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A searchable **Archive** of Health Stream articles, literature summaries and news items is available on the Web page.

US EPA Reviews Total Coliform Rule

The US EPA has selected the Total Coliform Rule (TCR) as a candidate for revision after its first review of National Primary Drinking Water Regulations (NPDWR). Under the 1996 amendments to the Safe Drinking Water Act, the agency is required to consider the need for revisions of the regulations at 6 yearly intervals. Revisions may also be conducted more frequently if considered warranted by evidence of public health risk.

The EPA conducted a preliminary assessment of 69 NPDWRs promulgated before 1997 which have not been revised to date. The assessment process included consideration of the availability of new scientific evidence, whether a health risk assessment was already being conducted, the effect of changes in analytical methods and treatment feasibility, and potential gains in public health protection or reduction in costs.

Only the Total Coliform Rule was selected for revision, with changes to the remaining 68 NPDWRs (all relating to chemical contaminants) considered not warranted at this time for a variety of reasons:

- 36 chemicals were deemed not eligible for revision at present due to risk assessments being currently in progress,
- 12 chemicals had potential for revision due to new evidence but as predicted health benefits were negligible it was considered that revision was not justified,
- 17 chemicals were deemed to require no change to the NPDWR, and
- 3 chemicals were deemed to have significant data gaps that precluded revision at present.

The Total Coliform Rule, published in 1989, requires all public water systems to monitor for total coliform organisms in their distribution systems. The rule requires that consumers are notified of positive sample results, and specifies a follow up monitoring schedule whenever positive results are detected.

Concerns over the value of the total coliform test for public health protection have been increasing in recent years due to the recognition that the organisms detected are predominantly of environmental rather than faecal origin. Progressive changes to the testing method to simplify the procedure and shorten the time to obtain a result have reduced its specificity by broadening the range of organisms that will produce a positive result. Thus the presence of total coliform bacteria may not signify treatment failure or distribution system contamination but more frequently represents growth of non-pathogenic environmental microorganisms in water or pipe biofilms. Conversely, while the absence of total coliforms may provide some assurance that bacterial faecal pathogens are also likely to be absent, the correlation of total coliform occurrence with viral or protozoal pathogens is very poor.

The availability of rapid tests for *E.coli* (a specific indicator of faecal contamination) has led a number of countries to adopt this organism as the primary or sole microbial indicator for water supplies. For example the Drinking-Water Standards for New Zealand (2000) specify *E.coli* as the sole indicator organism, with Defined Substrate Technology methodology for detection. The status of the Total Coliform test is also being reviewed in Australia, with a Discussion Paper on Microbiological Indicators of Water Quality issued by the NHMRC in September 2001. The current Rolling Revision of the Australian Drinking Water Guidelines clarifies the distinction between total coliforms and thermotolerant coliforms/*E. coli*, and recommends that total coliforms be viewed as operational indicators for water supply systems rather than an indicator of health significance. Thus total coliforms comprise one of a range of parameters that may be used to assess whether the system is operating normally or whether some disturbance that warrants investigation may have occurred.

Submissions to the US EPA review have highlighted the deficiencies of total coliforms as a health risk indicator, and commented on the disproportionate demands on local and state resources that are a consequence of the frequent and numerous violations of the current rule. The American Water Works Association has suggested that the EPA should consider making *E.coli* the sole microbial indicator for compliance purposes, with total coliform testing used as a "flag condition".

The EPA has stated that only those measures that reduce the TCR implementation burden while still ensuring public health protection will be contemplated, and that any revisions would be considered in conjunction with a broader rulemaking initiative covering risks in water distribution systems. A series of nine discussion papers on different aspects of distribution system contamination risks have been developed as a starting point for discussions with stakeholders. The proposed revisions to the Rule are scheduled for release in 2004, with the final Rule expected in 2006.

Cryptosporidium Alerts for Scotland

The Scottish cities of Glasgow and Edinburgh had boil water alerts issued during August after elevated levels of *Cryptosporidium* oocysts were detected in their drinking water supplies. The incidents began on Friday 2 August when oocysts were detected in samples taken the previous day from the Mugdock reservoir which supplies Glasgow. While local doctors were alerted on Friday to be on the lookout for increased numbers of gastroenteritis cases, the boil water notice was not issued to the public until the evening of the next day. The notice was extended to further areas of the city on Monday 5 August, bringing the number of affected consumers to over 150,000, then lifted on Wednesday 8 August. According to newspaper reports, there was no reported increase in the number of cases of gastroenteritis in Glasgow following the alert.

Fears of a drinking water related outbreak were sparked by a coincident cluster of 8 cryptosporidiosis cases among young children in nearby Perthshire, however public health officials investigating the outbreak said the infections were attributed to a toddlers pool at a local leisure complex. Several

suspected cases also occurred in adults who were relatives of the affected children. The pool was closed for cleaning and disinfection.

The Glasgow incident had barely subsided when boil water alert was issued for Edinburgh, again following detection of oocyst numbers slightly above background concentrations. The alert was withdrawn by Scottish Water only one hour after it was issued, leading to criticism by the press and Opposition politicians that the organisation was operating in a state of confusion. Again, there were no indications of increased levels of illness in the community following the incident. A spokesman for Scottish Water later said that the company had taken an "extremely cautious approach" after earlier criticism that it had not informed the public quickly enough during the Glasgow incident. The problem in Edinburgh was attributed to a "filtration failure incident" but a review of the test results led health officials to decide that the levels of *Cryptosporidium* were not a risk to public health.

A ministerial working group has been established by the Scottish Executive to assess the handling of the incidents and lessons that can be learned to improve responses to any future emergencies. According to a report on the ProMed email list, the incidents were the result of a failure in communication. The trigger level for a *Cryptosporidium* alert in Scotland is 10-fold lower than that used in England (presumably a reference to the DWI regulatory level of 1 oocyst per 10 litres), and even the highest level recorded from the Mugdock reservoir (not stated in news reports) was lower than for most supplies in England.

Later in the month the planning committee of the East Dunbartonshire council rejected an application by Scottish Water to build a new water treatment plant to replace the 140 year-old plant that presently serves Glasgow. The planning application was the subject of over 1,000 objections lodged by local people and businesses, on the grounds that it would destroy parkland and damage a local tourist attraction. Scottish Water has announced that it will appeal the decision, saying that Glasgow was the only major urban centre in the UK where appropriate water filtration systems to remove parasites including *Cryptosporidium* were not either in place or under construction.

Waterborne Disease Website Launched

A new website providing information on waterborne disease was launched on 5 August. Development of the website, *Recognising Waterborne Disease and the Health Effects of Water Pollution: Physician On-Line Reference Guide*, was funded by the American Water Works Association and the Arnot Ogden Medical Centre in New York State.

The aim of the site is to provide information resources and educational tools for practising clinicians to raise awareness and knowledge of waterborne disease from both pathogens and chemical contaminants. As noted in the introductory sections of the site, medical practitioners face a number of diagnostic challenges in dealing with waterborne disease:

- the emergence or re-emergence of infectious diseases, some of which may be transmitted through drinking or recreational water
- an increasing number of chemicals in commercial use with potential for human exposure through environmental sources including water
- the possibility of deliberate contamination of water supplies

While abundant sources of information relating to waterborne disease exist in the internet, it is difficult and time-consuming for clinicians to locate scientifically credible and clinically relevant information. This website provides structured access to information in a number of key areas:

- **Introduction to the problem of waterborne disease** including data on waterborne disease trends and outbreaks in the US, and a discussion of future challenges to water protection
- **Understanding water pollution and water protection** including an overview of the issues, the effectiveness of water protection strategies and links to on-line references and informational resources.
- **Multiple environmental contaminant sources and exposure pathways** including consideration of the roles of water, food, air and soil in total human exposure to microbial and chemical contaminants. A series of case studies is included illustrating how different sources of environmental contamination have been recognised in various outbreak settings.

