Institution: University of East Anglia

Unit of Assessment: 2 - Public health, health services research and primary care

Title of case study:

Influencing international health policy to reduce acute waterborne diarrhoeal disease

1. Summary of the impact

Diarrhoeal disease is the world's second most common cause of death in children under five years old, killing 760,000 children each year according to the World Health Organisation (WHO). Microbial contamination of drinking water is one of the most important causes. In England and Wales acute diarrhoeal disease is estimated to cost the country £1.5 billion annually. UEA epidemiologists have shown the important role of water supply systems in spreading diarrhoeal disease in developed and developing countries; led WHO research projects on small scale drinking water systems; and influenced WHO policy on small scale drinking water systems in developed and developing countries. Methodological research on epidemiological methods for monitoring and regulating bathing water quality has led to changes in WHO guidance on bathing water quality standards and influenced US Environmental Protection Agency criteria. Hunter's participation in international expert panels facilitated the impact of this research on policy.

2. Underpinning research

Underpinning the impacts described in this case study is epidemiological research on infectious diarrhoeal disease associated with drinking and recreational water exposure. This research was led by Professor Hunter of UEA Norwich Medical School, working with epidemiologists from UEA's Schools of Environmental Science and International Development, and from Europe, the USA and Africa.

Small and very small drinking water systems

Small and very small drinking water systems supply water from well, borehole, spring or surface water sources instead of from large scale public utilities. Hunter and colleagues at UEA completed a large cohort study that demonstrated that children under 10 years of age in England who are reliant on contaminated private small water supplies have more than 5 times the risk of diarrhoea than children whose water is not contaminated (research reference 1). They have also shown that a high proportion of such water systems suffer from microbiological contamination which is much worse than in large, mains drinking water systems (research reference 2). This contamination is highly correlated with environmental and climatic variables.

Hunter and colleagues' economic analyses of water interventions to improve small-scale water supplies in developed countries showed that they reduce the direct and indirect costs of illness, outweighing the costs of improving the supplies (research reference 3). Their epidemiological modelling research quantified the impact of community water systems on health in developing countries and highlighted the problems caused by the unreliability of these supplies. It showed that even occasional days of water treatment failure could lead to an almost total loss of the health benefits of setting up these water sytems (research refererence 4). Similar epidemiological modelling was also applied to developed countries such as the UK and France, also highlighting the risks of small water systems.

Recreational water quality

Hunter and colleagues' epidemiological research on recreational water exposure has included case control and cohort studies, and methodological research on methods of monitoring water quality. The methodological research has shown that the statistical methods used by regulatory agencies to assess compliance with bathing water quality standards were flawed, and that more valid methods were preferable (research references 5 and 6).

UEA Researcher Involvement

This work was led by Hunter (Professor of Health Protection, at UEA since 2001) in collaboration with Lake (Senior Lecturer in Environmental Science, at UEA since 2002 (UOA7)), Roger Few

(Senior Research Fellow in International Development, at UEA since 2002 (UOA7)), and Helen Risebro (Senior Research Associate, at UEA since 2004), as well as with colleagues elsewhere in the UK, Europe, US and Africa.

3. References to the research

Key publications (UEA authors in bold)

Small and very small drinking water systems

1. **Risebro HL**, Breton L, Aird H, Hooper A, **Hunter PR**
   Contaminated small drinking water supplies and risk of infectious intestinal disease: a prospective cohort study
   PLoS One **2012** 7:article no. 42762
   doi: 10.1371/journal.pone.0042762
2. **Richardson HY**, Nichols G, Lane C, **Lake IR**, **Hunter PR**
   Microbiological surveillance of private water supplies in England: the impact of environmental and climate factors on water quality
   Water Res **2009** 43:2159-68
   doi: 10.1016/j.watres.2009.02.035
3. **Hunter PR**, Pond K, Jagals P, **Cameron J**
   An assessment of the costs and benefits of interventions aimed at improving rural community water supplies in developed countries
   Sci Total Environ **2009** 407:3681-5
   doi: 10.1016/j.scitotenv.2009.03.013
4. **Hunter PR**, Zmirou-Navier D, Hartemann P
   Estimating the impact on health of poor reliability of drinking water interventions in developing countries
   Sci Total Environ **2009** 407:2621-4
   doi: 10.1016/j.scitotenv.2009.01.018

Recreational water quality

5. **Hunter PR**
   Does calculation of the 95th percentile of microbiological results offer any advantage over percentage exceedence in determining compliance with bathing water quality standards?
   Lett Appl Microbiol **2002** 34:283-6
   doi: 10.1046/j.1472-765x.2002.01081.x
6. Chawla R, **Hunter PR**
   Classification of bathing water quality based on the parametric calculation of percentiles is unsound
   Water Res **2005** 39:4552-8.
   doi: 10.1016/j.watres.2005.08.022

Key research grants

- *AQUAVALENS: Programme grant to develop low cost rapid methods of detecting viruses, bacteria and parasites in drinking water*
  Hunter (PI), Tyler; EU FP7 2013-2018; €9M
- *Assessment of human health impacts from emerging microbial pathogens in drinking water by molecular and epidemiological studies (Healthy-Water)*
  Hunter, Lake, Hofle, Kasimir, Figueras, Bosch, Courtois, Torokne; EU FP6 2006 – 2009; €2,908,065
- *EpiBathe – Assessment of Human Health Effects caused by bathing waters*
  Kay (University of Wales, PI), Hunter; EU FP6 2005 –2007; €2M
- *Evaluation of the Costs & Benefits of Water and Sanitation Improvements*
  Cameron (PI), Hunter (PI); World Health Organisation 2006 –2007; US$251,933

