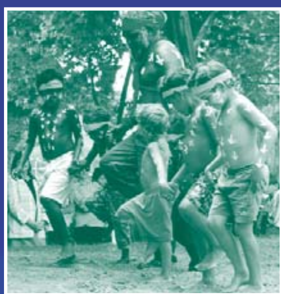
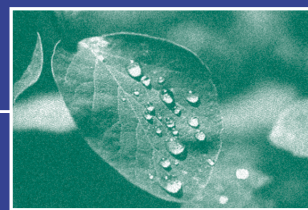
Environmental Health

The Journal of the Australian Institute of Environmental Health





...linking the science and practice of Environmental Health

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The Journal of the Australian Institute of Environmental Health

ISSN 1444-5212

Environmental Health is a quarterly, international, peer-reviewed journal designed to publish articles on a range of issues influencing environmental health. The Journal aims to provide a link between the science and practice of environmental health, with a particular emphasis on Australia and the Asia-Pacific Region.

The Journal publishes articles on research and theory, policy reports and analyses, case studies of professional practice initiatives, changes in legislation and regulations and their implications, global influences in environmental health, and book reviews. Special Issues of Conference Proceedings or on themes of particular interest, and review articles will also be published.

The Journal recognises the diversity of issues addressed in the environmental health field, and seeks to provide a forum for scientists and practitioners from a range of disciplines. *Environmental Health* covers the interaction between the natural, built and social environment and human health, including ecosystem health and sustainable development, the identification, assessment and control of occupational hazards, communicable disease control and prevention, and the general risk assessment and management of environmental health hazards.

Aims

- To provide a link between the science and practice of environmental health, with a particular emphasis on Australia and the Asia-Pacific Region
- To promote the standing and visibility of environmental health
- To provide a forum for discussion and information exchange
- To support and inform critical discussion on environmental health in relation to Australia's diverse society
- To support and inform critical discussion on environmental health in relation to Australia's Aboriginal and Torres Strait Islander communities
- To promote quality improvement and best practice in all areas of environmental health
- To encourage contributions from students

Correspondence

Associate Professor Heather Gardner
Editor, *Environmental Health*
P O Box 68
Kangaroo Ground, Victoria, 3097
Australia
Telephone: 61 3 9712 0550
Mobile: 0417 580 507
Fax: 61 3 9712 0511
Email: gardner@minerva.com.au
Website: www.aieh.org.au

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Call for Papers

The Journal is seeking papers for publication.

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Papers can be published under any of the following content areas:

Guest Editorials

Guest Editorials address topics of current interest. These may include Reports on current research, policy or practice issues, or on Symposia or Conferences. Editorials should be approximately 700 words in length.

Research and Theory

Articles under Research and Theory should be 3000-5000 words in length and can include either quantitative or qualitative research and theoretical articles. Up to six key words should be included. Name/s and affiliation/s of author/s to be included at start of paper and contact details including email address at the end.

Practice, Policy and Law

Articles and reports should be approximately 3000 words in length and can include articles and reports on successful practice interventions, discussion of practice initiatives and applications, and case studies; changes in policy, analyses, and implications; changes in laws and regulations and their implications, and global influences in environmental health. Up to six key words should be included. Name/s and affiliation/s of author/s should be included at start of paper and contact details including email address at the end.

Reports and Reviews

Short reports of topical interest should be approximately 1500 words. Book reviews should be approximately 700 words and Review Articles should not exceed 3000 words in length.

Correspondence

Associate Professor Heather Gardner
Editor, Environmental Health
PO Box 68, Kangaroo Ground, Victoria, 3097
AUSTRALIA
Guidelines for Authors can be obtained from the Editor
Telephone: 61 3 9712 0550
Fax: 61 3 9712 0511
Mobile: 0417 580 507
Email: gardner@minerva.com.au

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From the National President

It gives me great pleasure to write the inaugural editorial for the very first issue of Environmental Health. I am sure all members have been waiting for the publication of this special issue with anticipation and high expectation for a quality publication that will lift the profile of the profession of environmental health throughout Australia and the Asia – Pacific Region.

The launch of the Journal is again an example of the excellent relationship the Institute enjoys with the Department of Health and Aged Care. The Department's encouragement, financial support and assistance in this project, together with its support for National Conferences and other projects, is acknowledged. The Directors and Chief Executive Officer of the Australian Institute of Environmental Health and the Department of Health and Aged Care have worked jointly to ensure the success of this venture through their commitment to the environmental health field to produce an outstanding publication of which the Institute can be justly proud.

The Journal will give members and others the opportunity to publish their research work and to disseminate information about their practice, and for this to be recognised through a quality, peer reviewed publication. It will support the research environment of environmental health. The Advisory Board and the Editorial Committee, with the Editor, are comprised of highly respected members who are extremely well qualified in their areas of expertise within the field of environmental health.

The field of environmental health is wide and I am sure the Journal will attract a larger and more diverse membership, which is something the Institute has been striving to attract into the membership for a number of years. It is hoped that Environmental Health will enhance the profession and become a sought after quality publication not only for scientists and practitioners in the field of environmental health but also for a much wider audience. From the content of the papers in the inaugural issue of Environmental Health, it can be seen that this publication will go some way towards informing Australians and others what environmental health is about.

I conclude by congratulating all those members who have been involved in this historic issue and the project and wish them well for all future issues.

Owen Ashby
National President
Australian Institute of Environmental Health
15 January 2001

Welcome to The Journal of the Australian Institute of Environmental Health

We do not claim to be comprehensive in this first issue of all the important areas encompassed by environmental health, but rather to provide a range. Future issues will, we hope, include more material from overseas as well as from Australia, but the research and practice issues covered do have a relevance and significance which go beyond Australia.

'The Agenda for Action', which came from the National Conference of the Australian Institute of Environmental Health held in Cairns, Queensland and from the following Satellite Workshop in Singapore, is an important set of statements and strategic responses to improving environmental health in the region. Because of its importance, we have published it here as well as in the Institute's Environmental Health Review.

The Journal's two main sections, or departments, are "Research and Theory", and "Practice, Policy and Law", both of which are peer reviewed. The importance of providing papers under these areas and in the Reports section goes back to the main aim of the Journal which is " …linking the science and practice of environmental health". The first paper makes a strong argument for the importance of viewing both the research carried out by scientists and the practice of environmental health officers as research in its conceptual and practical methods.

We are pleased with the range and with the themes linking papers. There are papers on monitoring the state of the environment and the risk assessment and management of environmental hazards, including research and practice interventions arising from the dangers to human health of contaminated water, from allergens, from the occupational environment, and from the sun. There are also a number of papers on foodborne diseases which together cover research, practice and policy and regulatory aspects. The critical importance of appropriate and relevant action for improvements in the health of Indigenous people and for methods of monitoring for sustainable development is outlined in other papers.

We should like to echo the sentiments of the President and acknowledge the support and dedicated hard work of the Advisory Board and the Editorial Committee, without whom the Journal, and in particular this the first issue, would not have been possible. In addition they, like the authors and reviewers, have been unfailingly patient, tolerant and fun to work with. So, finally, a very sincere thank you to all the authors and reviewers.

The future of the Journal depends on your active participation and on its continuing to receive high quality papers from scientists and environmental health practitioners, and we look forward to receiving your contributions for any of the sections of the Journal, including reviews of books and reports. As a whole we hope that the Journal makes a contribution to professional development and value your participation and suggestions.

Heather Gardner
Editor
January 2001

Angela Ivanovici
Chief Executive Officer
Australian Institute of Environmental Health

Regulatory Enforcement as Research: A Commentary

Eve Richards

TAFE Tasmania

The role of research in environmental health regulatory enforcement all too often is not recognised or, if it is acknowledged, is treated as a purely technical process. This is far from the case in reality. Indeed, much of the investigative regulatory enforcement process resembles the pure science research model when analysed. This article sets out the case for regulatory enforcement investigation to be recognised as a valid form of research in its own right. The article argues that, because environmental health regulatory officers work in adversarial systems, they are compelled routinely to present logically constructed arguments supported by valid evidence. This creates a process that has genuine parallels with academic research. In order to develop this comparison, the practice of environmental health officers in Australia has been reviewed. It is found that the inquiries made by environmental health officers approximate the research process pursued in the scientific strand of environmental health and thus can be understood as "research" in a meaningful way.

Key Words: *Environmental Health, Law, Regulatory Enforcement, Research Process*

One of the reasons for the birth of the journal, *Environmental Health*, is to bring together the various elements of environmental health into a more coherent and self-aware profession. An impediment to this goal, I believe, has been the lack of appreciation of each other's contribution that sometimes divides the several streams of interests that flow together to form the profession of environmental health practitioners. On one hand environmental health officers all too often are brushed aside as being merely "technicians" by scientists in environmental health. On the other hand, officers sometimes view the scientists as having no real appreciation of what they, the officers in the field, have to do. Having had experience both of working at the grass roots level of environmental health as a regulatory enforcement practitioner in local government and of researching this field at an academic level, I have become aware how similar these two strands of the profession can be even though to many they seem so different. My conviction holds even in the sensitive area of research. This commentary seeks to open a debate on the proposition that officers and academics have much in common in relation to their research skills and processes. Due recognition of the research undertaken by both sides is not only warranted but will advance a parity of esteem for both strands of the profession.

Regulatory enforcement officers engage in a continuous research process as a normal part of their work. As developed below, they must identify a specific problem for investigation, devise a research program to gather relevant data, collect the data, assess their significance and reach a conclusion. This process requires rigour and scrupulous attention to detail if serious consequences to individuals and the community at large are to be avoided. It is duly acknowledged that all research requires rigour and attention to detail. Nevertheless, it will be shown that the consequences of error when working with the law can be greater in regulatory enforcement than for similar "research" errors made by members of the scientific community especially with regard to immediate consequences. Environmental health regulatory law profoundly affects the lives of every member of the community. Many benefits are enjoyed when the law is enforced and much harm, economic, psychological or physical, may be experienced when there is non-enforcement or there are deficiencies in the work of officers. A research process that has such a profound effect on the whole community is worthy of being written into the literature on research processes for its own intrinsic value. If one adds to this, the fact that the final outcomes of the research process: a) may contribute to the development of the law in the community, and b) become highly reliable primary source data for researchers in a range of disciplines, then the task becomes even more compelling.

The focus in this research commentary is on interpreting the investigative activities of environmental health officers in terms of the standard (hypothetico-deductive) scientific research model. Broadly, it is argued that these officers work in adversarial systems where they are compelled routinely to present logically constructed arguments supported by valid evidence; a process that has genuine parallels to academic research. In order to make this comparison, the practice of environmental health officers in Australia is considered (although most illustrations are drawn more narrowly from the experience of Tasmania.) The rules, principles and skills of working with the law apply throughout Australia and beyond to many other common law countries and, while the precise legislation may vary between jurisdictions, this is unimportant to the present commentary because the focus is not on legislation per se but on legislation for the purpose of example. The key issue is that the inquiries made by environmental health officers approximate the research process pursued in the scientific strand of the profession and thus can be understood as "research" in a meaningful way.

The Research Process

The research process used in regulatory enforcement replicates the standard science research model used by academic researchers because it follows the same steps with much the same purpose at each stage. The hypothetico-deductive research model comprises six stages namely 1) formulating a pre-hypothesis (identifying a problem for research); 2) framing an hypothesis (a proposition of relationship); 3) devising a methodology (a logic of proof); 4) gathering the data; 5) analysing the data; and, finally, 6) making a finding (Chalmers 1976; Harrè 1972; Nachmias & Nachmias 1992; Popper 1972).

Regulatory enforcement research is investigative in nature and parallels this procedure by 1) the awareness of matters which will/may need attention in the course of work; 2) posing the appropriate regulatory question; 3) determining the appropriate methodology; 4) gathering the evidence; 5) assessing the evidence; and, finally, 6) deciding if the matter should be subject to further action (which in the case of litigation will become the court's hypothesis).

Perhaps one major difference between academic and enforcement research is the influence of time on the work undertaken. Academics and practising scientists normally have ample time to carry out their work and to consult colleagues during the research process. Time is a resource that enforcement officers may not have when there is a risk to public health and safety. The research process from the data gathering phase onwards may have to be completed in a very short time, perhaps only hours (or less) if the focus is public safety or health when there is imminent danger or serious risk. There is, of course, more time when determining, for example, whether an applicant is a fit and proper person to be granted a food licence, or when a hazard analysis and critical control point proposal is the focus of attention, or if preparing for possible litigation. But even then, the law may impose, directly or indirectly, time constraints on the decision making process.

Background Legal Research

This stage can be approximated to the pre-hypothesis stage in the pure research model where the literature is searched to determine the current state of knowledge. Environmental health officers have to keep up with changes in the law as well as with current environmental health research in order to do their jobs responsibly, just as research scientists must do. For both, this must be done before new questions are formulated or old questions retested. Perhaps, one key difference between the pure science and enforcement models is that, while the basic questions may remain the same for both strands, environmental health officers have to be sensitive not only to new health knowledge but also must adapt their investigative agenda as the law changes.

In environmental health, the law assumes a critical and parallel place alongside "knowledge" literature. Indeed, for the most part, it is this body of "literature" which prioritises and directs the environmental health officer's research agenda. Just as scientific knowledge is constantly changing, the "law … is not fixed and static. It moves and grows with the needs of the community it serves" (Waller 2000, p. 207). This necessitates on-going familiarity in those areas of statute and common law that are relevant to environmental health officers in order to maintain currency with respect to knowledge about the state of the law and the understanding of that law. Additionally, detailed awareness of the legislative contents must be achieved and maintained. This background work is critical. Any research, scientific or environmental health, that is built on a flawed foundation can be expected to fail ultimately, no matter how good the subsequent work. Thus, it is to aspects of the law and its effects on environmental health regulatory enforcement that I now turn.

Statute law (legislative) currency

Legislation, which is relevant to officers, can be grouped into three categories. There is that which pertains to environmental health per se; the legislation governing the legal process; and, laws which focus on transparency and accountability. This legislation must be searched regularly for changes. The changes may take the form of new enactments, the coming into force of legislation, statutory repeals, implied repeals, expiry, rescissions, amendments and disallowance of subordinate legislation. Changes may significantly affect what officers do and how they do things. For example, the *Public Health Act 1997* (Tas) contains an area of responsibility pertaining to systems for air and cooling towers which was not in the now repealed *Public Health Act 1962*. In 1998, a new subsection was inserted into s.200 *Local Government Act 1993* (Tas) which prescribes the contents of an abatement notice. Officers must take due notice of such changes and act on them.

Failure to maintain currency can prove to be fatal in litigation. Gifford and Gifford (1994, p. 37) cite one prosecution that failed because the Act at issue had not been proclaimed. The appeal court described the prosecution as resembling "nothing so much as pulling a bell-handle without a bell at the end." What might seem to have been a simple oversight to some would have cost, unnecessarily, the community a great deal of money because, as Waller (2000, p. 24) notes, all litigation is expensive. Errors pertaining to legislative currency usually cannot be corrected by further work once the matter has reached the courts. The case is likely to fail when such errors, if detected, have been made.

The severity with which Courts may deal with currency errors can be contrasted with the consequences of similar errors in law publications. Two examples of errors in a book on legal research can be cited.

1. Campbell, Poh-York and Tooher (1996, p. 305) state that one of the principal Tasmanian Acts on subordinate legislation is the *Local Government Act 1962*. In fact, this Act was repealed in 1994 when the *Local Government Act 1993* came into force, some two years before publication. This does not appear to be a case where the work was current when the manuscript was submitted for publication, because in the same section in which this legislation is mentioned reference is made to a 1995 Statutory Rule.

2. In the same publication (at 228) there is a statement to the effect that Tasmania does not have legislation dealing with the purposive or purpose approach to legislative interpretation. In fact, the *Acts Interpretation Act 1931* was amended in 1992 to insert s. 8A which deals with this matter.

These errors do not necessarily detract from the publication. It may be embarrassing for the authors but the errors can be corrected readily when the book is revised. And, the errors, if detected, will be quickly forgotten. However, the various types of errors that officers or agencies may make when working with the law, together with those of lower courts, are sometimes visible for decades because cases are constantly cited in the process of judicial precedent and in law publications. Visibility has increased recently because judgements of the higher courts are now placed on the Internet.

Common law currency

Maintaining currency of knowledge with respect to common law is more complicated than that associated with legislation. Environmental health officers must search for cases outside the parameters of environmental health. This is because common law is concerned with establishing rules and principles that apply throughout the relevant legal system. One problem is that of keeping track of cases as they pass through the appeal system.

Environmental health officers, particularly, need to search in the areas of negligence and administrative law. For example, the *Shaddock v Parramatta City Council* case ((1981) 150 CLR 225) which involved a planning related matter in New South Wales on appeal went to the High Court of Australia. This is now the leading Australian case on negligent mis-statements and the decision is binding throughout Australia.