- **Evaluation and management of disease resulting from waterborne pathogens** including links to a collection of fact sheets on microbial pathogens from the Centers for Disease Control and Prevention. This section incorporates guidance for clinicians on taking an exposure history to assess pathogen exposure from drinking water, recreational water and other environmental sources, and a discussion of the importance of reporting suspected waterborne disease cases to relevant health authorities. Links to case studies of disease outbreaks due to waterborne pathogens, and other relevant recommendations and reports are also included.

- **Evaluation and management of waterborne disease resulting from chemical contaminants** including a list of chemicals which are regulated in US public water supply systems, their MCLG (Maximum Contaminant Level Goal), MCL (Maximum Contaminant Level) and/or TT (Treatment Techniques), potential health effects and contaminant sources. This section also provides some guidance on evaluating chemical exposure and taking an exposure history, and links to specialty clinics and physicians in occupational and environmental medicine. Case studies and reports of waterborne disease relating to chemical contaminants are also included.

- **Evaluation and management of water-related disease in susceptible populations** including a description of the various groups of people in this category, and links to information sheets on special health precautions and risk reduction guidelines. In parallel with previous sections, there are links to case studies and outbreak reports that illustrate the occurrence and effects of waterborne disease among susceptible populations.

- **Health risk communication and patient risk evaluation for waterborne contaminant exposure and water-related disease** including a discussion of the importance of effective risk communication by medical practitioners as one of the most trusted sources of information to the general public. In an age where members of the public may obtain abundant information and advice of unknown quality from the internet, the importance of access to scientifically sound information by clinicians is emphasised.

One section of the site provides access to a **Clinician Resource Guide and Search Engine**. The authors have reviewed a large number of internet sites from government, private, academic and professional organisations and identified 200 sites which they judge to provide the most useful and accessible information on waterborne disease and water pollution. A Resource Guide describing each of these sites has been compiled, with a quick reference grid to indicate whether or not the individual site contains information on waterborne pathogens, chemical contaminants, susceptible populations or risk communication. The Resource Guide may be browsed alphabetically or searched by topic or agency.

Additional information on waterborne diseases has been collected from 33 websites into a **Virtual Library of On-Line Texts and PDF Reports** which may also be searched, and there is an **External Search Engine** which searches the rest of the internet and produces rank scores for the search results to enable the most relevant sites to be identified. The website also includes a **Water-Related Glossary** of over 900 terms.

Website address:

www.waterhealthconnection.aomc.org

Comment This site provides organised access to a range of reputable resources, and seems well suited to achieve its aims of providing information for clinicians. The original material written for the site is not extensive, but provides a well balanced view that places water in context as one of several potential exposure routes for pathogens and chemical contaminants. Coverage of some topics is scanty - for example there appears to be no material on cyanobacteria among the top 200 websites, presumably reflecting the low profile of this issue for US water supplies to date. As one might expect, the site is US-focused with relatively few references to sites or information in other countries with the exception of Canada. However even the External Search Engine appears to target mainly US sites. Some problems were encountered using Netscape to view the website, but not with Internet Explorer.

Book Review

Drinking Water and Infectious Disease: Establishing the Links

Edited by PR Hunter, M Waite and E Ronchi.

CRC Press and IWA Publishing (2003)

ISBN 1-84339-027-2

This publication represents the outcomes of a three day expert meeting held in Basingstoke, UK in July 2000. The meeting, organised by the Organisation for Economic Cooperation and Development and the World Health Organisation, was attended by about forty public health and infectious disease experts from thirteen countries. The Executive Summary of the Basingstoke meeting report is reproduced as an Appendix in the book.

While a number of previous publications have presented information on the causes, occurrence and impact of waterborne disease, this is the first text to focus specifically on the methods used to identify the relationship between drinking water quality and infectious disease, and how such methods have been used in practice. The authors include many internationally recognised experts with firsthand experience in disease surveillance, outbreak investigation and epidemiological studies of waterborne disease.

The book begins with a brief foreword outlining the immense worldwide health burden associated with diarrhoeal illness and the difficulty of estimating what proportion of such illness is attributable to drinking waters supplies. Given the complexity of the issue and the difficulty in distinguishing waterborne sources from other pathways of transmission, the editors also remind readers of the need to assess the epidemiological evidence on waterborne disease according to accepted criteria (Bradford-Hill 1965)¹ to determine whether the weight of evidence is sufficient to attribute causation. The remainder of book is organised in to three sections comprising a total of nineteen chapters. Each section begins with a brief introduction that summarises the themes of the component chapters.

Surveillance of Waterborne Disease

The first chapter in this section succinctly describes the principles and components of surveillance systems, including a evaluation of how the desire to collect and analyse detailed data must be balanced against the reality that human and financial resources are limited, and complex and time-consuming reporting requirements will inevitably cause poor compliance. The author emphasises his opinion that a fundamental objective of surveillance systems from both ethical and economic viewpoints should be that the system improves the health of the community being surveyed, rather than simply being an exercise in data collection. Thus the knowledge gained from surveillance should feed back into public health policy and action.

The remaining three chapters in this section provide examples of current British and US local surveillance systems, compare national surveillance systems in the UK, US and Sweden, and discuss some examples of international disease surveillance. The core data for infectious disease surveillance (a combination of specific pathogen detection in clinical specimens and reports of unusual cases or clusters of illness) are common to most developed nations although the institutional responsibilities vary. The examples illustrate the limitations and inconsistencies of reporting and investigation systems, and highlight the need for better coordination and innovative approaches to data linkage and interpretation. In the UK and US the strength of evidence linking an outbreak to a water source is assessed with formal classification systems that take into account both epidemiological and water system information. Outbreak reports are collated and published at 6-monthly intervals in the UK and 2-yearly in the US.

Existing international surveillance systems differ in their degree of centralisation, formality of organisation and sources of data, but share a reliance on the adequacy of underlying national systems. Increasing rates of international trade and travel are likely to create a need for more effective international collaboration on surveillance.

Investigation of Outbreaks of Waterborne Disease

The seven chapters in this section describe current best practice in outbreak investigation and control, possible approaches to allow earlier detection and perhaps even prediction of outbreaks, the role of pathogen typing to elucidate transmission pathways, and engineering aspects of outbreak investigation. The causes of waterborne outbreaks in the US from 1991-1998 and the origins of the UK monitoring regulations on *Cryptosporidium* are also described.

The authors highlight the importance of preparedness and planning in outbreak investigation to ensure that the scope of the investigation and the roles and responsibilities of those involved are clearly defined and understood. An easily overlooked but essential step is to first ascertain whether an apparent outbreak is in fact real - there have been a number of documented instances where pseudo-outbreaks have occurred due to changes in laboratory test procedures or reporting practices. Suggested new approaches to outbreak detection are based mainly on moving down the reporting pyramid² to detect larger numbers of cases at an earlier stage in outbreaks, and these will probably require the use of computerised analysis methods to discern true changes in incidence from day-to-day and seasonal variations. Genotyping of pathogens is being increasingly used in outbreak investigations, although the often transient nature of water contamination may mean that the pathogen is no longer in the water supply by the time an outbreak has been detected. One chapter in this section emphasises the need for a prompt engineering investigation of the water supply system by appropriately skilled personnel as soon as an outbreak is discovered; something that is often neglected or performed only months after the situation has returned to normal.

Investigation of Sporadic Waterborne Disease

The final section of the book comprises eight chapters covering waterborne disease that occurs outside the setting of recognised outbreaks. While the conventional definition of an outbreak comprises two or more cases of illness arising from the same source, in reality small outbreaks (whether from water or any other source) are very unlikely to be detected by surveillance systems. The majority of gastrointestinal

disease cases in developed countries are not associated with known outbreaks, and a number of epidemiological approaches may be used to assess the role of water in contributing to this disease burden.