- *Seasonal environmental hazards: a multi-disciplinary approach to the analysis of health risks in lower-income countries*
  Few (PI), Lake, Hunter; NERC 2007 – 2009; £204K
- *Human health risks from contaminated tap water. Can we use microbial ecology to assess the integrity of water distribution systems?*
  Grant (PI), Hunter; NERC 2007 – 2008; £120K

4. Details of the impact

This research has led to changes in national and international health policy, including policies of the World Health Organisation, other international bodies such as the European Commission, and the United Nations Economic Commission for Europe, and the USA Environmental Protection Agency. It also led to changes in European Union and UK legislation. The impact of the research was strengthened by Hunter's participation in expert panels advising these public health agencies.

Small and very small drinking water systems
The research showing that small water systems in both developed and developing countries are far more likely to be prone to microbiological contamination than large mains systems influenced the recommendations of international expert groups and task forces, leading to changes in policy. Hunter was an expert member of the joint task force of the United Nations Economic Commission for Europe and the World Health Organisation Regional Office for Europe. These organisations jointly published guidance, "*Small-scale water supplies in the pan-European region*" (corroborating source A), which appraised policy-makers and regulators in the drinking-water sector of the need to address failings in the monitoring of small-scale water supplies. There is little objective research evidence on which to base policy and regulations. WHO cited two UEA studies as providing "exemplary drinking-water quality data" for England and Wales (corroborating source B). These studies were used to show that compliance with microbial indicators is a problem in many small-scale water supplies, resulting in water of a quality that is not safe for consumption and a risk to public health. Their economic assessment of the health benefits of improvements to small water supplies (research reference 3) led directly to WHO publishing guidance on social cost-benefit analysis of drinking-water interventions (corroborating source B).

Bathing water legislation
It is estimated that, globally, over 120 million gastrointestinal illnesses per year are caused by swimming and bathing in wastewater-polluted coastal waters. Hunter has been a member of two separate WHO expert groups to deliver improved guidance on bathing water quality. Hunter's methodological research was used specifically to underpin the WHO guidance documents on classification of bathing water quality, to avoid misclassification of recreational waters through inappropriate choice of methods of calculation (corroborating sources C, D, E). These WHO guidance documents form the basis of current European Union Bathing Water Directives (corroborating source F), which were consequently enacted into UK law in 2008 (corroborating source G).

Hunter worked with epidemiologists from the USA Environmental Protection Agency, identifying the uncertainties and shortcomings of current US EPA recreational water quality criteria, setting research priorities to support the development of better criteria, and advocating better methods for developing new criteria (corroborating source H). This work then led to EPA changing the criteria for regulating the microbiological quality of US bathing waters (corroborating source I).

5. Sources to corroborate the impact

A. *Small-scale water supplies in the pan-European region*
United Nations Economic Commission for Europe and World Health Organisation for Regional Office for Europe (2011)
Available at :http://www.euro.who.int/__data/assets/pdf_file/0018/140355/e94968.pdf
References to UEA research: p.22 (Hunter et al., 2009a; Richardson et al., 2009), pp.24-25 & p.30 (Hunter et al., 2009a)

B. *Valuing water, valuing livelihoods. Guidance on social cost-benefit analysis of drinking-water interventions, with special reference to small community water supplies*

World Health Organisation (2011)
Available at: http://whqlibdoc.who.int/publications/2011/9781843393108_eng.pdf
References to UEA contributions to the development of this guidance: John Cameron and Paul Hunter were editors. John Cameron authored four chapters (2, 3, 6 and 11). Paul Hunter authored two chapters (5 and 9)

C. *Guidelines for safe recreational water environments Volume 1: Coastal And Fresh Waters*
World Health Organisation (2003)
Available at: http://whqlibdoc.who.int/publications/2003/9241545801.pdf
References to UEA research: p.83 (Hunter 2002)

D. *Guidelines for safe recreational water environments: Addendum to volume 1*
World Health Organisation (2009)
Available at: http://whqlibdoc.who.int/hq/2010/WHO_HSE_WSH_10.04_eng.pdf
References to UEA research: p.18 (Hunter 2002; Chawla & Hunter 2005). Page 8 of this document also cites reference H below (Boehm et al, 2009).

E. *Guidelines for safe recreational water environments Volume 2: Swimming Pools And Similar Environments*
World Health Organisation (2006)
Available at: http://whqlibdoc.who.int/publications/2006/9241546808_eng.pdf

F. *Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC*
Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32006L0007:EN:NOT

G. *Statutory Instrument, Bathing Water Regulations 2008, SI 2008/1097*
Available at: http://www.legislation.gov.uk/uksi/2008/1097/contents/made

H. *A sea change ahead for recreational water quality criteria*
Boehm AB, Ashbolt NJ, Colford JM Jr, Dunbar LE, Fleming LE, Gold MA, Hansel JA, **Hunter PR**, Ichida AM, McGee CD, Soller JA, Weisberg SB.
J Water Health. 2009:9-20 doi: 10.2166/wh.2009.122

I. *Recreational Water Quality Criteria 2012*
US Environmental Protection Agency OFFICE OF WATER 820-F-12-058
Available at:
http://water.epa.gov/scitech/swguidance/standards/criteria/health/recreation/upload/RWQC2012.pdf
Page 49 of this document cites reference H as supporting evidence.