Reading and understanding legislation

Demonstrating currency with the law is one critical skill but it is not sufficient. Officers must be able to interpret the legislation. Special rules must be applied as a matter of routine in order to avoid costly errors (Gifford & Gifford 1994, pp. v-vi). This skill is considered to be so important in the Advanced Diploma of Health Services (Environmental Health) course offered by TAFE Tasmania that a higher pass mark is placed on the statutory interpretation examination than for other subjects. This alerts students to its importance. Basically, one cannot be only 50% right when working with the law in regulatory enforcement. An error in interpreting one word can lead to a chain of very costly legal proceedings (Jeffes, S. 2000, pers. comm., September).

For example, in *Woolworths (Vic) v City of Glenorchy* (1990 Tas. R 87) the Supreme Court of Tasmania overturned a decision of a magistrate who had declared lawful the seizure of dried fruit by council officers. On appeal, the magistrate's decision was overturned and the seizure declared unlawful. The officers (and the magistrate) had read down the meaning of the plain word "fruit". Neasey, J. said, "The basic rule of law is that the language of a statute is to be construed in its ordinary and natural sense, even if the result is inconvenient" (at 89). This case demonstrates that the courts even falter when interpreting the law and it highlights the level of expertise that is required to work with the law.

Familiarity with contents of legislation

Familiarity with the contents of environmental health legislation is another essential aspect of background research. Officers do not go out into the community to do their work armed with their legislation. It is carried in their heads. The basic questions which officers must ask as they fulfil their functions can only be asked if they are exceedingly familiar with the contents of legislation. Unfamiliarity with the legislation will put the health of the community in jeopardy, as matters that should be dealt with will go undetected and will affect the enforcement process generally (Frank & Lombness 1988, pp. 86-7). As will be discussed further below, familiarity with the law is essential also to the data gathering and data assessment stages of the research process.

The Question and Methodology

Unlike the pure science research model where the framing of the hypothesis and determining the methodology may be regarded as clearly separate stages, in regulatory enforcement research, these stages are often automatically linked by the wording of the law. This can be demonstrated readily using two examples:

Section 38 (1) *Food Act 1998* (Tas) states:

> *A person who handles food in the course of its manufacture or sale must –*
>
> *(a) comply with any regulations or relevant guidelines relating to hygiene; and*
>
> *(b) observe reasonable standards of personal hygiene.*

In this case, there is a two part provision for what must be met and thus the officer must ask whether there is compliance with respect to both parts. It is obvious from the wording of the legislation that the method for establishing the question of compliance is set by comparing the practice of the food handler with the regulations and guidelines and reasonable standards of personal hygiene. There is no choice of method here as the law prescribes the logic of proof. If it is established, through data gathering and assessment, that there is non-compliance with both or either of the parts, then, under this provision, an offence has been committed. It must be remembered, however, that in environmental health not all matters of non-compliance become offences and not all offences are a result of non-compliance.

The second example is from the *Public Health Act 1997* (Tas). Section 86 (1) states:

> *An environmental officer may issue a certificate to a relevant council stating that specified premises are so unhealthy that no person can safely occupy them.*

The question that has to be addressed is whether the conferred power should be exercised. A clinical, case study approach is warranted because the condition of the premises must be investigated and the findings used to discover their effects on health. Only when this has been done can the question be answered. However, it is reasonable to say if the results of the research are that the premises are so unhealthy that no person can safely occupy them, it would seem that there may be a duty to exercise the power in view of the High Court's decision in *Pyrenees Shire Council v Day* ((1998) 192 CLR 330).

Gathering Data or Evidence

In one respect, data gathering may be a little different in the enforcement model than in the science model where data are gathered only for the specific purpose of confirming or invalidating an hypothesis. Data gathering is an integral part of regulatory enforcement. Indeed, for the uninitiated in environmental health as in science, data gathering is often seen as "real" research. In environmental health, two types of gathering are employed regularly. The first is the on-going data collection that occurs as a result of normal routine. Such data are automatically placed on property, personal, or issue files to become archival data. The second type is where data are gathered for a specific purpose, such as the two examples used above. Although, in the first example used, it may be that the question was merely part of routine work rather than a response to a specific concern.

It can be argued reasonably that data gathering and triangulation are, perhaps, a little easier in regulatory enforcement than may be the case for some researchers. The legislation, which is primary source material in its own right, recognises that information and evidence must be collected by officers so that they may do their work. A power of entry is normally conferred on officers to enable them to inspect (observe) and collect data that eventually may become evidence. Depending on the legislation and the matter in question, the law may make provision for the seizure of certain items and the taking of samples, measurements, photographs, copies of documents, recordings and so forth. The *Public Health Act 1997* (Tas) and the *Food Act 1998* (Tas) are examples of statutes which cover all of these data matters and more.

The practice of observation, note-taking and the conduct of interviews for data gathering purposes is as critical in regulatory research just as it is in some social science research methods (Bell 1993; Gillham 2000). In regulatory investigation, however, such practices are governed by formal, often legally or judicially, determined rules. Aronson and Hunter (1998, p.904) note that the common law requirement regarding notes is that they "were made or adopted sufficiently close to the subject event as to assure the court that they are based on the witness's own first-hand knowledge or perceptions". Interviews are frequently conducted and formal statements taken in a manner that is consistent with the Judges' Rules (Abrahams 1964, Richards 1998, pp. 56-60) in so far as they apply to regulatory enforcement officers. While such precise evidentiary demands may be equally desirable in the work of scientific researchers, failure to meet these high standards carries far fewer consequences.

Rigorous and extensive gathering of data through observation, note-taking and interview for potential evidence in regulatory investigation is essential as one case clearly demonstrates. The matter in question was whether "a shed was a building". In dismissing the notice to review, Green, CJ said:

> *Upon the evidence the shed could have been as mobile as a caravan or set in concrete. There was almost no evidence as to the use to which it had been put in the past or the use to which it was going to be put in the future or indeed whether it had been or was going to be used for any purpose. The evidence did not show whether the shed had been moved during the period since it had been brought onto the land 4-6 weeks earlier: for all the evidence showed it might have been towed away every day. There was no evidence showing that it was connected to power or telephone lines or the drainage system* (*Waratah-Wynyard Council v Fairbrother*, Supreme Court of Tasmania, unreported 1994, para 17).

This case demonstrates how thorough and relevant evidence collection must be. Additionally, the evidence must be collected in a lawful manner. Evidence, no matter how pertinent, will be disregarded by a court if the evidence was obtained through trespass or a bad warrant and so forth. In regulatory research, decisions pertaining to data collection may be subject to review or appeal, even before the research project is completed. For example, the legislation may make provision for a person from whom an item is seized to appeal to a magistrate (as occurred in *Woolworths (Vic) v City of Glenorchy* referred to above), even if it is proposed to use the seized item as evidence in litigation. The possibility of a review or appeal, concurrent with the research in progress, marks out regulatory research from the scientific model where evidence and the method of collection are normally assessed only after the research is completed and reported.

Evidence Assessment and Analysis

Rigorous assessment or analysis of the data is equally important in both the science and enforcement models. Analysing the significance of the data collected and comparing the assessed significance with predicted outcomes is the core of the hypothetico-deductive method and it is equally essential to regulatory enforcement investigations. In the enforcement model, however, the implications may have more immediate social consequences as the data may have to be assessed for its potential as litigation evidence. This phase of the process also requires the officer to pose two further questions, namely what are the common law requirements and what are the legislative benefits. This is a kind of "question triangulation" which is necessary to get a fix on the matter at hand. For example, one common law requirement is that relevant considerations must be identified and irrelevant considerations excluded otherwise a decision involving an exercise of power may be regarded by the courts as ultra vires (Hotop 1995, pp. 458-75; Streets 2000, pp. 194-5) or by the Ombudsman as defective (*Ombudsman Act 1978* (Tas) s. 28 (1) (d)).

For a successful prosecution all the essential elements in an offence must be proved beyond reasonable doubt by the prosecution, unless the legislation has made provision for the burden of proof to be reversed. The defendant has to prove nothing (McEwan 1992, pp. 56-62; Reynolds 1995, p. 243). There is no definition of the expression "beyond reasonable doubt". Indeed, the High Court has expressed strong disapproval of the efforts of some English and Australian judges who have tried to explain the concept (Waight & Williams 1998, p. 102).

Contrasting with the pressures to publish that can drive scientific research, enforcement investigations do not have to result in what might be regarded as a "publication". In order to prevent a drain on the public purse and unnecessary emotional costs to a defendant, an officer must believe that there is a prima facie case rather than what McGonigle (1996, p. 175) refers to as a "bare" prima facie case. Bare prima facie means that there is only a case to answer. A prima facie case means that if the evidence is accepted as credible by a magistrate or properly directed jury, the magistrate or jury could find guilt proved beyond reasonable doubt.

Just as no responsible academic researcher or practising scientist would wish to report obviously incomplete and ill-considered findings to the "court" of peer assessment, no environmental health officer wants to take a weak case to court. So there must be a critical assessment of the evidence and the preparedness to reject its progress to court, if weak links are found that cannot be strengthened. Equally, there is no room for placing a notice or order on a person or premises without solid evidence because a challenge to the appeal authority is likely to result in a quashing of the instrument if the evidence is weak.

The Decision

In the pure research model, the assessment of the data leads to a decision as to whether to accept or reject the hypothesis posed at the beginning of the research design. This is the end of the "research" part of the project as the decision then becomes the thesis of the report or article publishing the project's findings. In the case of environmental health investigations, this assessment equally leads to a decision although the consequences will be different. The answer to the basic investigatory question, in many instances, will be that there is compliance with the law, that there is no offence, that a power need not be exercised or that there is no statutory duty. Thus, no further action is required apart from the recording of the decision. Nevertheless, a finding of compliance, for instance, may be subject to scrutiny by a court (*Pisano v Fairfield City Council*, (1991) 73 LGRA 184), a coroner (*Saturday Mercury* 6 Nov., 1999, p. 5), or an ombudsman

(Ombudsman (Tas) 1989, p. 27) if the compliance finding is alleged to be subsequently responsible for harm. Even if it is found that non-compliance may have occurred or an offence may have been committed, the response to the finding may be the application of mild sanctions which are located at or near the base of the enforcement pyramid (Braithwaite & Grabosky 1985, pp. 87-90). If, on the other hand, the officer believes the matter should be litigated, the officer is likely to have to place the findings, with a recommendation, before his or her council. Although, there is no guarantee that the council will accept a recommendation to prosecute (Richards 1999, p. 31).

If the council approves the litigation (that is, accepts the officer's conclusion to his/her investigation), the matter is placed before the court as a charge or allegation. This charge, in fact, then becomes a new hypothesis for testing. However, a prosecution is an exercise of public power which brings into play all the checks and balances of the judicial system. The defendant is innocent until proved guilty and is accorded special protection and advantages in an endeavour to avoid the wrongful conviction of innocent persons and to compensate for the imbalance in the strength of the disputants (Smith, Pose & Bryant 1994, p. 124). This is quite unlike the potential outcomes of most academic research.

The common law trial is adversarial and each side strongly presents their case. An officer will be cross-examined on the evidence he or she gives and every effort will be made to discredit the evidence. If the officer has researched the case well, the case is more likely to succeed than fail, but no matter how thorough the research has been, the element of uncertainty remains. No matter what the result, the case may become part of the evolution of the law or become another piece of highly reliable primary source material for other researchers. And this helps to bring the two research cycles back together to a common starting point. In the pure research model, peer assessment may reach an adverse finding on the research and so open another round of research to re-evaluate the problem posed in the original study or to reinterpret the data.

Conclusion

As noted above, this article is intended to open a debate not to conclude it. I am aware of a number of possible themes that might have been developed in this brief commentary. Indeed, I have had to excise some issues of importance to me from the text to keep within a reasonable length. Still, this commentary has shown that the regulatory enforcement research process can be compared usefully with conventionally understood research processes such as that used in science. In part, this comparison has been drawn to show that environmental health officers are more than just "mere" technicians. Their work has much in common with that of scientists. Both elements of environmental health must have high levels of skill and competence for their research to pass the judgment of their respective "courts". And, in part, this commentary has sought to promote a "meeting of the minds" based on mutual understanding between academic researchers and environmental health officers. If officers recognise that academics do employ a similar process to theirs and vice versa, the resulting parity of esteem will provide a positive foundation on which *Environmental Health* can build.

This is not to argue that the investigations of both are identical. Rather, it has been demonstrated that high levels of skill and competency in research are required by both research scientists and by environmental health officers. While the former is almost taken for granted, the precision of the work of environmental health officers is less recognised. Yet, as I have illustrated, an error in interpreting just one word can result in an officer's action being declared by a court as unlawful. Success in criminal litigation requires an officer to prove beyond reasonable doubt that an offence has been committed, a standard that is not easily attained in an adversarial system. While, at times, the requirement of meeting such demanding standards may make the process of researching a regulatory matter appear formalistic and perhaps even deterministic, many of the same skills used in academic research are necessary here. The linkage between the two strands of environmental health should not be overlooked or minimised.

Finally, an environmental health practitioner would find the regulatory process as presented in this commentary rather "sterile" because the environment in which the process occurs has not formed part of the discussion. Yet, these circumstances may affect the research and enforcement process to a significant extent (Richards 1999). The turbulent, often hostile, abusive and sometimes violent environment is well documented in the public health literature and archival records (Goldfinch 1984, p. 21; Richards 1999, p. 27; Walkerden, Raine & Stinton 2000, pp. 2-5). In building up the knowledge base about the regulatory research process, the vagaries of the environment should be brought into the debate at some time in the future.

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Correspondence to:
Eve Richards
9 Richardson Avenue
Dynnyrne
South Hobart, Tasmania, 7005
AUSTRALIA

Monitoring Changing Environments in Environmental Health[1]

Valerie A. Brown AO

Regional Integrated Monitoring Centre, University of Western Sydney

Changes in the relationship between people and the environment have always played a major part in determining the professional direction of Environmental Health. The agricultural revolution, industrialisation, and now globalisation, have each led to a fresh set of environmental risks and so to a need for new and different monitoring methods. With global environmental changes such as climate change, monitoring tools are needed that are able to evaluate changes in the patterns of existing risks to health, and also the local effects of long-term global risks to air, water, soils and food. This paper examines the current status of these global environmental changes, and in particular the shared agenda between environmental health and sustainable development. In the light of this shared agenda, the paper reviews the fresh focus brought to environmental health monitoring by the adoption of the Pressure-State-Response framework developed by the Organisation for Economic Cooperation and Development (OECD). This framework calls for forward projections of sustainable practices as well as the assessment of existing risk. A further development of the OECD framework is proposed through (a) incorporating the potential for changing systems of environmental management, and (b) linking community, specialised, strategic, and visionary knowledge in a networked information base.

Key Words: *Monitoring, Sustainable Development, Local/Global Systems, Networking Knowledge*

Monitoring risks to health from the immediate environment has always played a major part in environmental health practice. The profession was first established to address the infectious disease epidemics of early industrialisation, for which the principal reporting tool was, and still is, epidemiology, the statistical study of the health status of populations (Phase 1, Table 1). This was followed by an emphasis on the hygiene and building controls set in place to check the epidemics for the long term. Monitoring became a combination of the identification of toxicological and microbiological risks and environmental inspections supported by legal and regulatory processes (Phase 2, Table 1).

Table 1: Phases in Environmental Health Monitoring

Phase	Environmental Health Risk	Source	Monitoring base
1. Industrial revolution – Infectious diseases			
1850:	Cholera	water	Microbiology
	Diphtheria	air	Toxicology
	Tuberculosis	crowding	Epidemiology
2. Economic growth – Environmental pollutants			
1950:	Lead	transport, industry	Public Health standards
	Asbestos	workplace	Industry regulation
	Wastes	consumption	Costing, regulation
3. Sustainable development – Long-term risks to health and environment			
2000:	Air quality	transport	Airshed management
		ultraviolet light	Global convention
	Water quality	climate change	Energy budget
		polluted rivers	Catchment management
	Contaminated land	industry wastes	Precautionary principle
		urban development	Biodiversity plans

Adapted from V.A. Brown, J. Ritchie, & A. Rotem, 1992

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With the rapid spread of urban development and of industrial processes, the effects of pollution and infections from air, water, soil and food extend far beyond the immediate source (Pimental et al. 1998). In addition to changing the patterns of existing risks, new dimensions of risk have emerged. The global impacts of human activities include ozone depletion, particularly over each pole, increasing the risk of cancer from ultraviolet light; the loss of biodiversity and its resultant impact on ecological self-sustaining systems and food supplies; and climate change with its effects on hydrological systems and water quality (McMichael 1993, McMichael & Kovats 2000).

These environmental changes have become matters of concern for governments and communities, as well as for public health and environmental management (enHealth Council, National Environmental Health Strategy 1999, National Research Council USA 1999). There is increasing recognition from both health and environment professions of the need to extend monitoring programs to include not only localised risk, but local impacts of, and responses to, regional and long-term global risks to air, water, soils and food (Phase 3. Table 1) (Brown 1998; McMichael 1993; Soskolne & Bertollini 1999).