The Basingstoke meeting highlighted the need to consider the intended use of the information when designing epidemiological studies, recognising that all methods have strengths and weaknesses. This is particularly important when attempts are made to estimate the cost-effectiveness of interventions and provide guidance for policy making. The general conclusion was that available resources should better targeted to studies to produce data of suitable quality for specific purposes, in key areas of waterborne disease research.

Comment This book provides useful and wide ranging coverage of the topic with many examples of the diverse approaches that may be taken to assess the relationship between water quality and health. While the subject matter is sometimes complex, the text is accessible to those without specialised knowledge of the area, and the strengths and weaknesses of different investigational approaches are well described. Perhaps one slight criticism is that the section on Surveillance may leave one with the impression that the shortcomings of current surveillance systems are confined to the area of waterborne disease, when in fact they largely apply also to infectious disease from other sources.

Declaration of Interest: Health Stream's Editor is a coauthor of *Chapter 16: Case-control Studies* in the publication reviewed above.

1 Bradford-Hill A (1965) The environment and disease: association or causation? *Proc. R. Soc. Med.*, **58** p295.

2 The "reporting pyramid" refers to the decreasing number of cases captured at each stage of the reporting process - not all infected people will become ill, not all ill people visit a doctor, a minority of these will be asked for a faecal specimen, the specimen may not be tested for the relevant pathogen, tests may not detect a pathogen even if it is present, and not all positive test results are reported to the surveillance system.

News Items

Norwalk Virus Outbreak at Golf Tournament

An outbreak of gastroenteritis affecting over 80 people has been linked to contamination of water and/or ice supplies at a golf tournament in Phoenix, Arizona, US. The contamination is believed to have occurred over a few days during July, with about half of players and visitors during that period reporting illness when interviewed. Health officials are still investigating whether a 15 year-old boy who died two days after visiting the course was infected by the virus. An autopsy showed the immediate cause of death to be asphyxiation due to inhalation of vomit. The boy was found unconscious on the bathroom floor of his home and could not be revived by paramedics. Norwalk-like viruses usually cause vomiting and diarrhoea lasting 24-48hrs, with a low rate of serious complications.

Global Water Research Coalition Launched

The Global Water Research Coalition (GWRC) is an alliance of world leading research organisations formed to provide a mechanism for international cooperation and collaborative in water-related research. GWRC will address international issues related to drinking water, wastewater, water supply, and renewable water resources. GWRC is affiliated to the International Water Association, and was officially launched at the IWA World Water Conference in Melbourne, Australia in April 2002.

<http://globalwaterresearchcoalition.net/>

El Nino Affects Cholera Rates

Researchers from the University of Michigan have reported that the El Nino weather phenomenon is affecting the course of cholera epidemics in Bangladesh. A comparison of cholera rates with El Nino events showed little relationship in the first part of the 20th century, but during the last two decades the global weather phenomenon accounted for 70% of the variation in the number of cholera cases. The researchers hypothesis that increasing water temperatures may be allowing the causative bacterium *Vibrio cholerae* to grow more readily in the environment.

EERE 2002

The Environmental Engineering Research Event for 2002 will take place on 3-6 December in Blackheath, NSW, Australia. The event is a student-organised conference for postgraduate students

working on environmental issues. The theme for this year is *Multidisciplinary environmental problem solving - working together toward a sustainable future*, and organisers are seeking participation from social science students working on environmental issues as well as those in the applied sciences. More information:

www.civeng.unsw.edu.au/conferences/EERE2002

Guidelines on Food and Water Microbiology Culture Media

The Culture Media Special Interest Group of the Australian Society for Microbiology has developed a new guidance document "Guidelines for Assuring Quality of Food and Water Microbiological Culture Media". The Guidelines are expected to become an important document in the inspection and accreditation process in food and water microbiology in Australia. Copies of the draft Guidelines can be obtained from the National Convenor of the Culture Media SIG, Alida Scholtes alida@unimelb.edu.au, or the Hon.Sec. of the SIG, Peter Traynor.

peter.traynor@oxid.com.au

Warning on Groundwater Resources

An Australian scientist has warned that the world's groundwater resources are dwindling fast and that many areas of the world that rely on groundwater for irrigation will soon be plunged into a food crisis. Professor Lance Endersbee of Monash University challenges the conventional view that artesian water originates from rainwater percolating into the earth. He believes that most groundwater resources were formed by volcanic activity and are sealed under layers of impervious rock, making it impossible for rainwater to replenish them.

More information:

www.atse.org.au/publications/occasional/occ-endersbee2.htm.

Legionella Outbreak at Japanese Spa

A major outbreak of Legionnaire's disease affecting over 270 people and causing 6 deaths, has been traced to a newly opened "onsen" or hot springs spa in the town of Hyuga, Japan. The spa had been visited by over 20,000 customers before the outbreak was recognised. Health officials have warned that the risks of *Legionella* infection from spas may be rising as depressed economic conditions lead to cost-cutting by owners, including neglect of hygiene measures such as changing spa water frequently.

From the Literature

Arsenic

Assessment of cancer risk and environmental levels of arsenic in New Hampshire.

Karagas M R, Stukel T A and Tosteson T D. *Int J Hyg Environ Health* (2002) **205**(1-2) p85-94.

A population based epidemiological study was conducted in New Hampshire to: assess the risk of skin and bladder cancer associated with arsenic exposure in a US population, to evaluate methods of quantifying individual exposure to arsenic in low to moderate levels and to explore alternative models of determining the dose-response relationship at the lower end of exposure.

Toenail clippings were collected from study participants and analysed for trace elements including arsenic. Arsenic was measured in household water samples from a subset of study participants. Cases of basal cell carcinoma (BCC) and squamous cell carcinoma (SCC) who were aged 25 to 74 and diagnosed since July 1, 1993 were identified with the help of dermatologists and pathology laboratories. Controls were chosen from New Hampshire residents for the same age group and frequency matched on age and sex to the BCC and SCC cases.

A detailed personal interview of participants was conducted with questions on sociodemographic and lifestyle factors, medical history, family history of cancer and lifetime residential and occupational history prior to the reference date. Participants were also asked about skin sensitivity to the sun and time spent outdoors throughout their lifetime. Questions were also asked about the type of water supply in the house and amount consumed, years of use of their current water system and the use of water filters. Those with private domestic water systems were asked about the type of well they used.

Various dose-response models were used to estimate skin cancer risk in relation to toenail arsenic concentrations and for non-linear models the point (change-point) at which risk might begin to increase was to be estimated.

There were 587 BCC cases, 284 SCC cases and 524 controls included in this study. Drinking water arsenic concentrations ranged from less than 0.010 micrograms/l to 180 micrograms /l, with households using private well water containing more arsenic than those using municipal water. Elevated levels of arsenic were found throughout the state with four clusters identified with unusually high water concentrations (greater than 50 micrograms/l). Toenail concentrations of arsenic were significantly correlated with water concentrations above 1 microgram/l and reflected internal dose rather than external contamination. An increased risk of SCC at the highest concentrations of arsenic in toenails was found for all models. It was found that urinary arsenic cannot be detected reliably in a population which has below 50 micrograms/l arsenic in their drinking water.

This study showed that the use of a biological marker (arsenic in toe nail clippings) along with the use of various statistical models may help in establishing the concentrations at which arsenic influences cancer occurrence in the US.

Biological gradient between long-term arsenic exposure and carotid atherosclerosis.

Wang C H, Jeng J S, Yip P K, Chen C L, Hsu L I, Hsueh Y M, Chiou H Y, Wu M M and Chen C J. *Circulation* (2002) **105**(15) p1804-9.

The aim of this study was to examine the dose-response relationship between long-term exposure to ingested inorganic arsenic through the consumption of artesian well water and carotid atherosclerosis.

