Cryptosporidiosis: an emerging microbial threat in the Pacific

NINA RUSSELL, BPSYCH (HONS)***
PHIL WEINSTEIN, MBBS, PHD, FAFPHM**
ALISTAIR WOODWARD, MBBS, PHD, FAFPHM*

Introduction

A hardy and ubiquitous protozoon, *Cryptosporidium* is responsible for an increasing amount of severe gastrointestinal disease in both developed and developing countries. In New Zealand the number of reported cases has been increasing continuously since cryptosporidiosis became notifiable in June 1996. This paper looks at some environmental and social-political factors that play a role in the emergence of this disease in the community, discusses the potential impact of *Cryptosporidium* in the Pacific, and highlights the need for both effective surveillance systems and econologically based public health interventions.

This paper looks at some environmental and social-political factors that play a role in the emergence of this disease in the community, discusses the potential impact of *Cryptosporidium* in the Pacific ...

Status of cryptosporidiosis

Cryptosporidium is a major enteric pathogen, affecting people living in developed and developing countries including New Zealand and Pacific[1,2]. The first human case was diagnosed in 1976 and for the next six years cryptosporidiosis appeared mainly to affect people with compromised immune systems. This perception of cryptosporidiosis as an opportunistic infection only found in the immunocompromised was challenged and expanded in the eighties to include the immunocompetent, as it was realised that increasing numbers of otherwise healthy people (particularly children) were becoming infected. It is now known that the infection can be transmitted from animals (mainly cattle and sheep)[3,4] from person to person (via the faecal-oral route) and through contaminated food and water.

The water-borne route is of particular concern as infections transmitted in this way may involve a very large number of people. For example, approximately 403,000 people became ill during the Milwaukee waterborne outbreak of 1993[5], after exposure to drinking water from the city's public supply which had become contaminated with *Cryptosporidium* oocysts. During this outbreak 4,000 people were hopsitalised and it was estimated that cryptosporidiosis contributed to 104 deaths in immunocompromised individuals. There is substantial evidence that water may be the most important vehicle for transmission of *Cryptosporidium*. Epidemiological research and microbiological studies indicate that water supplies are frequently a primary source of infection These supplies include rivers, streams, spring water, surface water, ground water, well water, recreational water and importantly, treated disinfected potable water[4-17]. The biological characteristics of *Cryptosporidium* favour transmission by water. The infective dose is small (as little as 10 oocysts[18]), the oocysts are hardy, resistant to chlorine[19] and able to remain viable in water for months[20,21]. Also, *Cryptosporidium* is resistant to filtration due to the small size of the oocysts. Contamination of a water source may easily arise as a result of runoff from farmland or animal industry, or from sewage effluent contamination[7]

Countries in the South Pacific have historically been vulnerable to waterborne disease. This vulnerability has resulted from several factors, including the problems of maintaining clean water, effective sanitation and hygiene - all compounded by disastrous climatic events such as cyclones, floods, droughts and tidal waves[22]. Approximately 11% of the world's total cyclones occurs in the South-West Pacific region every year, leaving many homeless and severely

*Head Of Department, The Department of Public Health, Wellington School of Medicine **Senior Lecturer, Environmental Health, Department of Public Health. ***(Research Fellow), Department of Public Health. Address: PO Box 7343, Wellington, New Zealand. Tel (04)385-5999, fax: (04) 389-5319, email:woodward@wnmeds.ac.nz

affecting access to drinking and bathing water[23]. Environmental changes, such as global warming will see an increase in the frequency and severity of these events and as such play an important role in the emergence of infectious disease[24,25] and contributing to the South Pacific's vulnerability[26]. Our geographical isolation also makes us more vulnerable to infectious diseases and natural disasters, because the effects of these are aggravated and inescapable in isolated societies, especially those with small populations like the Tokelau Islands[22]. In order to reduce this vulnerability, we should seek to better understand environmental factors and use climatological information to prepare for national disasters which are detrimental to our water quality[27], for example heavy rains and flooding which increase the chance of contamination of water by animal and human faeces[28].