An outcome of the fresh demands on environmental health monitoring has been that many modern states now combine the epidemiology, toxicology and regulatory supervision traditional in environmental health, with state-of-the-environment reporting on the principles of sustainable development (World Commission on Environment and Development [WCED] 1986). To quote some key findings of the Environmental Health Commission set up by the combined British Chartered Institutes of Environmental Health:

1. Environmental health and sustainable development share a common agenda;
2. Environmental health, having invented itself in the nineteenth century, needs to reinvent itself for the 21st; and
3. The profession needs to be flexible in their approach and multidisciplinary in their skills - able to see the whole picture (Chartered Institute of Environmental Health 1999).

The new alignment calls on the skills both of environmental and health risk assessment, and involves monitoring the five dimensions of sustainable development, each of which have clear connections between health and environment (Soskolne & Bertollini 1999, WCED 1986). The principles of sustainable development, defined by WCED (1986) as development which supports the continuity of the environmental life-support systems, are:

- Preserving equity of social and environmental resources between generations;
- Protecting equity of social and environmental resources within this generation;
- Safeguarding biodiversity and environmental integrity;
- Practicing the precautionary principle (acting to prevent harm, and not acting if there is serious risk of harm); and
- Valuing and costing environmental resources (National Ecologically Sustainable Development Strategy 1992).

The inaugural Australian National Environmental Health Strategy, launched in 1999, makes the same connections, comes to much the same conclusions, and adds:

> *Traditionally, the role of environmental health has been strongly centred around the enforcement and monitoring of legislative requirements. However, new focusses,*

methodologies and technologies are altering the way issues are managed.

and

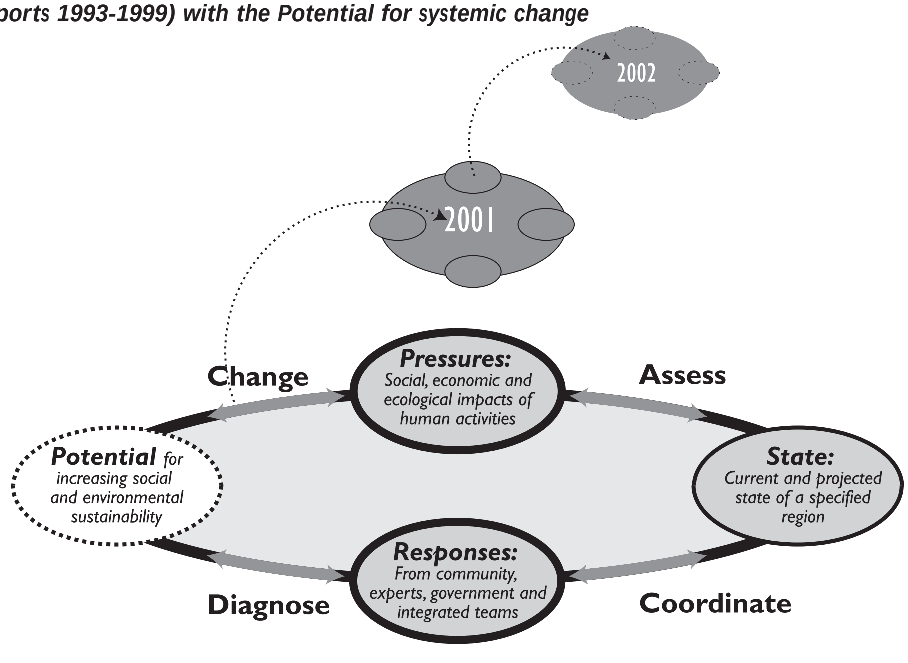
A major problem in the management of environmental health in Australia is that far too little systematic effort is made to measure accurately and to use information to improve policy and practice. Good information systems need to be built to enhance the knowledge base supporting environmental health decision-making (enHealth Council, 1999, ii).

Monitoring Sustainable Development

As a tool for monitoring progress towards implementing sustainable development, a Pressure-State-Response framework was developed by the Organisation for Economic Cooperation and Development (1993a, 1993b). See Figure 1. The Pressure-State-Response model of environmental decision-making is now routine for all the OECD industrialised countries (which sends a monitoring team to evaluate progress to each member country in turn). As a closed-circle, cause-and-effect model, it is effective to use for selecting and applying indicators for the sustainable development principles, and in evaluating the relevant environmental and social risks. However, it fails to provide for the feedback loops essential to the functioning of health-supporting environmental systems, to account for the need for systemic change, or to allow for progress toward future goals as well as present needs.

The addition of a change step, the potential for achieving sustainable development, allows for changing the system itself, as the principles of sustainable development require (Brown 1997; ESPHU 1997; National Science Council 1999). Decisions about moving towards sustainability require that the monitoring process assess the current State of the environment, identify the Pressures, and match them to effective Responses. Where the responses are found to be inadequate for progress toward sustainable development, it is necessary to diagnose the Potential of the

Figure 1. Pressure-State-Response Framework (OECD, National, State and Local Government reports 1993-1999) with the Potential for systemic change



Brown 2000; Western Sydney Regional Organisation of Councils and University of Western Sydney [WSROC], in press whole system to change, in order to alleviate the Pressures and so move towards a more sustainable State (Figure 1).

Australia's local, state and national state-of-the-environment (SoE) Reports have uniformly adopted the P-S-R framework. Together the SoE Reports make up a significant information base for decisions on achieving a sustainable and health-supporting environment (Brown et al. 1998). SoE Reports are often issued annually, but at least four-yearly, by seven of the eight States and Territories, many of the over 700 local government authorities, and the federal government. In the State of New South Wales, SoE Reports on progress towards sustainable development are mandatory for every local government authority every year. Preparing the Reports is usually the responsibility of the Environment Health Officers and the Environmental Management staff in each New South Wales (NSW) Council. To what extent and in what ways SoE Reporting influences public and private environmental and health decision making is still uncertain, and is the theme of this paper.

The Medium and the Message

At the beginning of the media explosion, McLuhan first put the proposition that the medium is part of the message (McLuhan & Fiore 1967). The adage applies as much to environmental health monitoring and SoE reports as to the magazines, news shots and video clips that have been carefully designed for their target market. In this information age, SoE monitoring exists as a medium of communication. What is its target market and what are the appropriate images and languages to use? Even more important, does its format carry the messages its designers intend it to carry? These questions have no easy answers because a SoE report carries so many mixed messages. On the one hand, reliability in SoE monitoring requires long-term consistency in collecting time series of data from proven sources. On the other hand, its validity will depend on its versatility in recognising the key factors in the current continual social and environmental change. The substantial shift required in environmental health monitoring to include sustainable development goes beyond changes in content, professional practice, and information sources. It represents a marked shift in the interpretation and form of such information; the messages and the media of environmental health practice. The 21st Century's information revolution can redefine public health monitoring by way of new ideas, new community expectations, and new information technology, as well as the need to report on unprecedented social and environmental change (US National Research Council 1999).

As a communication medium in itself, SoE reporting is in the process of changing format, storyline and content to incorporate sustainable development into environmental management and environmental health (Table 2.). With the adoption of Agenda 21 (a program for achieving social and environmental sustainability within the 21st Century) by the United Nations Conference on Environment and Development (UNCED 1992), there was a radical shift in emphasis towards monitoring the human-environment interaction rather than merely the biophysical environment. Preparation of a Local Agenda 21 (Whitaker 1995) plan by each of the local government authorities of the attending nations was the only full commitment signed off by the 112 nations attending UNCED. In 1993 the economic union of industrialised countries, OECD, adopted the SoE Report as an important decision making tool for all its members (OECD 1993a, 1993b) and a vehicle for Agenda 21. Every developed nation and each of their local government authorities were thereby committed to an environmental monitoring program to monitor the future as well as the past and the present.

Despite the baseline of legislated requirements in many states, the formats of SoE Reports are as varied as their purposes. Australian SoE Reports have been written in each of the following forms: a reference work for scientists, a databank for administrators, a right-to-know resource for the community, rules for regulators, a set of limits for planners, a tool for politicians, and, more recently, as a scenario for sustainability. The stated audience can be quite different from the mode of presentation, as in the most common case where the language of the report is technical, but the audience is intended to be the community. In one case, a SoE report was derived from local tourism publicity data, when the purpose of the report was stated to be informed management decision making (Brown et al. 1998).

Table 2: Changes in Australian SoE Reporting 1984-2000 (sources in references)

Year	Author	Framework	Content
1984	Federal Dep't of Env't (a)	Environmental risks	National biophysical resources data
	AIH	Health risks	Environmental risk source data
1986	WCED (Brundtland)	Sustainable development	Global social/biophysical trends
1989	Shoalhaven City Council	Environmental themes	Local biophysical risk data
1992	UNCED	Local Agenda 21: sustainability	Local response/global risk projections
1993	OECD	Pressure-State -Response	National social/biophysical risk (P-S-R}indicators
1993	NSW State Gov't (a)	P-S-R + Sustainable Dev't	Local social/biophysical indicators
1994	ACT Gov't	P-S-R + advice to Gov't	Local social/biophysical indicators
1995	NSW Gov't (b).	P-S-R + goals	Social/economic/biophysical indicators, State
1998	Federal Dep't of Env't (b)	P-S-R	Demographic/biophysical data, national
	AIHW	Determinants of health	Sunlight, water, air (lead) indicators
1999	NSW Gov't (c)	P-S-R + Sustainability	Local sociopolitical/ biophysical indicators
2000	WSROC	P-S-R + Potential for change	Regional/local socio/biophysical past, present and future
2001	Federal Dep't of Env't (b)	P-S-R + Implications	National socio/biophysical indicators and scenarios

For SoE Report sponsors, their authors, and their audience, the variations in framework and content outlined in Table 2 bring with them considerable tensions between priorities (Australian Local Government Association [ALGA] 1995). There are equally strong reasons for a SoE report to be presented as an open, creative, problem-solving, future-oriented enterprise on the one hand, and as an accurate keeper of records and benchmarks, and store of health and environmental history on the other. This need to contain two very different types of message at once, to bridge local and global scales, and to inform multiple audiences means that, for it to inform decision making, the medium (communication channels, languages, framework and design) of the SoE report is as important as its message.

The File and the Grid

From a narrow base in the biological sciences in 1984, by the year 2000 SoE monitoring in Australia has recruited the services of local communities as users and informants, specialists from the natural and social sciences, and politicians and administrators from all spheres of government (Tables 1 and 2). Some conclusions can be drawn as to the emerging directions of purpose, reference framework content, contributors, users, uses, time scale, and geographic scale (Table 3).

The changes in the medium of SoE reporting (Table 3) can be summarised as being a storage file until 1990, an information grid until 1995, and with a knowledge network emerging in 2000. The move from the SoE report as a data repository to include the monitoring of environmental risk was the first major change. Until the early 1980s, monitoring systems consisted of collections of specialised information accessible only to the specialists who derived and collated them. Between 1984 and 1986 reports on the state of Australia's natural resources and on the nation's health status, respectively, were first issued in a publicly available form (Australian Institute of Health 1986; Department of Arts, Heritage and Environment [DAHE] 1985). From the file-based data collections of 1984 to the P-S-R risk management grid of 1994 (Figure 1) was a considerable step. The challenge was to increase comprehensiveness, use meaningful indicators of progress rather than simply collections of data, and enable the capacity to cross-reference. Specialist decision-makers in Health and Environment could make use of the reports after 1995, but they are still largely inaccessible to politicians, industry or the community (Brown et al. 1997).

The majority of approaches to Health and SoE reporting have continued to maintain the focus on risk management (Aadrianse 1993; Australian Institute of Health and Welfare [AIH&W] 1994, 1996, 1998; Harding 1996; Jesinghous 1996). The content of the reports tends to be similar to the 1998 first national SoE Report; mainly restricted to traditional applied science indicators, cross-referencing some seven key environmental issues against a battery of individual indicators, usually between one and two hundred. The geographic scale is specific to either local, regional or national. There are few bridges across the scales. The users are assumed to be managers, specialists and consultants; infrequently, the community and rarely the local or national industries (much less the global industries). The overall format of such reports can best be represented as the grid in Table 4.

Both the strengths and the weaknesses of the grid approach are illustrated in Table 4. The grid medium helps to ensure that nothing known is omitted, coverage of the

Table 3: Changes in Direction of State-of-the-Environment Reporting, 1984-2000 (drawn from Table 2)

Turning Points:	1985: The File	1995: The Grid	2000: The Network
Design elements:			
Purpose	Data collection	Risk management	Sustainability guide
Framework	Biophysical state	P-S-R (transactions)	P-S-R (transformation)
Content	Biophysical data	Specialised indicator sets	Social, economic and envir'l signals of change
Contributors:	Biophysical scientists	Biophysical and social scientists	Community, specialists, politicians, forecasters
Audience:	Government, scientists	Government, specialists, managers	All sections of the community
Uses:	Reference	Environmental management decisions	Social, economic and environmental decisions
Time scale:	Present record	Move away from past errors	Move towards future goals
Geographic scale:	National	Local/National/Global separate scales	Local/National/Global regional networks
Indicators	Scientific data	Scientific level of risk	Signs of progress towards sustainability

essential issues and principles is secured, there is easy access to the detail, and a capacity to cross reference from issue to issue. Information technology has made the storage of vast quantities of data, and systematic extraction of data, not only possible but also simple and cost-effective. A grid increases the capacity to ensure consistency and reliability, since the provenance of each piece of information, and its validity and accuracy can easily be confirmed.

factors put together. Blue-green algae eruptions, slow viruses, and a severe El Nino are cases in point. While there is excellent access to cases of interaction between two or three factors, there is neither capacity to examine how such events change the existing relationships between multiple factors, nor to identify shifts in the entire system.

The questions then arise, as to what is the appropriate medium for an open use,

Table 4. Cross-referenced format of standard Australian SoE reports, 2000 (Example conforming to NSW Local Government Act Amendment 1997: Ecologically Sustainable Development)

	Environmental Themes						
ESD Principles	Land	Air	Water	Biodiversity	Waste	Noise	Herit-age
Pressures (+ and -):							
Intergenerational equity	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Intragenerational equity	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Biodiversity	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Precautionary principle	•••••••	••••••	••••••			••••••••	••••••••
Eco-accounting						••••••••	••••••••
						••••••••	••••••••
						••••••••	••••••••
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							••••••••
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							••••••••
							••••••••
State (trends):							
Intergenerational equity	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Intragenerational equity	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Biodiversity	•••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Precautionary principle	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Eco-accounting	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
	•••		••••••••	••••••••	••••••••	••••••••	••••••••
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							••••••••
							••••••••
							••••••••
Response (+ and -):							
Intergenerational equity	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Intragenerational equity	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Biodiversity	•••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Precautionary principle	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
Eco-accounting	••••••	••••••	••••••••	••••••••	••••••••	••••••••	••••••••
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Weaknesses of the grid approach include there being no place for the unexpected, the unintended or the one-off events. These may influence the sustainability of society and/or the environment more than all the identified

futures-oriented decision-making SoE report? What is an appropriate framework, content, audience, time and geographic scale? The move towards the use of SoE reports in wider social and political decision making may mean sending quite different messages, to a larger audience, in quite different formats.

SoE Medium: the Network

One of the most significant reports on environmental sustainability to follow the Brundtland Report of 1986 (WCED) is *Our Common Journey: A Transition Toward Sustainability*. Prepared by expert teams from the United States' Academies of Research, Science, Engineering and Medicine over three years, the Report lists the essential principles in monitoring for sustainable development as:

- Accepting monitoring against uncertainty as a research enterprise;
- Protecting the independence and validity of sustainability science;
- Incorporating policy assessment as an invaluable political resource;
- Respecting community experience as important place-based knowledge; and
- Designing indicator systems that allow for uncertainty and complexity.

These principles for monitoring for sustainability suggest a SoE purpose and format that could be better described as State-of-the-Sustainable-Environment (SoSE) reporting. The specifications for a SoSE reporting system, which has the accuracy of the file, the cross-referencing capacities of the grid, and the networking of information and audience required by future-oriented monitoring for sustainability, is summarised in Table 5.

Table 5. A Change in Logic for State-of-the-Sustainable-Environment Reporting: a Networked System

Component	Multi-dimensional Content	Integrative Tools
Purpose	Sustainable, just, and healthy futures	Visioning
Framework	P-S-R-P as transformational change	Scenarios
Content	Signs of progress, signs of caution	Icons
Contributors	Community, experts, politicians, leadership	Equally valued
Users	As above	Appropriate translation
Uses	Decisions on people, place and products	Negotiation
Time scale	Past, present and future	Systems modelling
Geographic scale	Local/regional/global	Interactive GIS

With this set of structural changes to the SoE monitoring process, the logic of the monitoring process has changed from a cause and effect approach within a continuous and unchanging cycle, to a systemic interaction between multifaceted parts, addressing an as yet unknown future. The components, content base, and integrative tools of a networked monitoring system are identified in Table 5. Each component requires a distinctive integrative process, and complex as that may sound, well-tried tools for this approach are already available in the public domain. Visioning processes include the classic guided imagery exercise of the WHO Healthy Cities program (Tsouros 1995), the Charette which employs artistic interpretation, and skills in foresighting (Slaughter 1998). Scenarios (often inappropriately confused with visioning) are suitable for projecting the direction of complex systems, and essential where the parameters and constituents are also in a state of flux. Content of most SoE reports has moved from merely collections of data, to information (data in relation to a standard or interpretive framework), and in some cases to the status of knowledge (information that is evaluated against other sources and referred to a value system).