The study area was in southwestern Taiwan and included four villages in Putai Township. Residents had consumed high-arsenic artesian well water for over 50 years. Study subjects who had lived for more than 6 months in the study area and spent at least 5 days a week in the study area were given a detailed interview which included socio-economic and demographic characteristics, alcohol intake, cigarette smoking, physical activities, dietary consumption frequency, residential and water consumption history and personal and family history of hypertension, diabetes and cardiovascular

diseases. Six follow-up health examinations were carried out after the initial recruitment. In the sixth examination, to evaluate the extent and severity of the extracranial carotid artery (ECCA) as an indicator of atherosclerosis, an ultrasonographic examination was conducted on a subgroup of 436 residents. Fasting blood samples were collected from study subjects and a glucose tolerance test was performed.

Three indices of long-term exposure to ingested arsenic were used, these included: the duration of consuming artesian well water, the average arsenic concentration in consumed artesian water and cumulative arsenic exposure. All three indices were significantly associated with prevalence of carotid atherosclerosis in a dose-response relationship. This relationship remained after adjustment for age, sex, hypertension, diabetes mellitus, dyslipidemia, cigarette smoking and alcohol consumption, waist-to-hip ratio, and serum levels of total cholesterol and LDL cholesterol.

The findings indicate that long-term arsenic exposure may lead to the development and/or acceleration of carotid atherosclerosis and probably generalised atherosclerosis.

Birth defects

Chlorination byproducts and nitrate in drinking water and risk for congenital cardiac defects.

Cedergren M I, Selbing A J, Lofman O and Kallen B A J. *Environ Res* (2002) **89**(2) p124-30.

This study examined the possible association between maternal periconception exposure to public drinking water chlorination byproducts, including trihalomethanes (THMs) and nitrate, and the incidence of congenital cardiac defects.

The population examined included 75,832 infants born in a Swedish County (Ostergotland) between January 1, 1982 and December 31, 1996. The study population consisted of 71,978 infants whose mothers residence could be defined spatially on a digital map on 31 December of the year before the child was born. Subjects were allocated a specific water supply by using geographical information

systems. The 80 water supplies in this Swedish County were asked for information on physical and chemical properties of the potable water for a 10-year period, 1983-1994 if available. Information was also obtained on chlorination procedures at each supply and on THM levels from the National Food Administration board, collected in 1994-1995.

Of the study population there were 58,669 mothers who were allocated a municipality water supply during the periconceptional period and in early pregnancy. There were a total of 753 cardiac defects recorded for infants born to these mothers. Among the 13,309 mothers who received water from private wells, there were 184 infants recorded with cardiac defects. There was no significant difference in the rate of cardiac defects between the two groups (crude OR 1.08, 95% CI 0.91 - 1.27).

The risk of cardiac defect was calculated for groundwater versus surface water and for various chlorination procedures, and for THMs and nitrate concentrations. The analysis was stratified by maternal age, parity, maternal smoking and educational level. Groundwater was found to be a risk factor for cardiac defects with a statistically significant excess risk (adjusted OR 1.31, 95% CI 1.09-1.57). There was an excess of cardiac defects found when chlorine dioxide was used as a disinfection chemical. There was a significant trend seen for cardiac malformation with increasing THM levels. THM concentrations higher than 10 micrograms/L were statistically significantly associated with cardiac defects. No excess risk for cardiac defect was found with increasing nitrate concentrations. The interactions between risk factors were examined and living in a rural district was also included in the comparison. In this analysis only chlorine dioxide persisted as a statistically significant risk factor after stratification.

Overall this study found an increased risk of congenital cardiac defects associated with the chlorination procedure, specifically chlorine dioxide and with increasing total THM concentration.

Comment Most of the disinfected water supplies in this study used hypochlorite for disinfection, in some

cases combined with chlorine dioxide. Few cases or controls were served by supplies treated with chlorine gas, and water treatment information was missing for 16% of cases and 14% of controls. THM levels in these water supplies are relatively low, with the highest reported level being 41 micrograms /litre. The authors note that there is no information available on exposure to nitrates or THMs from sources other than drinking water, nor indeed is it known whether the women in this study drank tap water.

Bottled Water

Microbiological safety of natural mineral water.

Leclerc H and Moreau A. FEMS Microbiol Rev (2002) **26**(2 Special Issue SI) p207-22.

This paper reviews the microbiological content of natural mineral waters and the changes which occur as a result of extraction and bottling. In situ, natural mineral waters normally contain bacterial populations in starvation-survival state, because of a lack of nutrients. These bacteria are mainly in a viable but non-culturable state, but there are also some bacteria present which are capable of growth. After the water is bottled, bacteria rapidly multiply, with the number of viable counts reaching $10^4 - 10^5$ CFU ml⁻¹ within 3-7 days.

Under European regulations, natural mineral water cannot be subjected to any type of disinfection that modifies or eliminates its biological components. Therefore assessing the microbial risks is a distinct issue from that of drinking water. The measurement of heterotrophic plate counts (HPC) in bottled mineral waters is useful as it proves no disinfection has occurred and it helps to ensure that no major quantitative changes have occurred in the microbial status of the water. In order to characterise microbiologically safe natural mineral water, indicators of faecal contamination need to be absent such as *E. coli* and indicators of vulnerability such as *P. aeruginosa* need to be as low as possible. As there are no indicators for pathogenic viruses and protozoa, the author recommends regular examination for viral and protozoan pathogens.

Cryptosporidium

Three drinking-water-associated cryptosporidiosis outbreaks, Northern Ireland.

Glaberman S, Moore J E, Lowery C J, Chalmers R M, Sulaiman I, Elwin K, Rooney P J, Millar B C, Dooley J S G, Lal A A and Xiao L H. Emerg Infect Dis (2002) **8**(6) p631-3.

Three epidemiologically unrelated cryptosporidiosis outbreaks occurred from April 2000 to April 2001 in Northern Ireland. The outbreaks occurred in the greater Belfast area and were associated with drinking water. The possible relationship between *Cryptosporidium parvum* genotypes and subgenotypes associated with these outbreaks was investigated in this study. Genotyping was based on characterisation of the small subunit RNA restriction fragment length polymorphisms and oocyst wall protein, while subgenotyping was done by sequencing the 60kDa glycoprotein.

Microscopically positive stool samples from each of the outbreaks were analysed, 34 from outbreak A, 42 from outbreak B and 44 from outbreak C. A wastewater sample from a blocked drain implicated in outbreak C was also analysed. The subgenotyping analysis also included control isolates of *C. parvum* genotypes. There were 14 control isolates from sporadic *C. parvum* infections of the bovine genotype in a rural area in the west of Ireland with a separate water supply and 10 control isolates from sporadic *C. parvum* infections of the human genotype in northwest England during the time of outbreak C.

The genotyping analysis found that the three outbreaks were indeed unrelated even though they occurred in a 1-year period. Outbreak A was caused by the *C. parvum* bovine genotype and outbreak B and C were caused by the *C. parvum* human genotype. The finding of the human genotype in outbreaks B and C supported the environmental investigations that implicated contamination of the drinking water supply by raw sewage (outbreak B) and wastewater (outbreak C). The subgenotyping analysis of the blocked drain sample found one *C. parvum* human subgenotype indistinguishable from the subgenotype found in the majority of infected

people. The subgenotyping analysis indicates that the three outbreaks were caused by two main subgenotypes of *C. parvum* that were probably circulating in the community before the outbreaks. Also these subgenotypes are the most common found in Northern Ireland and northwest England.

Cryptosporidium oocysts in a water supply associated with a cryptosporidiosis outbreak.

Howe A D, Forster S, Morton S, Marshall R, Osborn K S, Wright P and Hunter P R. Emerg Infect Dis (2002) **8**(6) p619-24.

During March 2000, an outbreak of cryptosporidiosis occurred in northwest England in and near Clitheroe, Lancashire. During March 1-15, the Ribble Valley Environmental Health Department reported nine cases of cryptosporidiosis to the East Lancashire Health Authority. This represented an unusually high rate and an investigation was initiated. It was noted that six of these cases lived in one water zone supplied by the same water treatment works.