Cryptosporidium is becoming increasingly common in New Zealand's water supplies, as evidenced by a recent waterborne outbreak in Te Aroha in the Waikato (September, 1997)[1]. There are many population centres in New Zealand that may be particularly susceptible to waterborne disease (both endemic and epidemic) including cryptosporidiosis. For example, 68 of the 137 New Zealand communities with more than 2,000 people face a high level of risk from their drinking water as recorded by Ministry of Health water quality gradings. Many New Zealand cities and towns obtain their drinking water supplies from surface catchments and systems which rely on chlorination treatment alone for disinfection[30]. Yet there is a lack of information about the prevalence of *Cryptosporidium* in our waters, little is known about effective methods to remove *Cryptosporidium* from the water, and the current waterborne disease surveillance systems capture only a small percentage of actual cases. Some Pacific countries do not yet have cryptosporidiosis registered as a notifiable disease, despite international recommendations to do so[24, 27, 31, 32].

Economics of cryptosporidosis

Levins (1994)[33] succinctly noted that *"sometimes we face a rather bizarre situation, where we have to prove the disease is costing money before we can convince somebody to do something about it"*(p. 325). That disease-causing protozoa make people unwell is not in itself sufficient reason for governments to spend money on preventative measures (such as monitoring water quality for oocysts) or surveillance systems. It is not until the disease is couched in monetary terms that government expenditure becomes a priority (and often then only if the disease creates more expense than prevention). Sadly, those most at risk from contracting gastrointestinal diseases like cryptosporidiosis are children and subsequently, their carers whose illness often does not impact on the workforce and who, in terms of government balance sheets, are generally without economic worth. Indeed, true understanding of the economic value of microbially safe water supplies has been cited as one of the main points that needs to be made in order to motivate governments into action[27]. The direct impact of cryptosporidiosis on public health (doctor's fees, hospital admissions, etc) is only one dimension of the fiscal drain this waterborne disease contributes to. Contaminated water is a risk to the armed forces (diarrhoeal illness leads the list of infectious diseases that affect the military[34]), to the food industry – as water is used to clean and process products, and in products themselves[1]. Of particular importance in the Pacific is the risk contaminated water poses to tourism. This industry is significantly affected by waterborne disease outbreaks and 'boil water' notices[27, 32].

Other indirect costs of cryptosporidiosis (which may last up to two weeks in an otherwise healthy person) include the impact on industry through absenteeism[35] and loss of productivity . Calculating the exact cost of cryptosporidiosis is difficult, but implementing effective surveillance systems in the Pacific would provide a better basis for estimating the economic significance of *Cryptosporidium* in the region. Surveillance for *Cryptosporidium* involves stool samples being routinely collected and tested (the modified acid-fast stain test is commonly used in New Zealand), if oocysts are detected the case should be promptly notified to the relevant public health official and recorded on a nationwide database. The case should be followed up to discuss management and to prevent the spread of cryptosporidiosis, ideally also with an assessment of the likely source of infection.

Discussions

The surveillance data available (for cases of cryptosporidiosis in New Zealand and reported diarrhoeal disease in some South Pacific countries) are shown in Table 1. These data are

Table 1. Diarrhoeal disease in the South Pacific and New Zealand

Countries	Population (Year / Reference)	Reported diarrhoeal disease (Year / Reference)	Reported cases of cryptosporidiosis (Year / Reference)
*Member countries of the South Pacific Commission**	*2,329,981 (1994 / 50)*	*69,255 (Jan. 1993 – Dec 1993 / 50)*	no data
New Zealand	*3,618,392 (1996 / 51)*	*12,398 (Sept. 1996 – Sept 1997 / 2, 52, 53, 54)*	*248 (Sept. 1996 – Sept. 1997 / 2)*

* Excludes Papua New Guinea, Palau, Guam and Nauru (no notification data available for these countries)

likely to represent only a fraction of the true incidence of diarrhoeal disease in the community as much goes unreported. The financial cost of monitoring water borne disease such as cryptosporidiosis can be recovered by the benefits generated from efficient surveillance systems and accompanying timely public health interventions[27] particularly in nations that are, especially vulnerable to such diseases. Unfortunately, these same nations are usually those that can least afford to set up and maintain reliable surveillance systems. Nevertheless, public health surveillance of cryptosporidiosis is vital for the early control of waterborne outbreaks to prevent secondary transmission[16]; index cases resulting from the consumption of contaminated water once introduced into the population, can quickly lead to spread by person to person transmission.