Networked Knowledges and the SoSE Report

The SoSE reporting enterprise calls for a combination of the lived experience of the community; the skill of the specialist disciplines; the strategic interpretations of the planners, politicians and administrators; and the need for holistic future oriented goals. While some monitoring systems already claim to include each these groups, it is often under conditions where an advisory committee or public forum is informed by government of goals and outcomes set by specialised advice (Brown et al. 1998; Brown & Greene 1994). Each of the stakeholder groups of community, specialists, strategists and holists have their own knowledge systems, their own mode of setting priorities and their own familiar language. If, as more and more monitoring programs require, all four groups of stakeholders are to contribute to each SoE report, active steps will be needed to encourage their inclusion as respected equal partners.

The rings of knowledge, which together make up every place-based decision making system are represented diagrammatically in Figure 2. Braun and Castree (1998) suggest that a change in the human-environment relationship invokes a reconstruction of reality involving shifts in the perspectives of the different knowledge sources. Extensive studies of local decision making on health and environmental issues confirm that proposition (Brown 2000; Brown et al. 2000; Brown, Griffith & Ohlin 1998). The knowledge sources are individually distinct. Local knowledge, which includes a community's sense of place, is built from past and present stories of local lived experience. It is practical, richly diverse and sensitive to local communities' needs and conditions. Community indicators based on local knowledge have been developed for SoE reporting at the national scale (Alexandra, Higgins & White 1998) and at the local scale (Australia Institute 2000). Specialised knowledge (pictured as a ring of separate disciplinary boxes of knowledge in Figure 2) is derived by experts in the field from detailed experiments and case studies, each referenced to its own particular theoretical framework and not necessarily connected to the others. Most of the SoE reports listed in Table 2 are based on data collected within specialised disciplines. The political representatives, interest groups, and administrators who determine the policy directions and other responses to environmental impacts construct the strategic knowledge of any decision making system. Strategic knowledge is values-based and directional, and is best represented by an agenda for policy development. Holist knowledge is the outcome of reaching a shared understanding of the future directions of a place, by residents and others with a stake in that future. It is constructed through integrative teamwork or skilled leadership. Holistic understanding does not represent the sum of the other constructions of knowledge, but rather the core.

Data collection methods differ between the knowledge bases: the community tell stories, the experts use case studies, the strategists work to their agenda, and the holist creates an icon or goal which acts as a synthesis for all the others. The first requirement of a competent monitoring system for informed decision making on the state of a sustainable environment is to value the contributions of all four forms of knowledge; thereby constructing a networked knowledge system which builds on the file and the grid.

In 1997, the NSW Government issued the NSW Local Government Act Amendment 1997: Ecologically Sustainable Development. The Act required councils to report on progress towards the principles of sustainable development in their annual SoE reports, and specified that these reports be related to the goals of the local community, environmental specialised standards and council management plans. This changed the status of the SoE reports to SoSE reports, requiring the incorporation of all four of the systems of knowledge. The knowledge systems have been documented during research and development studies of the preparation of several NSW Councils' SoSe Reports, for example Shoalhaven City Council and the integrated regional report of the nine Councils of the Western Sydney Regional Organisation of Councils (Brown et al. 2000; Brown, Griffith & Ohlin 1998; WSROC 2000). Indicators were derived for the Western Sydney Regional SoSE report through a four-stage process, which addressed each knowledge group in turn. Industry, conservation, social welfare and other community groups from throughout Western Sydney attended workshops to determine their personal vision for an environmentally and socially sustainable Western Sydney, using the WHO Healthy Cities visioning process. There was a strong consensus on 15 priority goals across all 20 workshops. In a second stage of the consultation, each workshop group selected a representative to work with Western Sydney political and administrative interests in establishing measurable indicators for the 15 sustainability goals. The third stage involved calling on experts from a wide range of disciplines and professions to determine what data and other measures would best ensure the reliability and validity of the indicator set. A fourth stage fed back the final set of goals and indicators for validation by all the four knowledge groups (Figure 2).

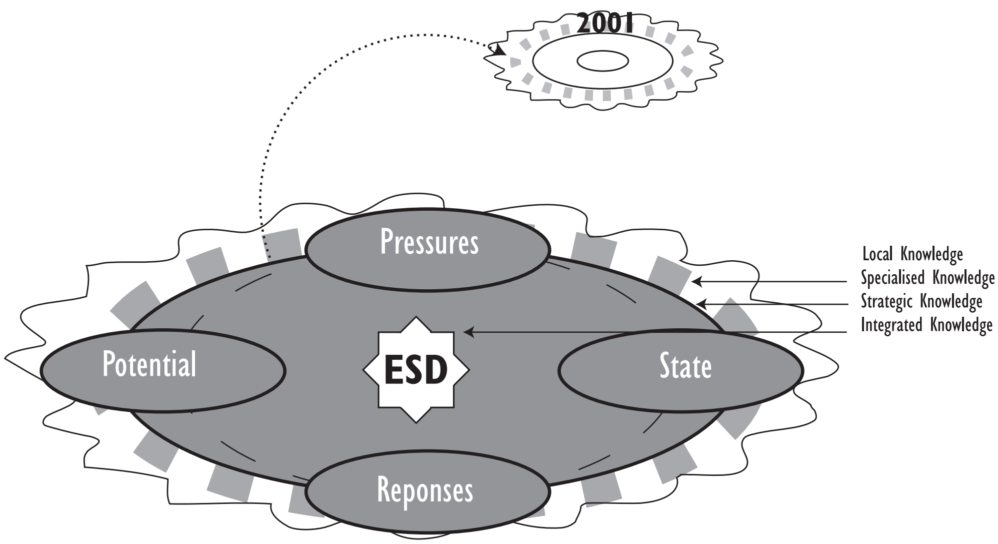
The discussion of the change from monitoring risk to monitoring sustainability earlier in this paper led to the conclusion that the Pressure-State-Response monitoring framework needed to be extended to include the Potential for sustainable development (Figure 1). This extension meant that the file and the grid formats of earlier SoE reports needed to be developed into an SoSE report in which the format is a network made up of the knowledge of the compilers and users of the report (Figure 3). The experience of bringing the four constructions of knowledge (local, specialist, strategic and holist) together in

Figure 2: Networked Knowledge - The basis for constructing the goals and indicators of local sustainability (Brown 199, 1998)

the design of the WSROC regional report confirmed the capacity of these networked knowledges to establish the basis for change towards a more sustainable social and ecological environment (Figure 3).

multidisciplinary nature of the environmental health area, practitioners are likely to be more open than are other specialists to setting up collaborative teams. Their work brings them into regular contact with their local community, and for much of

Figure 3. Networked Knowledge System of State-of-the-Sustainable Environment Reporting



(Brown 2000; WSROC in press)

Conclusion

Environmental health monitoring for the future

Like sustainable development itself, SoSE reporting has to take account of the tension between the need to ensure continuity of social and ecological systems, and the need to respond to the pressures of change. To be effective, a report requires multiple sources of information, a focus on practical applications, and an influence on policy. Environmental health practitioners already collect much of the information required for the SoSE and work with all four constructions of knowledge. While trained as specialists, in Australia they predominantly work within local government authorities and public health units and so are familiar with the strategic thinking of those sectors. Given the their regulatory work they depend on community information. Many of the integrative projects that depend on a shared vision, such as Healthy Cities, Local Agenda 21, and Sustainable Communities, such as Sustainable Seattle (see Metrocenter YMCA 1995), are mounted within the environmental health sections of councils and public health units.

Recent trends in environmental monitoring require the networking of knowledge, people and skills to address the issues of environmental management for health, and to monitor the use of the five sustainable development principles. The design represents a step towards addressing the many challenges posed by the complex network of stakeholders and the different constructions of knowledge involved in 21st Century human-environment relationships. The monitoring process remains firmly based in the collection and filing of the mass of data which is necessary to document properly the condition of the local environment. The grid format enables cross-referencing of the otherwise overwhelming amounts of social, economic and environmental information required to interpret the effects of the pressures on environmental resources. The networked knowledges format permits evaluation of the potential responses, which can best encourage progress towards social and environmental sustainability; the very basis of environmental health.

Each of the three formats carries a different message as well as contributing different components of the monitoring system, and each message has both strengths and weaknesses. The file ensures the safe storage and retrieval of data and acts as a reliable repository; but it can also be a dead-letter office, since there is a tendency for the custodians of information to hold it closely and to restrict access. The grid allows a large number of possibilities to be canvassed, but without a value basis for selection the large number of variables involved in the interaction between environment and health can be simply overwhelming and without direction. The network provides the opportunity to document the complex interactive health-environment system, to canvass options and to evaluate the outcomes of interventions.

For environmental health, the professional environment is changing. The increase in the spread of infectious diseases from global travel and climate change, and the increased rate of dissemination of air and water pollutants through increased industrial activity and private consumption, has led to greater public and government recognition of the importance of the environmental health field. The first national strategies for environmental health appeared in Great Britain and Australia in 1997 and 1999. The place of the community as a partner in local environmental health, rather than simply a client, is identified in each of these strategies and in regulations for state-of-the-environment reporting in NSW. Underlying these changes is a shift in the public attitudes to expert knowledge. Not only are expert conclusions being questioned, but also a single discipline is no longer regarded as sufficient to address the multi-faceted issues discussed above. Environmental health monitoring still requires the filing system and the reference grid, but the effectiveness of the profession now rests on the networking with other knowledges, not only other specialists, but community, strategic and holistic knowledge as well. Monitoring the changing health environment requires a file, a grid and a network.

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Correspondence to:
Valerie A. Brown AO
Regional Integrated Monitoring Centre
Hawkesbury Campus
University of Western Sydney
Locked Bag 1797
Penrith South DC, NSW, 1797
Email valerie.brown@uws.edu.au

Efficacy of the Thermal Process in Destroying Antimicrobial-resistant Bacteria in Commercially Prepared Barbecued Rotisserie Chicken

Dean Bertolatti[1], Steven J. Munyard[2], Warren B. Grubb[3] and Colin W. Binns[1]

School of Public Health[1], and School of Biomedical Sciences[3], Curtin University of Technology and the Western Australian Centre for Pathology and Medical Research[2], Western Australia

The occurrence of antimicrobial-resistant Gram-positive cocci in poultry and poultry-meat products constitutes a potential reservoir for disseminating antibiotic resistance into the community via the food chain. This potential risk demands an ever-present requirement to ensure public safety by utilising thermal processes that have a high probability of achieving target process lethality in preparing commercially cooked ready-to-eat poultry. As a significant quantity of chicken meat in Australia is sold through the food service industry, such as the fast food chains, this study investigated the lethality of the cooking process in destroying these bacteria in barbecued (BBQ) rotisserie chicken prepared at a fast food outlet. The antimicrobial-resistant, Gram-positive cocci for this study were isolated from two poultry processing plants in Western Australia. The results confirm that the lethal effect of the cooking process assures the destruction of these antimicrobial-resistant organisms in BBQ rotisserie chicken.

Key Words: *Chicken, Process Lethality, Antimicrobial Resistance, Gram-positive Cocci*

The emergence of pathogenic bacteria resistant to currently available antibiotics has resulted in increased morbidity and mortality, and costs of health care (Shlaes et al. 1997). Gram-positive cocci, such as staphylococci and enterococci, have emerged as important pathogens of nosocomially acquired infections and have been reported globally with increasing frequency (Jacoby 1996; Jeljaszewicz, Mlynarczyk & Mlynarczyk 1998; Perez-Trallero & Zigorraga 1995). The frequent isolation of antibiotic-resistant, Gram-positive bacteria from food animals (Aarestrup 1995; Bates, Jordens & Griffiths 1994; Borgen et al. 2000; Klare et al. 1995) may impact on human health by contributing to an increase in the prevalence of multidrug-resistant, foodborne pathogens.

Staphylococci produce a variety of local and systemic infections with a range of clinical manifestations. The ability of *S. aureus* to develop resistance to antimicrobials has made the species one of the most important community and nosocomially acquired pathogenic organisms (Mitsuyama et al. 1997). It is also one of the most frequently reported causative agents of foodborne intoxication (Ash 1997).

Enterococci grow and survive under a wide range of environmental conditions and are found in the intestinal tract and faeces of animals, including food animals (Hardie & Wiley 1997). They are of concern because of their increasing importance in nosocomial infections and the increasing numbers of them resistant to glycopeptide antibiotics, such as vancomycin and teicoplanin. Since the early 1990s, vancomycin-resistant enterococci (VRE) have been recovered from environmental sources, food producing animals, poultry meat and other meat products (Aarestrup 1995; Bates, Jordens & Griffiths 1994; Borgen et al. 2000; Klare et al. 1995; Pavia et al. 2000). While it has been suggested that there are links between the emergence of vancomycin resistance in animal enterococci and vancomycin resistance in human enterococcal isolates the evidence for this is contentious (Bates, Jordens & Griffiths 1994).

It is suggested that the use of antimicrobial agents in commercial food animal production might constitute a risk factor in creating an animal reservoir of antimicrobial resistant bacteria (Tenover & Hughes 1996; Tenover & McGowan 1996). From this reservoir, resistant strains or resistance genes might spread via the food supply chain. The possibility that bacteria from commercial poultry may be a vehicle for transmitting antimicrobial-resistance determinants has important relevance to public health, considering that the annual per capita consumption of chicken meat in Australia is about 27 kg per person (Rural Industries Research and Development Corporation 1998). It is estimated that about 13% of this chicken meat is prepared and sold through the fast food industry (Kite 1995).

The thermal destruction of bacteria is a critical control point in the safe preparation of fully cooked ready-to-eat poultry products, therefore, defining the safety margins of inactivation of antimicrobial-resistant bacteria is of considerable importance in ensuring public safety.

Although Australia does not have mandatory performance standards that specify a quantifiable reduction in bacterial pathogens for cooked poultry products, the USA Federal Code of Regulations provides a useful reference in establishing critical limits for this important critical control point. Regulation 9CFR381.150 requires that any thermal process used for fully cooked poultry products must be sufficient to cause a 7-D reduction in salmonellae (Code of Federal Regulations 1999). This level of lethality is also applicable to other vegetative cells of bacteria that are potential food pathogens. As a significant quantity of ready-to-eat chicken meat is sold through the fast food industry, it is prudent to investigate the process lethality (F-value) for BBQ rotisserie chicken at the retail level.

The purpose of this study was to investigate the effectiveness of the thermal process in destroying antimicrobial-resistant, Gram-positive cocci in preparing fully cooked BBQ rotisserie chicken in a Western Australian fast food chicken chain. The thermal resistant data (D-values and Z-values) used in this study were determined from recent thermal death time experiments conducted in ground chicken meat at temperatures of 60, 65 and 70°C (Bertolatti et al. in press).

Methods

Determination of the heating rate of BBQ rotisserie chicken

The thermal properties of three broiler chickens were determined from three cooking trials.

The heating rate of the chickens through to end-point cooking temperatures was determined by measuring the internal temperature under normal cooking conditions in a Semak model M6 industrial rotisserie oven (Semak Australia Pty Ltd) at a fast food retail outlet. The weight of the chickens ranged from 1.1 to 1.2 kg (pre-stuffing) and for each trial 11 birds were loaded onto three of the six available skewers (two skewers each with four birds and one skewer with three birds, plus the isolation box containing the data logger). The time-temperature characteristics were mapped using a probe and an Ebro logger EBI 125A enclosed in an Ebro thermal isolation box (Ebro Electronics Ingolstadt, Germany). The probe was inserted adjacent to the clavicle and positioned on the lateral aspect between the seasoning and the sternum, as this is a slow heating portion of the product. The data were analysed using the Ebro Software Ebi Winlog 2000 (Ebro Electronics Ingolstodt, Germany). The lowest heating rate recorded from three trials was used to determine the process lethality, as this would represent a worst-case scenario. Process parameters, including the surface temperature of the chicken and oven settings and temperatures, were monitored but are not presented in this paper to preserve commercial confidentiality.

Bacterial isolates

The antimicrobial-resistant, Gram-positive bacteria investigated in this study (Table 1) were obtained from two poultry processing plants in Western Australia during 1995-1997 (Bertolatti et al. 1996, 1998; Coombs et al. 1999).