Patients with cryptosporidiosis were interviewed using a structured questionnaire. Cases were defined as those who had a positive stool sample who lived in or visited the implicated water zone and who had onset of diarrhoea since March 1, 2000. Information on the water supply was provided by the local water company as well as rainfall statistics for the weeks prior to the outbreak. Water samples were collected from domestic properties, water treatment works and fire hydrants during flushing operations and analysed for *Cryptosporidium* oocysts.

There were 58 cases that met the case definition and had *Cryptosporidium* in their stool samples. Of these 51 lived in the same water supply zone and drank unboiled mains tap water. The crude attack rate for residents of this zone was 29.6 per 10,000 population, whereas the crude attack rate for people in the same local government area but not in the same water supply zone was 1.8 per 10,000 population. Approximately 90% of the water supplied to the affected zone came from The Lowcocks Water Treatment Works, sourced from Grindleton Springs. *Cryptosporidium* oocysts were found in samples of water from the treatment works and from domestic

taps. Environmental investigations suggested that contamination of Grindleton Springs with animal faeces via a damaged spring head structure was the possible cause of the outbreak. Genotyping results were consistent with an animal source.

This outbreak was unusual because the high attack rate of laboratory-confirmed cases. The authors suggest this may be due to low immunity in the population and a high concentration of oocysts at the time of initial contamination. It was also unusual that after the water supply in the area was changed to an alternate supply and the system was flushed, the oocysts persisted in the water distribution system. This may have been due to captured oocysts being released from the biofilm on distribution pipes. The evidence suggests that changing the water supply was the important public health measure as few, if any cases of infection occurred after the source was changed even though oocysts persisted.

Fluoride

A blind caries and fluorosis prevalence study of school-children in naturally fluoridated and nonfluoridated townships of Morayshire, Scotland.

Stephen K W, Macpherson L M D, Gilmour W H, Stuart R A M and Merrett M C W. Commun Dent Oral Epidemiol (2002) **30**(1) p70-9.

This study was undertaken to examine under blinded conditions, caries and fluorosis prevalence in 5 and 6 year old children and 8 to 12 year old children. Five Morayshire coastal communities in Scotland were investigated. Three of these communities were in Scotland's only known naturally fluoridated public water supply area, which has been fluoridated (F) since 1985 (diluted from 2.4ppmF to 1 ppmF). The other two communities were similar socioeconomically and were in nearby low-fluoride regions (N-F) (0.03ppmF).

The 5 and 6 year old children were lifetime residents of their communities and the 8 to 12 year olds were either lifetime or school-lifetime residents. Children were bussed to one examination site in a town hall for five consecutive days. They were examined for

caries presence and DMFT/dmft and DMFS/dmfs values were calculated; these values describe the prevalence of dental caries in an individual (lower case representing primary teeth). Children were asked about their own perception of the aesthetics of their maxillary front teeth. Fluorosis was assessed using a TF Index criteria and photographic slides of teeth. The slides were viewed blind and scored by four dental staff and two lay staff. A parental questionnaire was distributed to obtain information on fluoride supplement and dentifrice usage history.

There were 101 children included in the study from the F communities and 216 from the N-F communities. The percentage of caries free primary teeth in 5 and 6 yr-old children in the F group was significantly greater (87%) compared with the N-F group (32%). For 8 to 12 yr-old children the caries free percent for permanent teeth was significantly greater in the F group (83%) than in the N-F group (51%). DMFT values indicated fewer caries in the F group than the N-F group but were not significant for all age groups; the same patterns were seen for DMFS. There was a higher prevalence of fluorosis in permanent teeth of children from the lifetime water-fluoridated 8 to 12 yr-old cohort, this was just statistically significant. Assessment of the photographic slides overall found more mottled F (43.6%) than N-F (30.9%) students, although only 14 scorings were unanimous decisions.

From the results found here there is strong evidence that the primary school lifetime residents in the townships with the naturally fluoridated drinking water overall have considerably better dental health than those in the low fluoride townships.

Comment The authors note that this study has clearly shown the benefits of water fluoridation on tooth decay despite the majority of children in both F and N-F groups using fluoridated toothpaste.

Esthetically objectionable fluorosis attributable to water fluoridation.

Griffin S O, Beltran E D, Lockwood S A and Barker L K. *Commun Dent Oral Epidemiol* (2002) **30**(3) p199-209.

This study estimated the prevalence of perceived esthetic teeth problems, which can be attributed to current water fluoridation policy in the US (attributable burden) and compared estimates of fluorosis prevalence and risk attributable to fluoridation using two separate indices applied to the teeth.

Estimates of enamel fluorosis prevalence by severity were obtained from the National Survey of Oral Health in US School Children: 1986-87. A Dean's fluorosis index (value of second highest scored tooth among all teeth) and an anterior fluorosis index (value of the highest scored maxillary anterior tooth) were used to measure the degree of fluorosis in fully erupted permanent teeth. The child's parent or guardian completed a questionnaire with questions on race or ethnicity, whether he or she had been exposed to fluoride drops or fluoride tablets and duration if applicable. Parents also completed a residential history including whether the residence was connected to a public water system. Questionnaire data and the 1985 CDC Fluoridation Census were used to determine if the public water systems serving each residence were optimally fluoridated and the date when fluoridation began. A water sample was collected from each school where the children were examined to ascertain the fluoride content of the school's drinking water.

There were 1868 children in the survey aged 12-14 years who had never received fluoride drops or tablets and had lived in only one house, served by a public water system with known fluoridation status. Of these children, 1839 had adequate information to calculate Dean's fluorosis index and had at least one anterior tooth scored for fluorosis. Children were divided into two groups on the basis of fluoride content of their school water sample: low (0.3ppm F or less) and optimal (between 0.7 ppm and 1.2ppm F). The risk of fluorosis attributable to fluoridation was calculated. The results from five published studies were used to calculate risk of perceived esthetic problems attributable to fluorosis, by severity. The attributable burden was then estimated.

Using the Dean's index, the prevalence of fluorosis (very mild or greater) among all children was 26%

whereas it was only 18% using the anterior index. Calculations with the anterior index found fluoridation was a risk factor for very mild and mild fluorosis. Among children in the optimal water fluoridation group, the prevalence of very mild or greater fluorosis using the anterior index was 23%, while in the low fluoride group it was 5%.

The mean values of risk of perceived esthetic problems attributable to very mild and mild fluorosis were found to be 9% and 33% respectively. It was estimated that around 2% of US school children may experience perceived esthetic problems which could be attributed to the current recommended fluoride levels. This must be balanced against the lifetime benefits of fluoridation and the related costs of alternative solutions.

Comment Fluorosis of the anterior (front) teeth is of greater aesthetic significance than the posterior teeth. Fluorosis examinations are performed by drying the teeth and examining them under strong light which reveals defects that may not be apparent in everyday circumstances. The authors suggest that a reduction in fluoride levels in children's toothpaste and education of parents to prevent children swallowing toothpaste may be more efficient to reduce the incidence of esthetic fluorosis than altering water fluoridation policy.

Metals

Metals in drinking water from new housing estates in the Sydney area.

Rajaratnam G, Winder C and An M. Environ Res (2002) **89**(2) p165-70.

The aims of this study were to investigate concentrations of lead (Pb), copper (Cu), manganese (Mn), zinc (Zn), cadmium (Cd) and Aluminium (Al) in the drinking water of metropolitan Sydney, to identify sources and processes of contamination and to determine whether these metals in household drinking water supplies pose a public health risk.

Houses were selected randomly from 10 suburbs in Sydney. There were 95 houses sampled, all less than 18 months old. Control samples of water before

delivery to houses were taken from five Sydney Water points. Householders collected three samples from their houses: sample 1 first-flush water (125 ml), sample 2 post-first-flush water (1 litre) and sample 3 fully flushed water (125 ml taken after 2 minutes of flushing).

