant effect on bowel habits among adults from a low sulphate water supply who drank bottled water containing up to 1200 mg/L sulphate for 3 days. Further research on adults, and animal experiments to model infant exposure are needed to clarify at what level adverse health effects are likely.

♦

Water Quality Monitoring

Escherichia coli: the best biological drinking water indicator for public health protection .
Edberg, S. C., E. W. Rice, et al. (2000). J Appl Microbiol **88**: 106S-116S.

This paper reviews the use of faecal indicator organisms for the measurement of water quality, and the properties of *E.coli* which make it the best organism for this purpose. The authors summarise three studies dating back to the 1920s which examined the biological origin of *E.coli* and other coliform bacteria. Despite the range of different methods used, the common finding was that *E.coli* is the only member of the group that is truly of faecal origin.

E.coli was proposed as the primary drinking water indicator as far back as the 1890s, however the lack of a rapid single step test for the species meant that confirmatory subcultures and a delay of several days were required for unequivocal identification. As a result, a number of surrogate tests were developed for routine monitoring including total coliforms and faecal coliforms.

The paper presents some interesting insights on how the practical usefulness of these surrogate tests has declined over the decades, as improvements in water supply management have altered the composition of populations of waterborne bacteria. While the total coliform test was a valid indicator of faecal contamination in the early part of the 20th century, it no longer has any relevance for this purpose. The authors are of the opinion that this test remains a valid tool for assessing the operational status of water supply systems (eg nutrient levels, adequacy of disinfectant residual concentration), but feel it should not have status in terms of triggering

public reporting as is presently the case in the US. Tests currently employed for faecal or thermotolerant coliforms also detect thermotolerant environmental bacteria such as *Klebsiella*, are subject to a significant rate of false positive and false negative results, and interference by heterotrophic bacteria.

After assessing the properties of alternative faecal indicators, the authors conclude that *E.coli* remains the most practical and widely applicable measure of faecal contamination for drinking water supplies. The advent of defined substrate technology (DST) for detection of the beta-glucuronidase enzyme system now provides a rapid and specific test for this organism. The authors strongly recommend that this test be used for routine water quality monitoring, and that the less precise faecal coliform test be abandoned for monitoring and regulatory purposes.

The plain, hard truth about pathogen monitoring.
Allen, M. J., J. L. Clancy, et al. (2000). J AWWA **92**(9): 64-76.

Debate on how best to monitor the microbiological quality of water supplies to protect public health has undergone a revival in recent years, driven mainly by a number of waterborne outbreaks of *Giardia* and *Cryptosporidium*. For many decades testing for faecal indicator organisms has been the mainstay of water quality monitoring, but there is increasing pressure from a number of quarters to directly monitor for pathogens.

This paper reviews the issue using *Cryptosporidium* as an illustrative case. Following the Milwaukee outbreak in 1993 when approximately 400,000 people were affected by waterborne cryptosporidiosis, many water authorities began monitoring programs for this pathogen. In the US, the EPA enforced an 18 month mandatory monitoring scheme for large water utilities despite evidence that the specified test method was significantly flawed. Of 5,829 raw water samples tested, only 7% were positive for *Cryptosporidium*, and there is serious doubt that this expensive exercise produced any useful information for water supply management.

Improvements in the sensitivity and specificity of detection techniques have been made, however quality control remains a critical issue. There have been a number of "false alarms" where public health alerts have been issued after the apparent detection of *Cryptosporidium* in water supplies, but investigations have thrown doubt on the test results and no evidence of waterborne disease has been found. Even if test results are accurate, we presently have no accepted means of determining the viability and human infectivity of oocysts. Thus the risk to public health cannot be reliably predicted from the test result. In addition to the specific difficulties relating to *Cryptosporidium*, there are many other problems in routine monitoring for any pathogen.

The authors believe that the water profession and public health authorities should recognise that routine monitoring for pathogens cannot provide useful information for the protection of public health. The reduction of health risks would be better achieved by concentrating on the protection of source water, optimisation of water treatment processes, and maintenance of water quality through storage and distribution. Traditional contaminant by contaminant approaches to water quality regulation also need to be reassessed and a more imaginative and pragmatic approach developed. The authors advocate an international workshop to seek a broad-based consensus on alternative approaches to water quality assurance.

Comment *This paper summarises the inherent limitations of pathogen monitoring and discusses the pressures and misconceptions that drive monitoring programs. Many of these limitations also apply to routine monitoring for indicator organisms. It needs to be recognised that microbiological monitoring of treated water is reactive management tool, capable of triggering action only after something has gone wrong and affected the finished product. Effective public health protection requires preventive action to anticipate, detect, and remove or reduce risks before they affect the treated water supply.*

List of Articles

Arsenic

Arsenic-induced skin lesions among Atacameno people in Northern Chile despite good nutrition and centuries of exposure.
Smith, A. H., A. P. Arroyo, et al. (2000). Environ Health Perspect **108**(7): 617-20.

Cryptosporidium

National surveillance for infection with *Cryptosporidium parvum*, 1995-1998:What have we learned?
Dietz, V. J. and J. M. Roberts (2000). Public Health Rep **115**(4): 358-63.

Operation of modern day process plants - minimising Cryptosporidium risk.
Edwards, D. (2000). Wat Sci Technol **41**(7): 149-58.

DBPs

Identification of new drinking water disinfection by-products from ozone, chlorine dioxide, chloramine, and chlorine.
Richardson, S. D., A. D. Thruston, et al. (2000). Water Air Soil Pollution **123**(1-4): 95-102.

Outbreaks

Climate and waterborne disease outbreaks.
Rose, J. B., S. Daeschner, et al. (2000). J AWWA **92**(9): 77-87.

E.coli

UV inactivation, liquid-holding recovery, and photoreactivation of Escherichia coli O157 and other pathogenic Escherichia coli strains in water.
Sommer, R., M. Lhotsky, et al. (2000). J Food Protect **63**(8): 1015-20.

Reuse

Guidelines for the microbiological quality of treated wastewater used in agriculture: recommendations for revising WHO guidelines.
Blumenthal, U. J., D. D. Mara, et al. (2000). Bull WHO **78**(9): 1104-16.

Risk Assessment

Balancing the risks and benefits of drinking water disinfection: Disability adjusted life-years on the scale.
Havelaar, A. H., A. E. M. De Hollander, et al. (2000). Environ Health Perspect **108**(4): 315-21.

Risk assessment model for a waterborne outbreak of cryptosporidiosis.
Gale, P. (2000). Wat Sci Technol **41**(7): 1-7.

Health Stream is the quarterly newsletter of Program 1 *Public Health Risk Assessment* of the CRC for Water Quality and Treatment. Health Stream provides information on Program 1 research activities, updates on the recent literature and topical issues in health research which are of particular relevance to the water industry.

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