Process lethality (F- value) determination

Thermal resistances (D-values and Z-values) for the bacterial isolates were determined in ground chicken meat at 60, 65 and 70°C in previous laboratory experiments (Bertolatti et al. in press). Cell suspensions tested included three groups of *S. aureus* (comprising composites of five and six isolates), a composite of VRE (comprising two *Enterococcus faecalis* isolates and an *E. gallinarum*), and a methicillin-resistant *S. epidermidis* isolate (Table 1).

The lethal rates were calculated by use of a Microsoft Excel spreadsheet available online from the American Meat Institute (http://www.meatami.org/HACCP/haccp_home.html). The spread sheet for

Table 1: Bacterial isolates

Groupings Tested	Isolates	Source of Isolation	Antimicrobial Resistance (Genes)	Staphylococcal Enterotoxin Production
	S. aureus isolates			
	1P4	C (throat)	P,S,T,S3,Cd,W	-ve
	1P5	DFM	P,S,T,S3,Cd	-ve
A	4P38	*C (under wing)	P,S,S3,Cd,W	-ve
	6P73	C (throat)	P,S,S3,Cd	+ve
	7P80	C (cloaca)	P,E,L,S3,Cd,W	-ve
	S. aureus isolates			
	6P061	*C (under wing)	P,E,L,W,T,S3,Cd,Eb	-ve
	6P064	C (under wing)	P,S,S3,Cd,Eb	+ve
B	7P79	C (cloaca)	P,S,E,L,T,S3,Cd,Eb,W	-ve
	8P126	DFM	P,S3,Cd,W	-ve
	8P128	C (under wing)	P,S3,Cd,Eb	-ve
	S. aureus isolates			
	3P23	C (neck skin)	P,S,E,L,S3,Cd	-ve
	6P68	DFM	P,S3,Cd,Eb	+ve
	6P070	C (throat)	P,S3,Cd,Eb	-ve
C	6P72	C (throat)	P,S3,Cd,W	-ve
	7AP86	C (cloaca)	P,S3,Cd,Eb	+ve
	7AP090	C (neck skin)	P,S3,Cd,Eb	+ve
	Enterococci			
	WBG9171	C (under wing)	V, Tc(*vanA*),	
VRE	WBG9172	C (neck)	V, Tc (*vanA*)	
	WBG9213	C (cloaca)	V, Tc (*vanA & vanC*)	
	S. epidermidis			
	Isolate 19A 1	C (throat)	M(*mecA*),P,E,L,T,S,Asa,Eb	

Abbreviations:

P, penicillin; S, streptomycin; T, tetracycline; S3, sulphamethoxazole; Cd, cadmium; W, trimethoprim; E, erythromycin; L, lincomycin; Eb, ethidium bromide; V, vancomycin; Tc, teicoplanin; M, methicillin; Asa, arsenate; C, broiler chicken; DFM, defeathering machine; * = live birds determining process lethality was derived from the formula: Lethal rate = 10^A, where A = (T-Tr)/Z, Tr is the reference temperature, T is the temperature for which the lethal rate is being determined, and Z is the Z-value for the organism concerned. The reference temperature of 70°C was selected for calculating the lethal effect of the cooking process because chickens cooked at this temperature are rated as well done. The F-value is calculated by entering the required Z-value and reference temperature together with the heating rate data (time-temperature characteristics). The total lethality is the final calculated F-value.

Results and Discussion

Heating rate

Figure 1 illustrates the results of three cooking trials to establish the internal time/temperature profile for BBQ chicken from an initial temperature of 3°C through to end-point cooking temperature. The variation in the time/temperature characteristics between the three trials represents the extremes that may occur in the cooking operation without exceeding tolerances specified in the company's quality manual.

Table 2 summarises the temperature (heat conduction in the chicken) as a function of exposure time. A temperature of ≥ 70°C was achieved for 38, 62 and 60 minutes over the cooking period for trials 1,

Table 2: Internal temperature and time profile for cooking BBQ rotisserie chicken in a Semak M6 industrial oven at a fast food chain outlet.

	Temperature (°C)	Time (Minutes)		
		Test 1	Test 2	Test 3
Cooking Range	< 60°C	66	46	48
	≥ 60°C	50	72	68
	≥ 60°C < 65°C	6	4	4
	≥ 65°C	44	68	64
	≥ 65°C < 70°C	6	6	4
	≥ 70°C	38	62	60
	≥ 70°C < 80°C	14	16	12
	≥ 80°C	24	46	48
	Total Cooking Time	116	118	116

2 and 3 respectively. Temperatures above 80°C were obtained for at least 20% of the time for trial 1, 38% for trial 2 and 40% for trial 3.

Figure 1: Three (3) internal time/termperature profiles for cooking BBQ Rotisserie chickens

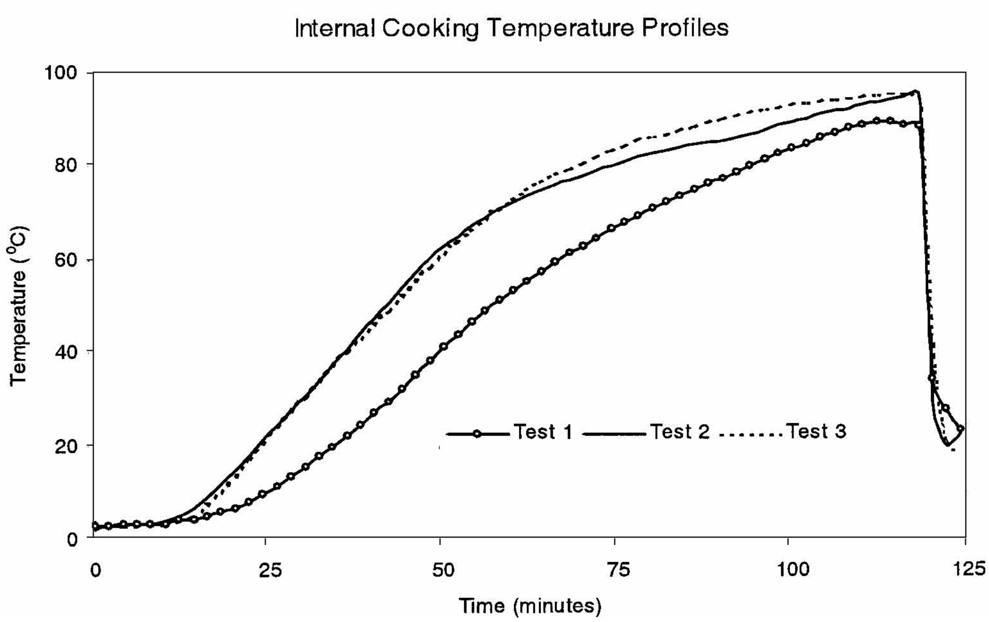

Table 3: Estimated F-values to achieve a 7-D reduction in BBQ chicken at 70°C.

Organisms	T Ref (°C)	Z (°C)	D (min)	Log Reduction	Required F-value (min)
S. aureus Gp A	70	6.84	0.24	7	1.68
S. aureus Gp B	70	7.04	0.25	7	1.75
S. aureus Gp C	70	6.66	0.23	7	1.61
VRE Group	70	7.24	0.30	7	2.10
S. epidermidis	70	7.46	0.25	7	1.75

The internal cooking temperature profiles indicate that these BBQ chickens are rated as well done. The study by Joseph et al. (1997) classified broiler chickens cooked to 70°C and above (up to 85°C) as well done and concluded that an end-point cooking temperature of 80°C for poultry meat was a good indicator of "doneness". On this basis, the reference temperature of 70°C was selected for calculating the lethal effect of the cooking process for BBQ rotisserie chicken. Further, to illustrate the highest risk potential (worst-case scenario) the lowest heating rate mapped (Figure 1) was used to calculate the process lethality.

Lethal process (F-value) estimates

As bacterial inactivation by thermal process is a critical control point (CCP) in the safe preparation of fully cooked poultry products, it is important that the lethal effect of the cooking process in reducing these antimicrobial-resistant organisms is established. Table 3 Provides estimates of F-values required for achieving a 7-D lethality in BBQ chicken from D70°C values. The estimated F-values ranged from 1.61 to 2.10 minutes, with the enterococcal group requiring a slightly longer process time to achieve a 7-log reduction. A comparison of these F-value estimates with the heating rate for cooking BBQ rotisserie chicken (Table 2) indicates that the lethal effect of the thermal process achieves a substantially greater reduction than a 7-D lethality. This confirms the effectiveness of the heat treatment in reducing the risk of cooked chicken

Table 4: Process Lethality (F-value) calculated from a 70°C reference temperature

		S. aureus				
		Gp A	Gp B	Gp C	VRE Group	*S. epidermidis*
Time (min)	Internal Temp (°C)	Z = 6.84 F-value (min)	Z = 7.04 F-value (min)	Z = 6.66 F-value (min)	Z = 7.24 F-value (min)	Z = 7.46 F-value (min)
0	3.0	0.00	0.00	0.00	0.00	0.00
46	35.3	0.00	0.00	0.00	0.00	0.00
52	44.2	0.00	0.00	0.00	0.00	0.00
58	51.5	0.01	0.01	0.01	0.01	0.01
62	55.7	0.03	0.03	0.02	0.04	0.04
64	57.7	0.05	0.06	0.04	0.07	0.08
66	59.7	0.10	0.11	0.09	0.13	0.14
68	61.5	0.19	0.21	0.17	0.23	0.26
72	64.8	0.65	0.70	0.61	0.75	0.80
78	69.5	3.70	3.79	3.63	3.88	3.98
82	72.4	9.88	9.88	9.89	9.88	9.89
86	75.0	25.13	24.52	25.75	23.98	23.44
90	77.6	61.73	58.81	64.69	56.21	53.68
94	80.2	149.54	139.05	160.38	129.91	121.16
98	82.7	355.32	322.62	389.80	294.73	268.55
102	84.9	800.69	711.49	895.57	636.85	568.11
104	86.1	1177.32	1035.86	1330.72	918.55	811.44
108	88.2	2544.90	2192.67	2934.49	1906.24	1649.75
110	88.9	3582.49	3061.26	4163.31	2640.53	2266.57
112	89.4	4848.03	4114.80	5670.01	3526.52	3006.76
116	89.4	7591.60	6393.79	8943.21	5439.10	4601.16

constituting a potential vehicle for the transfer of resistant bacteria through the food chain.

The USA Federal Code of Regulations 9CFR381.150 requires that any thermal process used for fully cooked poultry products must be sufficient to cause a 7-D reduction in salmonellae and other vegetative bacterial cells that are potential food pathogens (Code of Federal Regulations 1999). Where no mandatory performance standards are specified requiring a quantifiable reduction in microbial pathogens in cooked poultry products, then these standards provide a reference for establishing critical limits for the thermal process critical control point for fully cooked BBQ rotisserie chicken.

The lethal effect of the cooking process (F-value) for all cell suspensions is given in Table 4. The F-values ranged from circa 4600 to 8950 minutes, with the *S. epidermidis* isolate recording the lowest and the *S. aureus* group C the highest lethal rate. The calculated log reduction from these F-values of >1800 decimal reduction clearly demonstrates that a substantial margin of safety exists in this thermal process for reducing the number of viable bacteria. It is important to note that the lethal rate was calculated only on the cooking process and that the effect of the cooling period on bacterial inactivation was not considered. Including the cooling time would increase the lethality of the process because heat continues to diffuse into the centre of the chicken as the outside cools (Bellara et al. 1999). The data confirm the effectiveness of the thermal process in destroying these organisms. Further, they highlight the importance of the cooking process as a Critical Control Point (CCP) of a Hazard Analysis Critical Control Point (HACCP) system for inactivating antimicrobial-resistant bacteria in preparing fully cooked ready-to-eat BBQ rotisserie chicken.

Poultry and red meat products are frequently identified as vehicles of food poisoning with insufficient cooking often a factor contributing to outbreaks (Bellara et al. 1999). The overcooking of chicken to overcome the aesthetic problem of "bloody" chicken and the lack of certainty that the thermal process is effective in achieving pathogen reduction are problems for the retail chicken industry. "Bloody" chicken, a reddish discolouration around the bone area of leg, thighs and wings is attributed to the rapid growing and marketing of young broiler chickens with soft bones that may result in seepage of bone marrow into the surrounding meat and cause it to discolour (Snyder 1999). Considering the log reduction achieved in this study, it is likely that the process time for cooking BBQ chickens could be reduced without affecting the required safety margins for killing bacteria. This may assist in resolving quality problems associated with overcooked chicken that is a cause for concern in some sectors of the retail chicken industry.

Conclusion

It is evident that the relatively high rates of heating involved in preparing fully cooked BBQ rotisserie chicken is effective in destroying the antimicrobial-resistant, Gram-positive bacteria investigated. The findings indicate that the thermal process critical control point is able to reduce the risk of commercially cooked BBQ chicken transferring antimicrobial-resistant bacteria through the food chain. However, other risks such as cross contamination post-cooking and the potential for foodhandlers to be colonised by these resistant organisms cannot be overestimated. The effective management of these risks requires an organised HACCP system complemented by appropriately trained personnel and the application of good hygiene and manufacturing practices.

Glossary

D-value (decimal reduction time): The time in minutes to reduce a population of cells by 90% or 1 log cycle at a specific temperature. Z-value: The temperature change required for a ten-fold change of the D-value. F-value (process lethality): The equivalent heating time at a reference temperature with a specified Z-value.

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Correspondence to:
Dean Bertolatti
Department of Environmental Health
School of Public Health
Curtin University of Technology
GPO Box U1987
Perth, Western Australia, 6845
AUSTRALIA
Email: dbert@health.curtin.edu.au

The Effects of Temperature and Sediment Characteristics on Survival of *Escherichia Coli* in Recreational Coastal Water and Sediment

D. L. Craig, H. J. Fallowfield and N. J. Cromar

Department of Environmental Health, The Flinders University of South Australia

The survival of the faecal indicator organism Escherichia coli (E. coli) *in recreational coastal water and sediment was investigated using laboratory based microcosms. Intact sediment cores from three distinct coastal sites in metropolitan Adelaide were inoculated with known concentrations of* E. coli *and incubated at temperatures of 10°C, 20°C and 30°C. Enumeration of* E. coli *in sediment and overlying water was undertaken by the membrane filtration method on Days 0, 1, 2, 7, 14 and 28 following inoculation. Under all conditions studied, the decay rate of* E. coli *was greater in overlying water compared with the rate in sediment.* E. coli *survival was found to have an inverse relationship with temperature. Sediment characteristics (particle size and organic carbon content) were found to influence the decay of* E. coli. *The decay rate of* E. coli *was demonstrated to be lowest in sediment consisting of small particle size and high organic carbon content. Resuspension of* E. coli *into the water column was demonstrated when the top 10-20 millimetres of sediment was stirred immediately prior to enumeration, mimicking recreational activity. Greatest resuspension of* E. coli *was observed from sediment consisting mainly of sand when incubated at 10°C.*

Key Words: *Recreational Water, Faecal Coliforms,* Escherichia Coli, *Sediment, Survival, Resuspension*

The assessment of microbiological water quality for recreational coastal waters in Australia is primarily undertaken by enumeration of faecal coliforms and *Escherichia coli* from the water column. The presence of these indicator organisms is used to estimate the risk of other pathogenic organisms of faecal origin being present in the water body. Organisms released into the coastal environment are, however, subjected to numerous stressors such as temperature change, salinity, nutrient deficiencies, sunlight and predation (Davies et al. 1995; Mezrioui, Baleux & Troussellier 1995; Özkanca & Flint 1997; Thomas, Hill & Mabey 1999). Studies have demonstrated that organisms associated with suspended particles and sediment contribute greater numbers than in the water column under many in-situ conditions (Davies et al. 1995; Goulder 1977; Obiri-Danso & Jones 2000; Shiaris et al. 1987). It has been suggested that sediment characteristics such as particle size and organic carbon content influences the survival of microorganisms in sediment (Howell, Coyne & Cornelius 1996; Irvine & Pettibone 1993).

The possibility of resuspension of indicator microorganisms under environmental conditions has been discussed by a number of researchers (Irvine & Pettibone 1993; Obiri-Danso & Jones 2000). Studies have demonstrated exposure to recreational waters subjected to faecal contamination results in an increased risk of disease, in particular gastroenteritis (Fleisher et al. 1993; Fleisher et al. 1996; Kay et al. 1994). Resuspension of indicator organisms from the sediment into the water column will therefore indicate an increased risk of exposure to pathogenic organisms of faecal origin during recreational activity. It is unclear, however, the extent to which bacteria are resuspended from sediment of various compositions into the water column at recreational coastal sites, and thus the increased health risk which may be posed is unknown.

Microcosms of varying complexity have been used to estimate the survival of microorganisms in water and sediment (Bordalo 1993; Brenner, Muller & McBride 1999; Davies et al. 1995; Gerba & McLeod 1976; Thomas, Hill & Mabey 1999; Wagner-Döbler et al. 1992). Unlike many other studies, this study utilised intact, non-sterile sediment cores to determine the persistence of *E. coli* in different sediment types incubated at various temperatures. The ability of *E. coli* to be resuspended into the water column following disruption of the sediment was also investigated.