To interpret the results, the Australian Drinking Water Guidelines (ADWG) were used. In general the control samples had metal levels below ADWG levels. Analysis of the metal levels in the households showed that Pb and Zn levels in first-flush water were significantly higher than those in either post-flush or fully flushed samples ($P < 0.05$) and that Pb and Zn levels in post-first-flush samples were significantly higher than those in fully flushed samples ($P < 0.05$). Levels of Pb above the ADWG guideline limit of 10 micrograms/L were found in 60% of first-flush samples, 24% of post-first-flush samples and 4% of fully flushed samples. For the three types of samples, median Zn values were less than the ADWG value (3000 micrograms/L), with 1% of samples above the ADWG value. For Cu, 12% of the first-flush samples were above the ADWG value for Cu (1000 micrograms/L), 18% of post-first-flush samples and 3% of fully flushed samples were above the ADWG value. Only 4 houses exceeded the ADWG value for Cd (2 micrograms/L) being 4% of the sample. The other metal contaminants were within ADWG.

The low metal levels found in the supply reservoirs imply that the source of the metal contaminants in the drinking water was the household plumbing systems rather than supply points or storage tanks. Most first-flush water exceeded the ADWG levels. The authors recommend education programs to alert the public to risks from metals in drinking water, and encourage people to flush drinking water taps after prolonged standing.

Nitrate

An ecologic study of nitrate in municipal drinking water and cancer incidence in Trnava District, Slovakia.

Gulis G, Czompolyova M and Cerhan J R. Environ Res (2002) **88**(3) p182-7.

In an agricultural district (Trnava District) in the Slovak Republic, an ecological study was undertaken to determine whether nitrate levels in drinking water were correlated with non-Hodgkin lymphoma and cancers of the digestive and urinary tracts.

Data on nitrate levels in water from 1975 through 1995 was used. Each village using a municipal water supply was categorized according to levels of nitrate: less than or equal to 10 mg/l, 10.1-20 mg/l and greater than 20 mg/L total nitrate. Using the Trnava District Cancer Registry and extra data from the National Cancer Registry, the observed number of cancer cases for each village for the years 1986-1995 were determined. This was based on residence at the time of cancer diagnosis.

Standardized incidence ratios (SIRs) and 95% confidence intervals (CI) were calculated by indirect standardization for all cancer and selected cancer sites using age (10-year) and calendar year strata and sex-specific incidence rates from the entire district. Also a trend test in the SIRs across levels of nitrate exposure was calculated.

For total cancer occurrence there was a positive association between nitrate level and cancer incidence. For all cancer in women, SIRs increased progressively from villages with low to medium to high levels of nitrate. For men there was a similar trend for all cancer from low to medium levels but not for high nitrate levels. There was a positive association found for cancer of all digestive organs and non-Hodgkin lymphoma and nitrate level. The increase in cancers from low to high nitrate levels was found for stomach cancer in women, colorectal cancer in women and men and non-Hodgkin lymphoma in women and men. No associations were found for incidence of kidney or bladder cancer and nitrate levels.

This ecological study was unable to assess other exposures that may be relevant to cancer risks including smoking, pesticides or other sources of nitrate including diet and some medications.

Nosocomial infections

The hospital water supply as a source of nosocomial infections.

Anaïssie E J, Penzak S R and Dignani M C. Arch Intern Med (2002) **162**(13) p1483-92.

The aim of this paper was to examine waterborne nosocomial infections and evaluate the extent of the problem they cause. Their mode of transmission was also considered and recommendations for guidelines for their prevention were made.

A MEDLINE search of the literature was conducted for articles published between January 1, 1966 and December 31, 2001. Abstracts published at yearly meeting of the American Society for Microbiology, the Infectious Disease Society of America and the Society of Healthcare Epidemiology of America from January 1, 1987 to December 31, 2000, were also reviewed. Waterborne nosocomial infections other than *Legionella* species were analysed.

Legionella pneumophila is the pathogen most likely to be recognized by health care workers as the cause of nosocomial infection and recommendations for prevention of infection have been well published. However, nosocomial waterborne infections by other microbes have been mostly overlooked even though high morbidity and mortality rates have been associated with them.

The review identified 29 outbreaks where epidemiological evidence and molecular typing of microorganisms implicated tap water as the infection source, and a further 13 outbreaks had lower quality evidence without molecular typing. Bacteria have been associated with waterborne nosocomial infections and have been responsible for serious morbidity and even mortality. *Pseudomonas aeruginosa* in particular can live in hospital water for long periods of time and has been responsible for nosocomial outbreaks. Mycobacteria have been found in hospital water and implicated in serious nosocomial outbreaks, they can survive over several years in water systems. Fungi, parasites and viruses have been reported in hospital water supplies and may also cause nosocomial infection

Hospital patients are exposed to waterborne microorganisms when showering, bathing and drinking (water or ice) and by contact with contaminated medical equipment rinsed with tap water. Organisms can be traced back to hospital water tanks, faucet tap water and showers.

There are no established guidelines for preventing hospital waterborne infections although there are guidelines for water safety in the community, particularly for immunocompromised individuals. The authors recommend that exposure to hospital water should be avoided as much as possible for immunocompromised patients, and that sterile water should be supplied for drinking and washing of medical equipment. Staff members and patients need to be educated on procedures to prevent infection from waterborne pathogens. Intensive surveillance and monitoring of water systems when infections occur and routine surveillance in hospitals with high risk patients is also recommended. The repair and disinfection of damaged water systems and regular maintenance of hospital water systems is also important.

Norwalk-like virus

Waterborne outbreak of Norwalk-like virus gastroenteritis at a tourist resort, Italy.

Boccia D, Tozzi A E, Cotter B, Rizzo C, Russo T, Buttinelli G, Caprioli A, Marziano M L and Ruggeri F M. *Emerg Infect Dis* (2002) **8**(6) p563-8.

This paper describes the investigation of an outbreak of gastroenteritis that occurred during July 2000 at a tourist resort in the Gulf of Taranto, southern Italy. Cases were those guests or employees who stayed at the resort from July 1 to 31 and who had diarrhea or vomiting or both as defined by the inclusion criteria, in the same period. Identified cases were interviewed and demographic data and information on symptoms was collected. There were 344 cases identified and 69 (20%) were staff members. A retrospective cohort study was performed to assess risk factors associated with illness in staff members. All 224 staff were sent a questionnaire to answer.

From July 18 to 28, 28 faecal and 2 vomit samples were collected from 30 case patients. Water samples were collected after July 13 from various points of the main public water supply outside and inside the resort. Samples were also collected from food in the kitchen and the refrigerators.

Information on personal characteristics and clinical presentation was available for 248 ill people. Five patients were hospitalised and then discharged within a few hours. Attack rates did not vary by age, sex or symptoms for cases. Three peaks in the number of cases occurred at approximately weekly intervals for 3 weeks, consistent with an influx of new guests each weekend becoming infected.

There were 181 questionnaires completed by the staff members in the cohort study. The attack rate was found to be 38.1% in this group. Lowest attack rates were found in kitchen staff or office staff and the highest rates were in waiters, sports trainers, entertainers and cleaning staff. Those staff members who showered on the beach or consumed drinks with ice were more likely to become ill than those who did not.

Of the 28 faecal samples examined, 22 were positive for Norwalk-like virus (NLV) and 7 were positive for *Clostridium perfringens* and NLV. Food samples were negative for enteropathogenic bacteria. Water samples that were collected from faucets in the bar, the kitchen and a guest room on July 13 were found to have high levels of coliforms and faecal streptococci. This level of contamination was also found in water samples from the pipe connecting the resort's water tank to the public water supply, but not in the public supply itself.