Cryptosporidium has a complex relationship with its host and the disease outcome is often unpredictable. Some people are more vulnerable to infection (e.g. AIDS patients[37], children and travellers[38]) than others who may have immunity through low level continual exposure to oocysts in the environment[39,40]. In addition cryptosporidiosis, like most environmental hazards, has an equally complex relationship with the many social, economic, political and demographic factors which in turn influence the health of the host[41].

The financial cost of monitoring water borne disease such as cryptosporidiosis can be recovered by the benefits generated from efficient surveillance systems and accompanying timely public health interventions particularly in nations that are, especially vulnerable to such diseases.

Cryptosporidiosis can occur at all ages but is most common in children[42,43]. Societal changes such as the increase of single parent families have seen an expanding use of childcare facilities[24] which in turn maximises the potential for further spread of cryptosporidiosis. *Cryptosporidium* was detected in stool specimens in over 6% of childcare facilities in Brazil[44], a rate which may arguably be at least equalled in Pacific communities with close communal living. The declining rate of the duration of breastfeeding, which could arguably be related to inadequate government maternity leave policies (women in New Zealand are currently not entitled to any paid leave) also contributes to the susceptibility of children to diarrhoeal diseases. An increased risk of cryptosporidiosis in weaned children has been found[45,46,47] possibly as a result of contaminated water being used in bottles. In June 1996, the proportion of mothers in New Zealand giving any breastfeeding to infants at six months was approximately 50% for Pacific and European women, and around 45% for Maori women[48], these proportions are well below the Ministry of Health's breastfeeding goals[49]. Furthermore, malnutrition (and the subsequent lowering of a person's immunity to communicable disease) and poverty-induced overcrowding all add to the threat of *Cryptosporidium* as an emergent infection. Like all emergent waterborne infections cryptosporidiosis must be seen in a socio-economic context[41] particularly where this context relates to the use of microbially safe water for drinking, washing, food preparation and ablution.

Conclusion

Because of the complexities of the interactions between humans and sources of *Cryptosporidium*, public health education campaigns aimed at reducing water and foodborne transmission are often ineffective. Therefore, our efforts would perhaps be better aimed at stopping *Cryptosporidium* at its source. For example, it may be more cost effective to concentrate public health interventions on means of reducing the frequency with which the organism contaminates water, thereby reducing the hazard rather than focusing on decreasing exposure. To effectively decrease the hazard in this way requires a detailed local analysis of the ecology of the disease, including the relationship between climate, vegetation, geology, pathogens, animals and humans. Such an ecological approach has proven effective in developing novel intervention strategies for mosquito borne disease[55], and would have the potential to result in a better environment for all users of drinking and recreational water in the Pacific.

References

1 Laberge I, Griffiths M, Griffiths MW. Prevalence, detection and control of *Cryptosporidium parvum* in food. *International Journal of Food Microbiology*, 1996, 31 1-26.

2. Environmental Science Research Communicable Disease Centre (ESR CDC) *The New Zealand Public Health Report*. *Vol.4*. No. 11/12. Nov/Dec. 1997

3 Anderson BC. Prevalence of *Cryptosporidium muris*-like oocysts among cattle populations of the United States: Preliminary report. *J Protozool.*, 1991; 38(6): 14S-15S.

4 Casemore D. Cryptosporidiosis: another source. *BMJ.*,1989; 298: 750-751.

5 Mac Kensie WR, Hoxie NJ, Proctor M, et al A massive outbreak in Milwaukee of *Cryptosporidium* infection transmitted through the public water supply *New Engl J of Med.*, 1994; 331(3): 161-167.

6 Rush B, Chapman P, Ineson RW. *Cryptosporidium* and drinking water *Lancet*, 1987, 632-633. September 12.

7. Smith HV, Girdwood RWA, Patterson WJ et al Waterborne outbreak of Cryptosporidiosis *Lancet.*, 1988: 1484 December 24.

8. Hayes EB, Matte TD, O'Brien TR, et al. Large community outbreak of Cryptosporidiosis due to contamination of a filtered public water supply. *New Engl. J of Med.*, 1989; 320· 1372-6.