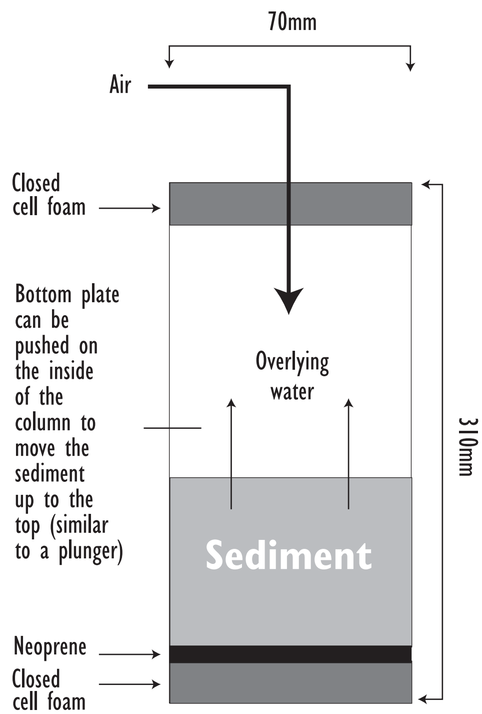
Methodology

Microcosm design

For each microcosm experiment, six intact sediment cores were collected from three sites in metropolitan Adelaide (Henley Beach, Onkaparinga River and Port Adelaide River) which represented distinct coastal sites with different physical characteristics. Sediment was characterised (percentage sand, silt and clay) using the pipette method (Sheldrick & Wang 1993). The percent of organic carbon present in the sediment was determined by the dichromate method (Tiessen & Moir 1993). In addition to these, six cores were filled only with overlying water to act as controls.

Perspex columns (70mm diameter, 310mm length) were inserted approximately 100mm into sediment and overlying water at respective sites. The top of the column was capped with a rubber bung to aid the removal of the core from the sediment. The sediment core was kept in place by inserting neoprene (5mm thick) and closed-cell foam (20mm thick) bungs into the bottom of the core (Figure 1). This prevented the movement of both sediment and water within and from the column.

Figure 1: Microcosm design.



To enable investigation of the effect of sediment composition on *E. coli* survival, the incubations were conducted with identical overlying water to remove the influence of conductivity changes. Columns were then placed in a water bath held at a constant temperature for a maximum of 28 days.

Inoculation of microcosm

A stock bacterial suspension was prepared by inoculating *E. coli* (ATCC 25922) into 10mL of nutrient broth and incubating overnight at 37°C. Cells were harvested by centrifugation at 2,500g for 10 minutes. The pelleted sample was resuspended in 1mL of 0.1M phosphate buffered saline (pH 7.2), washed by centrifugation at 8,000g in a microcentrifuge, followed by resuspension in 1.5mL PBS. Stock *E. coli* suspension was stored at 4°C until use. Each column was inoculated by adding 50mL of stock *E. coli* suspension to overlying water giving a final concentration of approximately 1 x 10^7 CFU/100mL. Aeration of the overlying water in the column provided adequate oxygenation of the overlying water.

Determination of E. coli survival

Both sediment and water from the columns were analysed on Day 0 (1 hour after inoculation), and after 1, 2, 7, 14 and 28 days incubation. Due to there being a rapid decay of *E. coli* when incubated at 30°C, columns incubated at this temperature were analysed on Day 0, 1, 2, 4 and 7. In an effort to simulate disruption of sediment due to recreational activities, the microcosm experiment was repeated at all three temperatures with the top 10-20mm of sediment being gently mixed immediately prior to sampling. To identify the possible resuspension of *E. coli*, results were expressed as percent partitioning between the sediment and water column under both static and stirred conditions.

The number of *E. coli* present in the water was determined using the membrane filtration method (Australian Standard AS 4276.7, 1995). This involved filtering the overlying water sample through a membrane filter (GN-6, Gellman), placing the filter on membrane lauryl sulphate agar (Oxoid) and incubating at 30°C for 4 hours followed by 44°C for 18 hours. Results were expressed as number of colony forming units (CFU)/100mL.

Sediment samples for microbiological analysis were obtained by first removing the remaining overlying water. The column was then placed on a coring device that extruded the sediment at controlled intervals. The top 10mm of sediment was removed and placed into a sterile beaker. Of this sediment, 25g (wet weight) was placed into 75mL of sterile 0.1% peptone water (Oxoid). This sample was then placed into a sonication bath (Cooper Vision Model 895, 700W, 35kHz) for 10 minutes, stirred and sonicated for a further 10 minutes (Craig, Fallowfield & Cromar 1999). *E. coli* were enumerated from the supernatant removed from the sonicated sample (by the membrane filtration method).

For all microcosm experiments, a known weight of sediment was placed in a pre-weighed dish and dried at 105°C for 24 hours to determine the sediment dry weight. The results for *E. coli* concentration in sediment were expressed as number of CFU/100g (dry weight) sediment. Overlying water from the microcosms was monitored for conductivity and pH over the course of the experiment to indicate the relative stability of the cores.

The decay rate constant (k) was calculated as the slope of the line when $\log_{10}(N_t/N_0)$ was regressed against time, where N_t is the number of bacteria at time t and N_0 is the number of bacteria at time 0 (Davies & Evison 1991). All analyses were undertaken in triplicate and expressed as the mean ± standard deviation.

Results

Sediment from Henley Beach consisted mainly of sand, with very little silt and clay, and low percentage of organic carbon (Table 1). In comparison Port Adelaide sediment contained much higher proportions of silt, clay and organic carbon. Sediment from the Onkaparinga River could be described as intermediate. At the Port Adelaide River the sediment was distinctly stratified, with the top two centimetre layer comprising anaerobic horizon and below that a layer consisting of a mixture of sand and silt/clay. Only the surface layer of each column was examined, as this would provide the main source of exposure to microorganisms in any recreational activity.

Table 1: Sediment characterisation

Site	%Sand	%Silt	%Clay	%Organic C
Henley Beach	98.54	0.08	1.41	0.046
Onkaparinga	93.20	1.23	2.84	0.346
Pt Adelaide (upper horizon)	81.80	4.18	10.17	2.348

Monitoring of overlying water

conductivity and pH suggested the microcosms remained relatively stable over the sampling period of 28 days. Macro-invertebrates were present in the overlying water throughout the study; thus conditions were sustained similar to that of the natural environment to support in-situ organisms.

Results of the microcosm experiment illustrated at all temperatures there was a greater decay rate of *E. coli* in water compared with sediment for all sediment types (Table 2). It was also demonstrated that the greatest decay of *E. coli* (-2.13 d^{-1}) occurred in the column containing water only at 30°C. Increased temperature resulted in increased decay rates in both sediment and water from all sites, with a significant increase in decay rates in water incubated at 30°C. Of the microcosms containing sediment, greatest decay was observed in sediment from Henley Beach (high sand content). In contrast, persistence of *E. coli* was prolonged in sediment from Port Adelaide (high silt, clay and organic carbon content).

remained relatively high (approximately 2-log higher than the water column).

Resuspension of *E. coli* into the water column following disruption of the sediment was most noticeable for sediment from Henley Beach (high sand content) incubated at 10°C (Figure 2). Under static conditions the concentration of *E. coli* in the water column contributed to only 3.0% of the total concentration (sediment and water) by Day 2. After the same period of time under stirred conditions, when the top two centimetres of sediment was mixed immediately prior to enumeration, the concentration of *E. coli* in the water column contributed 85.3% of the total load. The effect of stirring on resuspension was time dependent, as by Day 7 under stirred conditions the number of *E. coli* in the water column had declined to 25.9% of the total number (compared with 3.9% for static). When incubated at 20°C, stirring the Henley Beach sediment resulted in a much more rapid resuspension of *E. coli* into the water column when compared with 10°C in the initial two day period (Figure 3), with most of the inoculum being resuspended on Day 1.

Table 2: Decay rate constants (k; days^{-1}) for E. coli in water and sediment under static conditions.

	Water			Sediment		
	10ºC	20ºC	30ºC	10ºC	20ºC	30ºC
Henley Beach	-0.45	-0.89	-2.40	-0.32	-0.32	-1.36
Onkaparinga	-0.24	-0.52	-2.09	-0.13	-0.22	-0.91
Port Adelaide	-0.21	-0.45	-2.10	-0.14	-0.49	-0.58
Water only	-1.04	-1.03	-2.13			

Note - more negative decay rate constant equals more rapid death of microorganisms.

Results expressed as decay rate constants for the stirred microcosms indicated a lower decay rate of *E. coli* (larger numbers of organisms) in the water column when incubated at 20°C and 30°C compared with static conditions (Table 3). Under static conditions at these higher temperatures, the concentration of *E. coli* in the water column declined very rapidly. In contrast, the concentration of *E. coli* in the sediment

Resuspension of *E. coli* from both Onkaparinga (Figure 4) and Port Adelaide sediment (not shown) into the water column was observed at 10°C. Under static

Table 3: Decay rate constants (k; days^{-1}) for E. coli in water and sediment following resuspension by agitation.

	Water			Sediment		
	10ºC	20ºC	30ºC	10ºC	20ºC	30ºC
Henley Beach	-0.48	-0.39	-1.46	-0.21	-0.28	-2.09
Onkaparinga	-0.31	-0.45	-1.29	-0.09	-0.24	-0.84
Port Adelaide	-0.30	-0.36	-1.32	-0.22	-0.24	-0.68
Water only	-0.51	-1.02	-2.59			

Figure 2: Partitioning between sediment and water for Henley Beach sediment incubated at 10ºC.

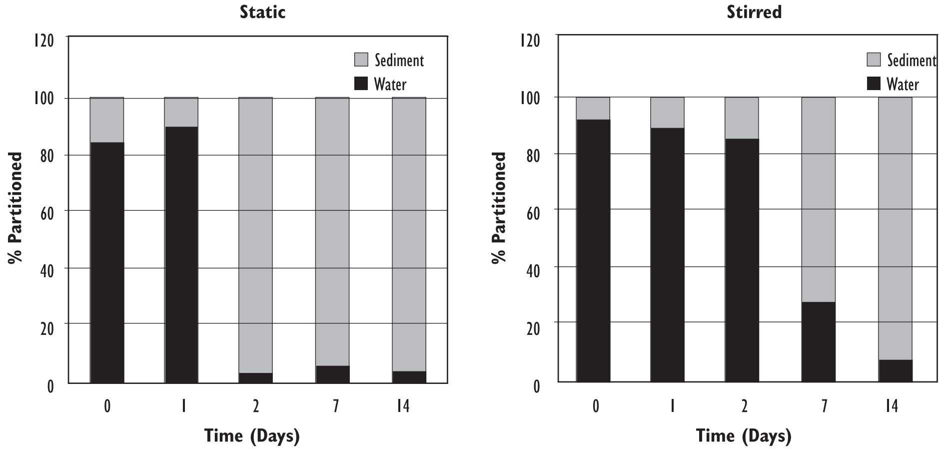


Figure 3: Henley Beach sediment incubated at 20ºC.

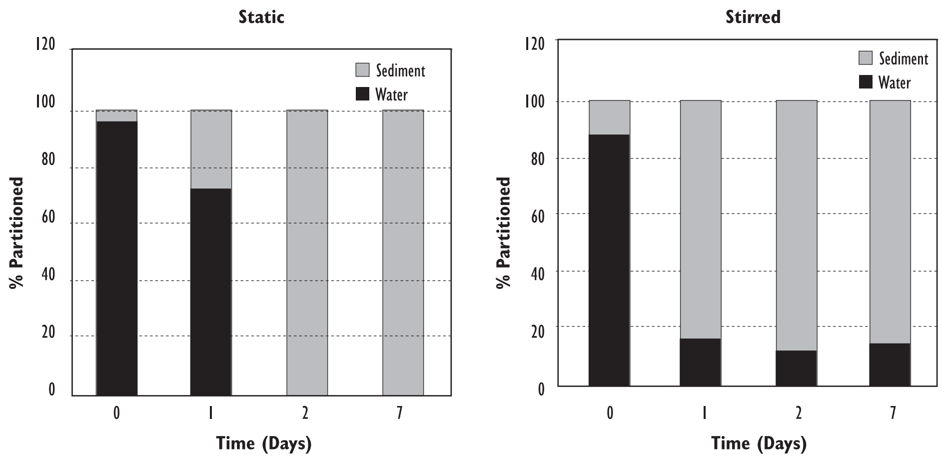
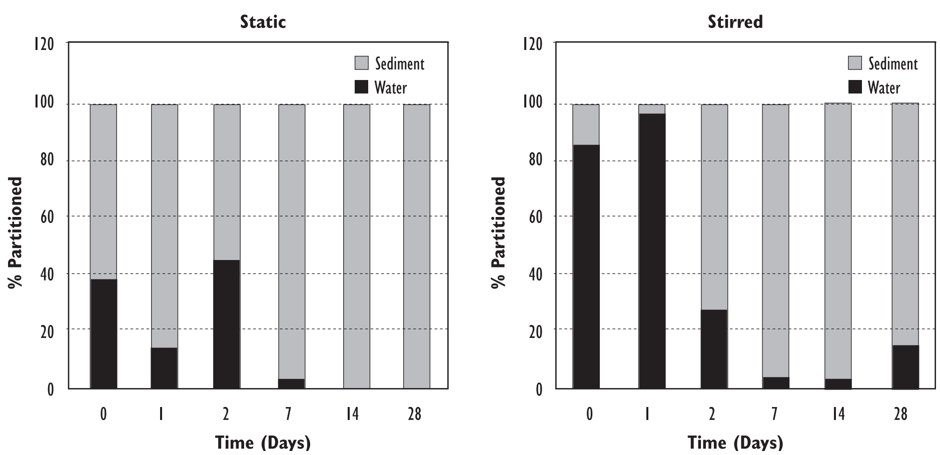


Figure 4: Onkaparinga sediment incubated at 10ºC.



conditions at 10°C the proportion of *E. coli* in these sediments were much greater than in the water column during the initial three days following inoculation. Results demonstrated under stirred conditions an elevated proportion of *E. coli* in the water column during the initial two days following inoculation compared with static conditions (Figure 4). Resuspension was, however, not evident for Onkaparinga or Port Adelaide sediment incubated at 20°C and 30°C (results not shown) when expressed as percent partitioning.

Discussion

Our results demonstrated that the microcosms remained relatively stable over the sampling period of 28 days. A study by Wagner-Döbler et al. (1992) demonstrated conditions of microcosms of a similar design closely resembled in-situ measurements over the same time period.

The highest decay rate of *E. coli* (-2.13 d^{-1}) was observed in the column containing water only incubated at 30°C. A study by Flint (1987) demonstrated a significantly increased decay rate of *E. coli* in unfiltered river water compared with 0.45μm filtered water and autoclaved water, which suggests that competition with natural microorganisms influences survival of *E. coli* in aquatic environments. The water used in these experiments was unfiltered and thus would also experience competition with natural microorganisms, however, numbers of the test organism inoculated into the water column were so large that competition would exert only a very minor influence.

Increases in temperature resulted in increased decay rates in both sediment and water from all sites. The influence of increased temperature was, however, less pronounced in sediment (particularly in the highly organic loaded sediment from Port Adelaide). Özkanca and Flint (1997) demonstrated that viability of *E. coli*, as determined by plate counts, in filtered-autoclaved river water declined faster at 37°C than other temperatures investigated and that numbers of organisms were highest at 4°C. In addition, under starvation, stress respiratory enzyme activity of *E. coli* declined more rapidly at 37°C than at 4°C. This might explain in part the increased effect of higher temperature on decay rates in water compared with sediment for this study. *E. coli* present in the water column would be under more starvation stress due to lower nutrient availability than for those in the sediment.

Greatest survival of *E. coli* was observed in Port Adelaide sediment (high silt, clay and organic carbon content). The influence of sediment type on *E. coli* survival reflects intrinsic differences such as particle size, organic carbon content and nutrients. A study by Irvine and Pettibone (1993) investigating in-situ populations of indicator bacteria in river water and sediment found a weak correlation between bacteria density with particle size and organic carbon content. Howell et al. (1996) also demonstrated a significant relationship between sediment particle size and faecal coliform mortality using a microcosm experiment consisting of 50g non-sterile sediment and 200mL sterile physiological saline. Greatest survival was observed in sediment consisting of small particle size incubated at lower temperatures (4°C > 25°C > 35°C).

It is difficult to compare directly results of this study with other microcosm studies investigating the effect of sediment type on the persistence of *E. coli*. Many previous studies used sterile sediment and water (Brenner, Muller & McBride 1999; Thomas, et al. 1999). The microcosms used in this study consisted of non-sterile, intact sediment cores and therefore included the added pressures to *E. coli* survival of competition with natural organisms and predators. It has also been suggested that the act of sterilising sediment by autoclaving might result in the increased transfer of nutrients from sediment into the water and this might therefore influence survival in the water column (Gerba & McLeod 1976). Davies and Evison (1991) demonstrated exposure of *E. coli* to natural sunlight had a greater effect of reducing survival in marine water compared with fresh water. As the current study was undertaken without exposure to sunlight, the decay rates observed can be considered a conservative estimate of in-situ rates.