The authors concluded that this was probably a waterborne outbreak. A breakdown in the pipe connecting the water system of the resort to the public supply was identified by environmental inspection and tap water samples from various places in the resort showed high levels of faecal bacteria contamination. In addition to water contamination, person-to-person transmission may have contributed to the outbreak. This was the first outbreak of NLV infection to be confirmed in Italy.

Comment Although some control measures (use of bottled water for drinking and washing vegetables) were introduced after the first week, these were ineffective as tap water was still used to make ice and for showering and irrigation. Attempts to clean up the water supply at the end of the second week were incomplete as only one part of the system was hyperchlorinated and no flushing was carried out. The contaminated water was gradually diluted as clean water from the municipal supply was trucked in to fill the storage tank at the resort.

Recreational Water

Predicted Public Health Consequences of Body-contact Recreation on a Potable Water Reservoir.

Stewart M H, Yates M V, Anderson M A, Gerba C P, Rose J B, De Leon R and Wolfe R. J AWWA (2002) 94(5) p84-97.

This study addressed the potential health consequences related to consuming water from a reservoir at which body-contact (BC) recreation such as swimming, water-skiing, sailing and fishing etc is permitted. The Metropolitan Water District of Southern California recently completed construction of a drinking water reservoir with a surface area of 4,500 acres. BC- recreation has been proposed at this reservoir however before allowing this to go ahead a modelling-based risk assessment study was conducted to assess the potential public health consequences to downstream potable water users consuming this reservoir water.

A finite-segment model was developed to estimate reservoir outlet concentrations of various pathogens including; *Cryptosporidium*, Giardia, rotavirus and poliovirus released by individuals engaged in BC recreation. Two recreational scenarios were considered: full basin usage (FBU) – BC recreation throughout the reservoir and east basin usage (EBU) – BC recreation restricted to the half or the reservoir furthest from the outlet tower. A risk assessment based on the calculated pathogen concentrations for the proposed BC recreational scenarios using dose-response models was performed to quantify the public health risk to water consumers.

The model found that the addition of BC recreation to this reservoir would increase the number of pathogens released into it and therefore increase the loading of pathogens entering the treatment plant. The main concern to downstream consumers was proposed to be increased risk of *Cryptosporidium* infection. The annual risk of infection under the FBU scenario ranged from 3 to 41 times above background depending on the confidence level and number of recreation users. This corresponds to 385 to 5,005 infections in the community annually. Under the EBU scenario the risk of annual infection ranged from 1.8 to 19 times background, corresponding to up to 224 to 2,345 community infections annually. The model was used to predict transient episodes of elevated pathogen levels. Under the FBU conditions the relative risk ranged from up to 13.2 to 6,600 times higher than background depending on the confidence level and the number of BC-recreational users. The number of daily infections associated with these peak events was estimated to be as high as 2,325.

Various treatment alternatives were examined to determine the most cost effective means of accomplishing additional pathogen reduction at the existing treatment facilities. The most cost effective alternative was to provide ozone disinfection in addition to existing treatment. However, this may result in increased treatment costs for plants receiving water from the reservoir, and may result in elevated bromate levels which could breach drinking water regulations. Studies were also undertaken to evaluate economic benefits of adding BC recreation to the reservoir. It was found that an economic loss that is equal to or greater than the proposed revenue raised from the addition BC recreational activities may occur if potential costs of waterborne disease are considered in addition to water treatment costs.

Risk Assessment

Effectiveness of different artificial neural network training algorithms in predicting protozoa risks in surface waters.

Neelakantan T R, Lingireddy S and Brion G M. J Environ Eng-ASCE (2002) 128(6) p533-42.

This study used artificial neural networks (ANN) to map relationships between surrogate parameters and concentrations of pathogenic contamination in surface water. Detection of *Cryptosporidium* and *Giardia* through analysis of water samples is tedious, expensive and difficult and therefore surrogate water quality parameters are useful. This study compared and contrasted the performance of different training schemes in predicting risky concentrations of *Cryptosporidium* and *Giardia* when using a relatively small dataset with limited pathogen observations.

The models produced better results for the classification of *Cryptosporidium* risks than for *Giardia* risks. This may be because of differences in principal sources and transport of these pathogens. The genetic algorithm based neural network training consistently provided better results compared to the other training methods. This study shows that neural networks can be used successfully to learn the distinctive characteristic signature of numerous water quality surrogates for the prediction of risky conditions of protozoan concentrations.

Sodium

Increased sodium concentrations in drinking water increase blood pressure in neonates.

Pomeranz A, Dolfen T, Korzets Z, Eliakim A and Wolach B. *J Hypertens* (2002) **20**(2) p203-7.

Dietary sodium intake is a risk factor for the development of hypertension in both animals and humans. The concentration of sodium in drinking water varies widely and in some developing countries it can exceed 250 mg/l. This study aimed to assess the influence of sodium concentration in the water used for diluting milk powder infant formula on blood pressure during the first 2 months of life.

Individuals participating in the study were enrolled in the Meir General Hospital's neonatal unit located in the central coastal plain of Israel. All babies were Jewish and from families with no history of hypertension. There were 58 newborn infants included in the study and they were randomly assigned to two groups. Group 1 consisted of 25 infants fed with a formula diluted with low-sodium

mineral water (LSMW) with a sodium concentration of 32 mg/l. Group 2 consisted of 33 infants fed the same formula diluted with high sodium tap water (HSTW) with a sodium concentration of 196 mg/l. A group of 15 breastfed babies were the control group (group 3). Weight, height, head circumference, heart rate and systolic, diastolic and mean arterial pressures were recorded weekly for the first 8-week period. After this period group 1 infants reverted to a diet similar to that of group 2. After 6 months, follow-up measurement of blood pressure was taken from 11, 20 and 7 infants in groups 1, 2 and 3, respectively. Urinary sodium:creatinine ratio was determined monthly during the first 2 months.

No difference was found between the groups in regard to body weight, height and head circumference at weeks 4 and 8. For the entire study period, heart rate did not differ between the groups. Results found that from the 6th week, systolic and diastolic blood pressure and mean arterial pressures were significantly greater in group 2 than in groups 1 and 3. The urinary:creatinine ratio was significantly greater in group 2 than in the other groups and was correlated with systolic, diastolic and mean arterial pressures. At 6 months the average blood pressure values in group 1 increased towards those of group 2. This study showed that milk formula diluted with tap water containing a high concentration of sodium results in infants consuming a high-salt diet, which may lead to an increase in blood pressure. Therefore infant formula should be diluted with low-salt water.

Surveillance

Spatial patterns of diarrhoeal illnesses with regard to water supply structures - a GIS analysis.

Dangendorf F, Herbst S, Reintjes R and Kistemann T. *Int J Hyg Environ Health* (2002) **205**(3) p183-91.

This study used geographical information system (GIS) to analyse the distribution of gastrointestinal infections in the Rhine-Berg District of Germany and examine whether spatial variations of diarrhoeal illness may be linked to different drinking water supply structures. The Rhine-Berg District includes two regions with different sources of drinking water.

The northern and southern subdistricts obtain drinking water from surface reservoirs whereas the western subdistrict is served by groundwater.

The GIS was used for storing and analysing a wide range of data sets, which included features of the water supply structure and epidemiological databases. Epidemiological data on diarrhoeal illness were available from the Local Health Department for the period 1988 to 1999. The data included information on causative pathogen, the date of disease outcome, the date of registration, other infected people, travel, age, sex, the connection to private or public water supply etc. Salmonella and Shigella infections were excluded as these are known to be mainly attributable to food or travel exposure.

The GIS analysis showed that there was spatial variation in the incidence of diarrhoeal illness.. Correlation models showed a moderately positive link between disease incidence and the amount of people served by groundwater, implying that districts with surface water supply had lower disease rates.

This study showed that GIS-technology can be applied successfully to area-based correlation studies in drinking water epidemiology and that cooperation from many disciplines is need to realise the full capacity of GIS-applications in environmental health.