9. Weinstein P, Macaitis M, Walker C, et al. Cryptosporidial diarrhoea in South Australia. *Med J Aust.* 1993; 158: 117-119.

10. Moore AC, Herwaldt BL, Craun GF, et al. Surveillance for waterborne disease outbreaks - United States, 1991-1992. *Morbidity and Mortality Weekly Report.* 1993, 42 (No SS-5) 1-21

11. Atherton F, Newman CPS, Casemore DP. An outbreak of Cryptosporidiosis associated with a public water supply in the UK. *Epidemiol. Infect.*, 1995; 115· 123-131.

12. Fogarty J, Thornton L, Hayes C, et al. Illness in a community asociated with an episode of water contaminated with sewage. *Epidemiol Infect*, 1995; 114: 289-295.

13. Goldstein ST, Juranek DD, Ravenholt O, et al. Cryptosporidiosis: An outbreak despite state-of-the-art water treatment. *Annals of Internal Med*, 1996; 124: 459-468

14. Gallaher MM, Herndon JL, Nims LJ, et al. Cryptosporidiosis and surface water. *AJPH.*, 1989, 79: 39-42.

15. Morgan D, Allaby M, Crook S, et al. Waterborne cryptosporidiosis associated with a borehole supply. *Communicable Disease Report*, 1995; 5 (Review no. 7) R93-R97.

16. Ongerth J, Stibbs H Identification of *Cryptosporidium* oocysts in river water. *Applied and Environmental Microbiology*, 1987; 672-676.

17. Marshall M, Naumovitz D, Ortega Y. Waterborne protozoan pathogens. *Clin. Microbiology Reviews.*, 1997; 10 (1): 76-85

An increased risk of cryptosporidiosis in weaned children has been found possibly as a result of contaminated water being used in bottles.

18. Casemore DP. Epidemiological Aspects of human Cryptosporidiosis. *Epidemiol Infect.*, 1990; 104· 1-28.

19 Hall T, Pressdee J, Carrington E Removal of *Cryptosporidium* during water treatment In: Betts WB (editors) *Protozoan parasites and water.* 1995 ; Cambridge: 193-195.

20. Peeters JE, Mazas EA, Masschelein WJ, et al. Effect of disinfection of drinking water with ozone or chlorine dioxide on survival of *Cryptosporidium parvum* oocysts. *Applied and Environmental Microbiology*, 1989; 55(6). 1519-1522.

21. Robertson LJ, Campbell AT, Smith HV. Survival of *Cryptosporidium parvum* oocysts under various environmental pressures. *Applied and Environmental Microbiology*, 1992; 58 (11): 3494-3500.

22. Wessen AF, Hooper A, Huntsman J, et al *Migration and Health in a Small Society: The case of Tokelau.* Clarendon Press, Oxford 1992

23. New Zealand Ministry of Foreign Affairs and Trade. *Natural Disasters.* Information Bulletin No.46. April 1994. Wellington, New Zealand

24. Bryan RT, Pinner RW, Berkelman RL. Emerging Infectious Diseases in the United States· Improved surveillance, a requisite for prevention. *Annals New York Academy of Sciences*, 1994; 740: 346-61.

25 Hales S, Woodward A, Weinstein P. Arboviral disease and climate in Oceania. 1997 (*in review*).

26 Woodward A, Hales S, Weinstein P. Climate change in the Asia Pacific region: who will be most vulnerable? *(Climate Research, in press)* 1997.

27 Ford T, Colwell R. *A Global Decline in Microbiological Safety of Water· A Call for Action* (Report). American Academy of Microbiology 1996.

28. Smith HV, Robertson LJ, Ongerth JE Cryptosporidiosis and giardiasis. the impact of waterborne transmission. *J Water SRT- Aqua*, 1995, 44(6): 258-274.

29. ESR Water Group for the Ministry of Health. *Register of community drinking-water supplies in New Zealand.* Oct. 1996 5th Ed

30 Fraser G. Giardia and water supply. *NZ Med J*, 1991; 203-204 22 May.

31. Juranek DD Cryptosporidiosis: Sources of infection and guidelines for prevention. *Clinical Infectious Diseases*, 1995;21(Suppl 1). S57-61

32 US Department of Health and Human Services Assessing the public health threat associated with waterborne cryptosporidiosis: report of a workshop. *Morbidity and Mortality Weekly Report.* Vol. 44 (No. RR-6) 1-16.