The effect of stirring the sediment immediately prior to sampling resulted in greater numbers of *E. coli* being enumerated from the water column, therefore producing lower overall decay rates compared with static conditions, when incubated at 20°C and 30°C. Results expressed as percent partitioning demonstrated greatest resuspension of *E. coli* into the water column occurred from Henley Beach sediment when incubated at 10°C. Incubation at higher temperatures resulted in a much more rapid resuspension of *E. coli* into the water column, with greatest resuspension occurring on Day 1. This could be explained by the higher decay rate of *E. coli* in the water column at 20°C. Under static conditions, the number of *E. coli* present in the water column was at the limit of detection by Day 7, however, a concentration of 2.9×10^3 CFU/100mL remained in the sediment. Therefore, immediately prior to stirring, only a small number of *E. coli* would have been present in the water column of the stirred experiment. Results suggest the organisms detected in the water column following stirring of the sediment were present as a result of resuspension.

The current National Health and Medical Research Council guideline for the microbiological quality of water used for primary contact recreation is a median value (from five samples) of less than 150 faecal coliforms (cfu)/100mL (NHRMC 1990). As this study has demonstrated, the concentration of organisms in the sediment may be one to two orders of magnitude higher than in the overlying water. If this is found to be the case, then this may indicate a significantly increased risk of exposure, and therefore disease. Research is ongoing to determine whether pathogenic and other indicator organisms behave similarly to *E. coli* and we may have to question the effectiveness of setting guideline faecal indicator organism values for the water column alone in estimating health risk at recreational coastal sites.

Conclusion

Results demonstrated a lower decay rate (higher survival) of *E. coli* in coastal sediment compared with overlying water. Sediment characteristics influenced decay rates, with high organic carbon content and small particle size found to be more conducive to *E. coli* persistence. Resuspension of *E. coli* into the water column during stirring of the surface layer was illustrated for sediment consisting of mainly sand, particularly at low temperatures (10°C). The greater resuspension of *E. coli* observed from the sandy Henley Beach sediment may be due to differences in the physical attachment of the organisms to the larger particle size. These findings have significant implications in regard to the estimation of risk of infection during recreational activities. If a recreational coastal site has been subjected to faecal contamination, the concentration of indicator organisms in the water column may rapidly decrease to below guideline values. Results of this study, however, demonstrated that *E. coli* can persist in coastal sediments for prolonged periods of time and be resuspended into the water column under certain conditions.

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Correspondence to:
N. J. Cromar
Department of Environmental Health
The Flinders University of South Australia
GPO Box 2100
Adelaide, South Australia, 5001
AUSTRALIA
Email Nancy.Cromar@flinders.edu.au

Domestic exposure of asthmatic and non-asthmatic children to house dust mite allergen *(Der p 1)* and cat allergen *(Fel d 1)* in Adelaide, South Australia

K. D. Thomas[1], S. M. Dyer[1], J. Ciuk[1], R. E. Volkmer[2] and J. W. Edwards[1]

Department of Environmental Health, The Flinders University of South Australia[1] and Child and Youth Health, Adelaide[2]

Domestic allergen exposures, such as those from house dust mite and pets, may represent sign ficant risks for the development of asthma and of acute asthma attack. Previous studies have been performed in Australia measuring allergen prevalence, atopy, and asthma, but these have largely been in eastern Australia, with few reported studies elsewhere. This study aimed to measure the major allergens of the mite (Dermatophagoides pteronyssinus, Der p 1), *and the cat* (Felis domesticus, Fel d 1), *in homes of preschool children in Adelaide, South Australia.*

Der p 1 *and* Fel d 1 *were measured in vacuum dust samples from the bed, bedroom floor and living room floor of 34 asthmatic and 37 non-asthmatic four-year old children, using a two-site monoclonal antibody assay. Geometric mean* Der p 1 *concentrations were significantly higher in beds of asthmatic children (8.30 µg/g dust) than non-asthmatic (3.16 µg/g). In asthmatics bed levels exceeded those of bedroom floor (3.16 µg/g) and living room floor (1.62 µg/g). For non-asthmatics, bed and bedroom samples (4.80 µg/g) were not different but these exceeded living room floors (1.21 µg/g). Over 80% of asthmatic children were exposed in beds to over 2 µg* Der p 1*/g, a level associated with the development of atopy and asthma, and over 40% were exposed to over 10 µg/g, a level implicated in acute asthma episodes. Fewer non-asthmatic children were exposed to these levels. Bed, bedroom and living room levels of* Der p 1 *were well correlated, suggesting common environmental or building factors may predispose to a high mite prevalence.*

Fel d 1 *levels were very high, with only a single sample found below 8 µg/g, a level considered "significant" exposure. Over 56% of asthmatics' beds contained over 1,000 µg* Fel d 1*/g dust, and 9% exceeded 100,000 µg/g, with lower frequencies for non-asthmatics. Beds of asthmatic children contained significantly more* Fel d 1 *than non-asthmatic (2600 µg/g versus 890 µg/g). For asthmatics, but not non-asthmatics, bed levels exceeded bedroom and living room levels. As with* Der p 1, *bed, bedroom and living room levels of* Fel d 1 *were well correlated, but* Der p 1 *poorly correlated with* Fel d 1, *suggesting different predisposing factors for the prevalence of these allergens. Different areas of Adelaide did not differ in the levels of mite or cat allergen. The study shows that while mite allergen levels are lower than those reported in the eastern states of Australia, cat allergen was very high, and both represent a significant risk of asthma in Adelaide*

Key Words: *House Dust Mite, Cat Antigen, Asthma, Bioaerosols,* Fel d 1, Der p 1

The indoor environment is a potential source of exposure to a wide variety of factors that may affect respiratory health. These include inorganic pollutants (such as nitrogen oxides from gas heaters or stoves), organic pollutants (including formaldehyde and volatile organic compounds from building materials, paints and adhesives and soft furnishings), and biological pollutants (of plant, fungal, or animal origin). Dusts in homes may comprise combinations of inorganic, organic and biological phases, originating from outside or inside the home. Asthmatics become exposed to dusts when they are suspended or resuspended in air and are inhaled. It is well known that dust exposures in homes may act as precipitating factors for asthma attacks, and early studies showed that many asthmatics tested positive for skin tests with house dust extracts (Kern 1921).

House dust mite and cat allergens are potent bioaerosols that are able to trigger allergic responses (Ohman et al. 1977; Sarsfield et al. 1976; Voorhorst et al. 1969). The major proteins isolated from mites are *Der p 1* (from *Dermatophagoides pteronyssinus*) and *Der f 1* (from *D. farinae*), and these are mainly associated with mite faeces. Cat allergen (*Fel d 1* from *Felis domesticus*) is a salivary and sebaceous protein released from cat hair following grooming. US studies have estimated that 2% of the population are allergic to cats and one third live in a house with a cat (Gergen et al. 1987; Ohman 1978). Similar ownership rates have been determined in Australia with 26% of homes having at least one cat (Petnet 2000). Between 60 and 80% of children in warm and temperate climates are sensitised to dust mite and the risk of asthma is significantly increased with dust mite exposure (Peat et al. 1993). Exposure to *Der p 1* over 2 µg/g is suggested as a risk factor for increased IgE and development of asthma, and dusts over 10 µg/g are a risk factor for acute asthma attack (Platts-Mills & de Weck 1989). Similar threshold levels (8 µg *Fel d 1*/g dust) have been proposed as significant exposure for cat allergen (Gelber et al. 1993). While it is acknowledged that these levels may not be definitive (Pearce et al. 2000) they are suggestive and act as a useful broad measure of exposure.

Many of the Australian studies of allergen concentrations have focused on south-eastern seaboard (predominantly Sydney and Melbourne), with very few studies elsewhere. Climatic conditions may contribute to the geographic variation in allergen levels, and the distribution of dust mite species. Humidity in particular may be an important determination in geographical distribution of dust mite, with excessive mite growth at relative humidities of about 60% at 21°C and 75% at 15°C. These factors may also be associated with differential distributions of mite species. Areas of low humidity favour *D. farinae*, whereas areas of high, continuous humidity favour *D. pteronyssinus* (Platts-Mills & Chapman 1987).

This work was a component of a larger study investigating the roles of various indoor contaminants, such as nitrogen dioxide (Ciuk et al. in press) and other domestic and construction factors on asthma prevalence in preschool children in metropolitan Adelaide, and aimed to quantitate the levels of cat and dust mite allergens (*Der p 1* and *Fel d 1*) in the homes of asthmatic and non-asthmatic children. While South Australia is the driest State, on the driest continent, Adelaide has Mediterranean-type climate, characterised by hot dry summers and mild wet winters. The data collected in this study will permit estimates of asthma risk in this area and may suggest the levels of control necessary to be achieved to reduce this risk.

Methods

Subject recruitment and questionnaire administration

Residents of 71 homes from four areas of Metropolitan Adelaide gave informed consent to participate in this study. The study group comprised four-year-old children sub-sampled from 13,116 children whose parents were surveyed at preschool health screenings conducted by Child and Youth Health in South Australia in 1996-97. The selection of these subjects was based on four geographical areas identified in a previous study as high or low asthma prevalence and high or low socio-economic status (SES)

(Volkmer et al. 1995a; Volkmer et al. 1995b). Asthma status was determined through parental reporting of previous asthma diagnosis. Table 1 shows the definition of these areas as A, B, C and D. Asthma prevalences in areas of low socioeconomic status were uniformly higher than in higher SES, so areas B and C were combined into a single low SES/high asthma area (area E) and areas A and D were combined to form area F (Ciuk et al. in press).

Table 1. Summary of study areas

	Areas of metropolitan Adelaide		Asthma (%)	N*	Homes in this study
1a	A	low asthma/high SES	22.6	252	17
	B	low asthma/low SES	26.1	199	18
	C	high asthma/low SES	26.3	308	16
	D	high asthma/high SES	21.8	362	20
1b	E	high asthma/low SES	26.2	507	34
	F	high asthma/high SES	22.1	614	37

(1a) Areas were identified from previous survey (Volkmer et al. 1995a; Volkmer et al. 1995b) as A, B, C and D.

(1b) Rate of asthma for the two areas: E and F, where area E is the result of combining area B and area C and F is the result of a combination of area A and area D.

** N represents the number of subjects used to estimate the asthma prevalence in each area (Ciuk et al. in press)*

Domestic dust sample collection and extraction

At each home a dust sample was obtained by vacuuming the child's bedding, and a 1 m^2 area of both the bedroom and living room floors using an Electrolux Royal vacuum cleaner with a viewerscope filter holder and dust sampling filter. If the floor was not carpeted a 2 m^2 area was vacuumed. Filters were carefully removed from the viewerscope, folded and closed with a clean metal bulldog clip. Filters were transferred to ziplock polyethylene bags for transport to the laboratory. A fresh viewerscope and hose nozzle were used on each sampling occasion. Dusts were sieved (425 µm mesh) and fine dust collected in polyethylene tubes for storage at -18°C. Fine dusts were extracted by adding two mL of phosphate buffered saline (pH 7.2) with 0.1% Tween 20 to 100 mg fine dust and shaken vigorously. Tubes were centrifuged and 1 mL of supernatant extract was removed for antigen analysis.

Measurement of house dust mite antigen **Der p I** *and cat antigen* **Fel d I**

Der p 1 and Fel d 1 in sieved dust extracts were measured in flat bottom microwell plates by enzyme-linked immunosorbant assays described by Luczynska et al. (1989) and de Blay et al. (1991), using commercially available test kits of monoclonal antibodies (Indoor Biotechnologies, Cardiff, UK). The colour reaction was read at 405 nm after five minutes development using a Bio-Rad 3550 microplate reader. The limit of detection of *Der p 1* was 0.06 µg/g and for *Fel d 1* was 6 µg/g.

Statistical analysis

Log transformed data were found to be normally distributed and differences between sample locations (bed, bedroom and living room) were assessed using repeated measures analysis of variance (ANOVA) and Tukey's Honestly Significant Difference test. Comparison of log transformed data from different geographical areas (metropolitan areas E and F) were made using Student's *t*-test. Comparisons between transformed data of asthmatic and non-asthmatic subjects and between data from summer and winter dust collections were made using Student's *t*-tests. Correlations between transformed data were performed using Pearson's *r*.

Results

Homes of 34 asthmatic and 37 non-asthmatic children were assessed. Of these, dust samples were not obtained from beds of two asthmatics and one non-asthmatic child. Figure 1 shows *Der p 1* levels for all children. For asthmatic children, geometric mean concentrations of *Der p 1* were highest in beds (8.30 µg/g) compared with bedroom floors (3.16 µg/g; $p<0.01$) and living room floors (1.62 µg/g; $p<0.001$). For non-asthmatics, bed and bedroom levels were not different (3.16 and 4.80 µg/g respectively; $p>0.05$), but these both exceeded living room levels (1.21 µg/g; $p<0.05$). Bed levels of asthmatics exceeded those of non-asthmatics ($p<0.05$), but there were no differences between asthmatics and non-asthmatics in either bedroom or living room levels ($p>0.05$). Table 2 shows that over 80% of asthmatic children were exposed to over 2 µg *Der p 1*/g dust in beds, and 40% were exposed to over 10 µg/g. Approximately 60% and 33% of non-asthmatics were exposed to these levels.

Table 2:* *Proportion of samples with* Der p 1 *exceeding 2 and 10 µg/g.

	> 2 µg/g	> 10 µg/g
Asthmatic		
Bed	27/32 (84.4%)	13/32 (40.6%)
Bedroom	22/34 (64.7%)	17/34 (50.0%)
Living room	20/34 (58.8 %)	6/34 (17.7%)
Non-asthmatic		
Bed	22/36 (61.1%)	12/36 (33.3%)
Bedroom	29/37 (78.4%)	17/37 (46.0%)
Living room	18/37 (48.7%)	7/37 (18.9%)

Cats were present in homes of 29% of asthmatics and 24% of non-asthmatics (27% overall), with up to four cats in a single household. Of homes with cats, 80% reported the a cat was permitted in the asthmatic child's bedroom, whereas 55% did so for non-asthmatics. *Fel d 1* data showed a similar pattern as for *Der p 1* (Figure 2), with geometric mean concentrations in beds of asthmatics (2600 µg/g) exceeding those of non-asthmatic (890 µg/g; $p<0.05$), and no differences seen between corresponding bedroom (1090 vs. 890 µg/g) or living room samples (1300 vs. 520 µg/g). For asthmatics,

Figure 1:* *Concentrations of house dust mite allergen* Der p 1 *in homes of asthmatic and non-asthmatic children

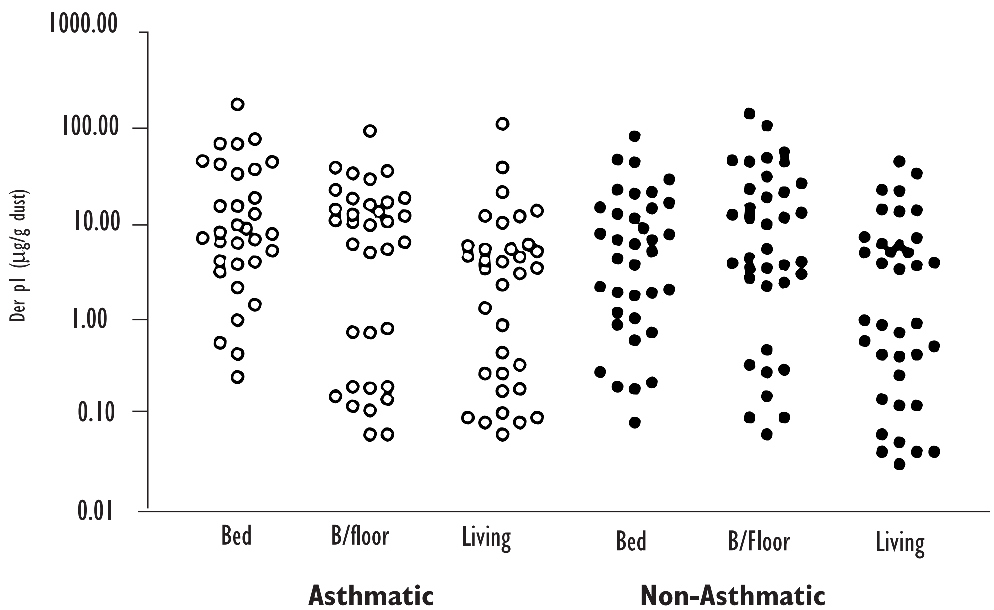
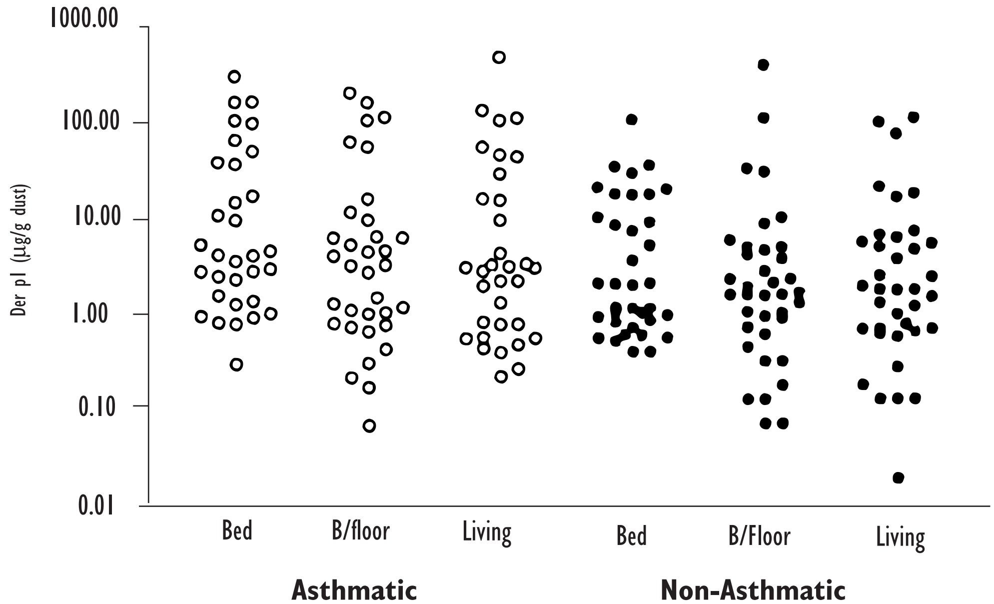


Figure 2: Concentrations of cat allergen* Fel d 1 *in homes of asthmatic and non-asthmatic children



bedroom *Fel d 1* was higher than both bedroom and living room, although these two locations did not differ from each other. For non-asthmatics, bed, bedroom and living room samples were not different (p>0.05). *Fel d 1* exceeded 1000 µg/g in over 50% of asthmatic's beds and exceeded 100,000 µg/g in almost 10%, but these frequencies were lower in non-asthmatics (Table 3).