Comment The authors note that there are many factors affecting the occurrence and reporting of diarrhoeal illness although attempts were made in this study to adjust for use of private wells, mobility of people and the density of physicians. The apparent increased incidence of disease with groundwater supplies may reflect lack of disinfection for most of these sources, or may be unrelated to the water type.

Uranium

Gastrointestinal absorption of uranium in humans.

Limson Zamora M, Zielinski J M, Meyerhof D P and Tracy B L. Health Phys (2002) **83**(1) p35-45.

This study was undertaken to obtain a more definitive value of the gastrointestinal (GI) absorption factor

(f_1); the fraction of the ingested uranium absorbed from the human gastrointestinal tract. Two sites were selected for this study. The village of New Ross in Nova Scotia, an inland agricultural community with privately owned wells as the water supply (30 participants) and with water uranium levels ranging from 2 to 780 micrograms L⁻¹ and the Ottawa region where the drinking water supply is obtained from the Ottawa river and uranium levels are consistently less than 1 microgram L⁻¹ (20 participants).

The participants from the two regions were matched for age and sex. The daily water intakes and food intakes of the participants were comparable. A duplicate diet method was used to ensure that total uranium intake was measured accurately. Urine and faecal samples were also collected daily for the same 3-day period. Participants completed a daily diary of food and water consumption and samples collected. The total uranium intake from water and food over the 3-day period was used to estimate the daily uranium intake for each participant. The amount of uranium excreted in urine in the 3-day period was used as an indicator of uranium absorbed in the GI.

The median uranium GI absorption factor, f_1 for all participants was 0.009 with a range of 0.001 to 0.06. Half of the f_1 values were less than 0.01 and 78% were below 0.02, this finding supports the International Commission on Radiological Protection recommendation of 0.02 as the appropriate f_1 value for adults and children over 1 year old. The f_1 values were not gender-sensitive and were independent of age at time of study. Analysis of the data suggests that when uranium is ingested in or with food, enhanced absorption in the GI tract does not occur. GI absorption of uranium was found to be independent of total uranium intake over the range of intake values included in this study. In this study, high intake of uranium in drinking water was not correlated with high intake through food.

The findings from this study provide useful information in terms of setting drinking water guidelines for uranium.

Water disinfection

UV disinfection of *Giardia lamblia* cysts in water.

Linden K G, Shin G A, Faubert G, Cairns W and Sobsey M D. Environ Sci Technol (2002) **36**(11) p2519-22.

Giardia lamblia cysts are not completely removed by conventional water and wastewater treatment processes including chemical disinfection. Research was undertaken to evaluate the kinetics and extent of inactivation of *G. lamblia* cyst infectivity using different doses of UV irradiation and to assess the capability of this parasite to repair UV-mediated DNA damage and restore infectivity.

Cysts were collected from experimentally infected Mongolian gerbils. A collimated beam bench scale UV apparatus consisting of two 15-W low pressure (LP) mercury vapour germicidal lamps was used emitting nearly monochromatic (254 nm) UV radiation. The UV doses were typical of those used in drinking water and wastewater treatment practices (160 and 400 JM⁻²). The kinetics and extent of DNA repair of UV-irradiated *G. lamblia* cysts was examined under dark and light repair conditions that are commonly used in bacterial, eukaryotic and mammalian cell DNA repair studies.

UV irradiation was very effective at inactivating *G. lamblia* in water, based on this animal model. Reduction of infectivity was fast and extensive reaching a detection limit of greater than 4 log within a dose of 10 JM⁻². There was no evidence of either light or dark repair of UV-damaged DNA in *G. lamblia* cysts. Typical UV disinfection doses used to inactivate pathogens including bacteria and viruses in drinking water and wastewater plants should be effective in controlling this pathogen.

Water Contaminants

A human health risk assessment of pharmaceuticals in the aquatic environment.

Schulman L J, Sargent E V, Naumann B D, Faria E C, Dolan D G and Wargo J P. Hum Ecol Risk Assess (2002) **8**(4) p657-80.

This paper reports on the environmental occurrence of four pharmaceutical compounds and an assessment of their potential risk to human health. The compounds chosen for this study were selected based on a review of the published literature on pharmaceuticals detected in aqueous environmental media including: sewage treatment plant effluent, surface water, drinking water and groundwater. The compounds were chosen to represent different therapeutic drug classes. The four compounds studied were: acetylsalicylic acid (aspirin), clofibrate (a cholesterol lowering drug), cyclophosphamide (a cancer chemotherapy drug) and indomethacin (a non-steroidal anti-inflammatory drug).

In order to estimate safe water quality limits for each pharmaceutical, the U.S. Environmental Protection Agency (USEPA) *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* was used to calculate provisional ambient water quality criteria (AWQC). The calculated values were used as benchmarks to compare the measured environment concentrations of these pharmaceuticals against. The provisional AWQCs were calculated from health-based limits (HBLs) for noncancer effects and risk-specific dose (RSD) for carcinogens. HBLs were established for acetylsalicylic acid, clofibrate, and indomethacin and RSD was established for cyclophosphamide. In addition to HBLs and RSD values, a bioaccumulation factor for each pharmaceutical and metabolites, where applicable, based on each compound's behaviour in the environment was calculated. The concentrations of a pharmaceutical detected in the environment were compared with the derived water quality limits, according to the AWQC methodology. Only surface water and drinking water were considered.

None of the four pharmaceutical compounds studied indicated an appreciable risk to human health based on the fact that the maximum measured concentrations in surface and or drinking water were all significantly below the provisional safe water quality limits. Therefore no adverse health effects for humans would be anticipated from the levels measured.

Additional Articles

Fungal flora in groundwater-derived public drinking water.

Gottlich, E., *et al.* International Journal of Hygiene & Environmental Health, 2002. **205**(4): p. 269-279.

Pseudo-outbreak of *Mycobacterium fortuitum* on a human immunodeficiency virus ward: Transient respiratory tract colonization from a contaminated ice machine.

Gebo, K.A., *et al.* Clinical Infectious Diseases, 2002. **35**(1): p. 32-38.

Domestic transmission routes of pathogens: the problem of in-house contamination of drinking water during storage in developing countries.

Jensen, P.K., *et al.* Tropical Medicine & International Health, 2002. **7**(7): p. 604-609.

Case-control studies of sporadic cryptosporidiosis in Melbourne and Adelaide, Australia.

Robertson, B., *et al.* Epidemiology & Infection, 2002. **128**(3): p. 419-431.

Association of very low birth weight with calcium levels in drinking water.

Yang, C.Y., *et al.* Environmental Research, 2002. **89**(3): p. 189-194.

Cryptosporidium and Giardia in natural, drinking, and recreational water of Northwestern Greece.

Karanis, P., *et al.* Acta Hydrochimica et Hydrobiologica, 2002. **30**(1): p. 49-58.

Trichloroacetic acid as a biomarker of exposure to disinfection by-products in drinking water: A human exposure trial in Adelaide, Australia.

Froese, K.L., M.I. Sinclair, and S.E. Hrudey. Environmental Health Perspectives, 2002. **110**(7): p. 679-687.

Outbreak of leptospirosis among triathlon participants and community residents in Springfield, Illinois, 1998.

Morgan, J., *et al.* Clinical Infectious Diseases, 2002. **34**(12): p. 1593-1599.

Hospital-acquired legionellosis: solutions for a preventable infection.

Sabria, M. and V.L. Yu. The Lancet Infectious Diseases, 2002. **2**(6): p. 368-373.

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The CRC for Water Quality and Treatment also produces the quarterly newsletter **Water Quality News** featuring current affairs, highlights from all research programs of the CRCWQT, and information about other CRCWQT activities.

Both newsletters are available free of charge to the water industry, public health professionals and others with an interest in water quality issues. Electronic versions of the newsletters and a searchable archive of Health Stream articles are available on the Web page of the CRCWQT.

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