33. Levins R. Theoretical and social approaches: Discussion Part A. The biosocial nature of disease emergence. pp. 325-328 In· Wilson M, Levins R, Spielman A (editors). *Disease and Evolution: Global changes and emergence of infectious diseases.* NY Academy of Science. New York 1994.

34. Guerrant RL, Bobak DA. Bacterial and protozoal gastroenteritis. *New Engl. J of Med.*, 1991; 325(5): 327-337.

35. Colley DG. Waterborne cyptosporidiosis threat addressed. *Emerging Infectious Diseases*, 1995; 1(2). 67-68

36. Berkelman R. Emerging infectious diseases in the United States, 1993. *Journal of Infectious diseases*, 1994; 170: 272-7.

37. Meinhardt PL, Casemore DP, Miller KB. Epidemiologic aspects of human cryptosporidiosis and the role of waterborne transmission. *Epidemiologic Reviews*, 1996; 18(2): 118-136.

38. Jokipii L, Pohjola S, Jokipii AM. Cryptosporidiosis associated with traveling and giardiasis. *Gastroenterolgy*, 1985;89: 838-842.

39. Goodgame RW. Understanding intestinal spore-forming protozoa: Cryptosporidia, Microsporidia, Isospora, and Cyclospora *Ann. Intern Med.*, 1996;124: 429-441.

40 Public Health Laboratory Service, NZCDC. Giardia and Cryptosporidium in drinking water. *Communicable Disease New Zealand*, 1992, 92(10). 97–98 Public Health Laboratory Service, NZCDC.

41. Satterthwaite D, Hart R, Levy, C, et al. *The Environment for Children*.1996, Earthscan Publications Ltd. U.K.

42 Public Health Laboratory Service Group Cryptosporidiosis in England and Wales: prevalence and clinical and epidemiological features. *BMJ*, 1990; 300: 774-7.

43. O'Donoghue PJ. *Cryptosporidium* and cryptosporidiosis in man and animals. *International Journal for Parasitology*, 1995; 25(2). 139-195

44. Franco RM, Cordeiro N da S. Giardiasis and cryptosporidiosis in day-care centres in the municipality Campinas SP. *Revista Da Sociedade Brasileira de Medicina Tropical*, 29(6): 585–91, 1996 Nov–Dec.

45. Zu S-X, Fang G-D, Fayer R, et al Cryposporidiosis. Pathogenesis and Immunology. *Parasitology Today*, 1992; 8(1): 24-27.

46. Molbak K, Aaby P, Hojlyng N, et al. Risk factors for *Cryptosporidium* diarrhea in early childhood A case-control study from Guinea-Bissau, West Africa *Amer. J. of Epidemiology*, 1994; 139 (7). 734-740

47 Nimri LF, Hijazi S. *Cryptosporidium*: A cause of gastroenteritis in preschool children in Jordan. *J Clin. Gastroenterol* 1994; 19(4): 288-91.

48 Statistics New Zealand *New Zealand Official Yearbook*. 1997, GP Publications, Wellington.

49. Ministry of Health *Progress on Health Outcome Targets 1996*. Ministry of Health, Wellington 1996.

50 South Pacific Epidemiological and Health Information Service. *Annual report for the year 1993*. South Pacific Commission, Noumea, New Caledonia 1995.

51. Statistics New Zealand. *New Zealand Census Data 1996*.

52 Environmental Science Research Communicable Disease Centre (ESR CDC). *The New Zealand Public Health Report Vol 3 No. 11/12*. Nov/Dec. 1996.

53. Environmental Science Research Communicable Disease Centre (ESR CDC). *The New Zealand Public Health Report Vol.4. No 1*. Jan. 1997.

54 Environmental Science Research Communicable Disease Centre (ESR CDC). *The New Zealand Public Health Report. Vol. 4. No. 2* Feb. 1997.

55. Weinstein P. An ecological approach to public health intervention. Ross River virus in Australia *Environmental Health Perspectives*, April 1997,105(4): 364-6 ▢

The first possibility of rural cleanliness
lies in the water supply.

Florence Nightingale (1820–1910)