Table 3: Proportion of samples with* Fel d 1 *exceeding 1000 and 100,000 µg/g.

	> 1,000 µg/g	> 100,000 µg/g
Asthmatic		
Bed	18/32 (56.2%)	3/32 (9.4%)
Bedroom	18/34 (52.9%)	2/34 (5.9%)
Living room	12/33 (36.4%)	1/34 (2.9%)
Non-asthmatic		
Bed	15/36 (41.7%)	0/36 (0.0%)
Bedroom	12/37 (32.4%)	1/37 (2.7%)
Living room	14/37 (37.8%)	0/37 (0.0%)

Der p 1 in bed correlated positively with that in bedroom (Pearson r=0.597; p<0.001) and living room (r=0.445; p<0.001), and bedroom correlated with living room (r=0.644; p<0.001). *Fel d 1* showed similar correlations between sampling locations. Within bedding, *Der p 1* correlated well with *Fel d 1* (r=0.276; p<0.05), but similar correlations were not seen between the two antigens in either bedroom or living room floor samples.

There were no differences between geographical areas seen between geometric mean levels of either *Der p 1* or *Fel d 1*. Areas of high SES and lower asthma (F) did not differ from the low SES/high asthma area (E).

Discussion

House dust mite allergen exposures found in this study are qualitatively consistent with those of other studies reported in Australia (Dharmage et al. 1999; Marks et al. 1995; Peat et al. 1993; Poulos et al. 1999; Tovey et al. 1981; Vanlaar et al. 2000), and confirm that levels of mite allergen in beds are higher than bedroom floors and these are higher than living rooms. However, our geometric mean data are somewhat lower than those reported from Sydney and NSW (Marks et al. 1995; Poulos et al. 1999; Tovey et al. 1992; Vanlaar et al. 2000), and Melbourne (Dharmage et al. 1999; Garrett et al. 1998), although the data ranges are similar. Such differences may reflect differences in climate, since arithmetic mean *Der p 1* in two areas of Western Australia were found to be approximately 4 µg/g in beds and approximately 4 to 9 µg/g (Colloff et al. 1991), and geometric mean levels at Moree, a dry part of inland NSW (7.2 µg/g in beds, 4 µg/g and 2.7 µg/g in bedroom and living room floors) (Peat et al. 1993) are closer to those found in Adelaide. Regional and climatic differences in house dust mite allergen have been reported in Australia (Peat et al. 1993), although differences have been more marked in international reports with greater extremes of climate (de Andrade et al. 1995; Ingram et al. 1995). For example, dust mite levels were highest (1.2 to 29.9 µg/g) under the continuously humid conditions of Casablanca, when compared with the very dry conditions (<65% RH) of Marrakech (allergen levels from <0.1 to 2.5 µg/g) (de Andrade et al. 1995). At Los Alamos, New Mexico, with low rainfall and at high altitude, only 4% of homes were found with over 2 µg/g of *Der p 1* and *Der f 1* combined (Ingram et al. 1995). It is likely that this current study and others (Marks et al. 1995) may have failed to demonstrate a seasonal variation in house dust mite allergens because seasonal conditions were not so marked.

It is significant that levels of mite allergen were higher in the beds of asthmatics than non-asthmatics, and that *Der p 1* was less than 2 µg/g dust in all sample locations in only 3/34 (8.8%) asthmatic's homes and 5/37 (13.5%) non-asthmatic's homes. Allergen levels exceeded 10 µg/g in at least one sample from 41/71 homes overall. These data suggest that house dust mite is a major allergenic risk in homes in Adelaide. Other studies have demonstrated the efficacy of simple interventions to reduce dust mite levels (Tovey et al. 1992; Vanlaar et al. 2000), and these should be more actively recommended in South Australia.

Cat allergen (*Fel d 1*) was found in all but one home, (yet only 19 of 71 homes had cats) with this the single sample of the total of 116 found below the risk estimate of 8 µg/g dust (Gelber et al. 1993). Eighty-nine samples (76.7%) exceeded 1,000 µg/g; a level likely to result in contamination of visitors and subsequent dispersal of cat allergen to homes without cats (Bollinger et al. 1996; Chew et al. 1998). As with *Der p 1*, cat allergen was highest in beds and particularly in the beds of asthmatics. De Blay et al. (1991), in a controlled environment study in the US showed that airborne *Fel d 1* increases rapidly when a cat is introduced to a room, and that carpet accumulates cat antigen about 100 times the rate of that of a polished floor (about 100 µg/day compared with 0.5 µg/day). Allergen aerosols are resuspended from reservoirs such as furnishings and carpets. Cat allergen is associated with small particles that settle slowly, so remain suspended and persist in the home environment (Findlay et al. 1983; Luczynska et al. 1990; Swanson et al. 1987; Van Metre, Marsh & Adkinson. 1986).

Correlation analysis showed that high levels of allergen in one location are associated with high levels at other locations, suggesting common domestic factors may predispose homes to contain high levels. Building factors, such as construction material and age (Dharmage et al. 1999), carpets and fittings (Marks et al. 1995; Sporik et al. 1998), or heating and cooking fuels (Marks et al. 1995) may cause or exacerbate conditions favouring allergen accumulation. The lack of significant correlations between cat and mite allergens in each location suggests that conditions favouring their accumulation are independent.

Areas of Adelaide identified previously as 'high' or 'low' asthma did not differ in respect of levels of either cat or mite allergen levels, although these areas were found to differ with respect to levels of nitrogen dioxide (Ciuk et al. in press). While nitrogen dioxide has also been investigated as a factor predisposing to the development of asthma, or as trigger for acute asthma attack, the interaction between environmental factors remains difficult to determine.

Conclusion

Levels of house dust mite and cat allergens found in homes in Metropolitan Adelaide exceed proposed levels of risk for allergy and asthma. Both allergens are found in reservoirs of bedding, soft furnishings and carpets so strategies to reduce asthma risk should be targeted at these sources. Only *Der p 1* was measured as an index of mite exposure, yet *D. pteronyssinus*, *Euroglyphus maynei* and *Tarsonemus* species have been recorded as dominant in Western Australian homes (Colloff et al. 1991). It is possible that the values reported in this study are underestimates of the total mite burden in Adelaide.

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Correspondence to:
John Edwards
Department of Environmental Health
School of Medicine
The Flinders University of South Australia
GPO Box 2100
Adelaide, South Australia, 5001
AUSTRALIA
Email john.edwards@flinders.edu.au

The Development of a Facet Job Satisfaction Scale for Environmental Health Officers in Australia

Ron E. Pickett[1], Peter P. Sevastos[2] and Colin W. Binns[1]

School of Public Health[1] and School of Psychology[2], Curtin University of Technology

Job satisfaction is an affective reaction to elements in the workplace and as one component of job-related attitudes it influences behaviour and mental health. The characteristics of these elements and the association between them are complex. This study describes the development of a measure on facet job satisfaction for Environmental Health Officers (EHO) in Australia (n = 761) and Scotland (n = 211). The Australian data set was subjected to an exploratory factor analysis, using Principal Axis Factoring with oblimin rotation, resulting in the identification of six factors with eigen values greater than 1. Initially, 27 items from a pool of 33 items were retained in the job satisfaction scales, as providing adequate description (i.e., loadings > 0.30) of their target construct. Constructs identified were "satisfaction with": status *(equity in relation to rewards and recognition for work),* workload *(number of hours worked),* worth *(the value of service provided),* harmony *(professional interaction with mentors and peers),* professional growth *(opportunities available for development), and* contribution *(opportunity to contribute to the community). Structural equations modelling using EQS further enhanced the measurement model, by identifying and retaining the best three indicators per construct (Bollen 1989). All retained items were good indicators of their target factors with loadings in excess of 0.40, while discriminant validity was demonstrated separately for each pair of constructs. To test for the generalisability of the measures, a multi-group analysis was carried out to test the invariance of the derived six-factor model across the Australian and Scottish samples. Invariance analysis was based on the six-factor baseline model, while first constraining the loadings for each construct invariant, and second, in addition to the loadings, the covariances among the constructs. Results confirmed the invariance of all model parameters as specified. Results are discussed in relation to future research in facet job satisfaction among EHOs.*

Key Words: *Environmental Health Officer, Job Satisfaction, Principal Axis Factoring, Structural Equations Modelling*

Locke (1976) defined job satisfaction as "a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences"(p. 1298). This definition, that has guided several decades of job satisfaction research (Organ & Near 1985), implies that feelings are the consequence of a cognitive appraisal of the working environment. More recently, job satisfaction was referred to by Robbins et al. (1998) as "an individual's general attitude towards their job" (p. 170). It is the view of these authors that, when "employee attitudes" are referred to "more often than not they mean job satisfaction – the two terms are frequently used interchangeably" (p. 170). Notwithstanding, these authors position job satisfaction in the context of two other job-related attitudes, namely "job involvement" and "organisational commitment". The appraisal of the external circumstances of work has been measured with such instruments as the Minnesota Satisfaction Questionnaire, or MSQ (Weiss et al. 1967), and the Brayfield and Rothe (1951), the Quinn and Staines (1979), and the Warr, Cook and Wall (1979) questionnaires (Warr 1991).

The above instruments are designed to capture general aspects of the work environment. Professional groups exhibit differences in the job-related factors that influence attitudes towards their work (Oleckno & Blaccionierre 1995; Wright, McGill & Collins 1990). Consequently, there is often a need to customise the general instruments in order to capture more specific information that characterises job satisfaction, for specific groups.

In 1994, the Department of Environmental Health at Curtin University commenced research to review job satisfaction for Environmental Health Officers (EHOs) throughout Australia and Scotland. The primary instrument for the research was a survey questionnaire mailed to all Institute members in both countries. The questionnaire was developed from a number of internationally recognised job satisfaction measures and following consultation and pilot testing within the profession, included additional aspects relevant to the Environmental Health Officers. A total of 35 positively worded questions (Cordery & Sevastos 1993) comprised the elements of the variable set. These included measures for global satisfaction (2) as "satisfaction with the job", and "satisfaction with the overall work environment", together with 33 questions relating to discrete elements of satisfaction. These variables represent evaluative judgements as responses to the question, "how satisfied are you with this element of your present job?". The ranking comprised a five-point numeric Likert rating scale with the extremes as "very dissatisfied" (1), "neither satisfied or dissatisfied" (3) and "very satisfied" (5). As the questions were not all occupation specific the limitations posed by very specific scales in relation to cross-occupational comparisons mentioned by Mueller and Mc Closkey (1990) were minimised. The response rate from the single mail-out was 42% for the Australian group and 30% for the Scottish group.

The first phase of the analysis disclosed that there was considerable correlation between the 33 discrete elements. Consequently, these elements were not independent (Pickett, Jackson & Phillips 1996) and data reduction and simplification by factor analysis was in order. The factor analysis process summarises the information contained in these variables to determine whether there are dimensions within job satisfaction, thereby improving explanatory parsimony. The "factorability" of the correlation matrix was established by evaluation against combined criteria from Coakes and Steed (1999) and Norusis (1997). The outcome confirmed that factor analysis was appropriate as, 40% of the correlations were significant (with the Pearson Coefficient 'r' > 0.3 and $p < 0.05$), the anti-image correlation matrix diagonals were greater than 0.05 (0.873 – 0.967), the Bartletts Test of Sphericity was significant ($p < 0.05$) and the Kaiser-Meyer Olkin Sampling Adequacy was greater than 0.6 (0.936).

An initial "exploratory factor analysis" as Principal Component Analysis (Afifi & Clark 1996, p. 331), with the original 33 variables and the Australian (and Scottish) satisfaction data sets identified one prominent factor (eigenvalue = 10.3, 31.6% of variance) and five additional factors (Scots eigenvalue = 11.03, 33.4% of variance and three additional factors). This outcome confirmed the works by Warr, Cook and Wall (1979), in that "the elements within job dimensions (clusters) are closely related suggesting that separate scores for each element was not always necessary" (p. 467). In Pickett, Jackson and Phillips (1996), the characteristics of job motivation, job satisfaction, the motivating potential score and the growth need for the EHOs, together with a job enhancement strategy for management is presented from the first phase of the research. Having demonstrated in 1996, that there was evidence of dimensionality within the construct, further exploratory and confirmatory factor analysis was warranted[1].

This paper outlines the rationale and the application of exploratory factor analysis, followed by confirmatory factor analysis with enhancement of the model using the structural equations modeling process, to define the characteristic profile of job satisfaction for EHOs in Australia. The model development does not introduce the complexity of mediation and does not install latent factors as dependant variables and as such is a "measurement model" representing a facet job satisfaction scale. The application of the model to the Scottish EHOs is introduced to illustrate the "generalisability" for the facet job satisfaction scale.

Method

Analyses

As a preliminary step for constructing an acceptable job satisfaction model, the 33 items representing the discrete elements were drawn from questionnaires and subjected to an exploratory factor analysis (EFA) using the Australian sample (n = 761). Principal axis analysis as an EFA procedure, examines only the common variance shared between variables. It is an appropriate method when the research is seeking to identify factors. The objective was to obtain a factor solution "that explains 50% to 75% of the variance in the original variables with one-quarter to one-third as many factors as there are variables" (Diekhoff 1992, p. 338).

A principal axis factoring procedure with oblimin rotation was used. The oblimin rotation does not assume independence for the factors. This analysis identified six reliable factors with eigenvalues > 1.0 that explained 54% of the variance. Constructs identified were "satisfaction with": *status* (equity in relation to rewards and recognition for work), *workload* (number of hours worked), *worth* (the value of service provided), *harmony* (professional interaction with mentors and peers), *professional growth* (opportunities available for development), and *contribution* (opportunity to contribute to the community).

Initially, 27 items from a pool of 33 items were retained in the job satisfaction scales as providing adequate description (i.e., loadings > 0.30) of their target construct. These 27 items identified in the EFA were then used to conduct a confirmatory factor analysis (CFA), and further refine the measurement model. Again the Australian sample was used for this process. A final set of 18 items was chosen for the final model (three per construct) to define job satisfaction, and this is consistent with the requirements of CFA. Bollen (1989) has suggested that a minimum of two indicators per construct is sufficient for defining a construct, while Bentler and Chou (1987) recommend three such indicators per construct.

The maximum likelihood (ML) method was used to estimate all models, and the covariance matrix for the 18 facet job satisfaction indicators was the input for all analyses. The variance of each of the six constructs was fixed at 1, while their covariances were calculated freely. To test the hypothesised models only random error was taken into consideration.

EQS version 5.7 was used to conduct confirmatory factor analyses to compare the fit of a model without structure (i.e., the null model), a single-factor model (i.e., all 18 items loaded onto one factor), and the six-factor model of facet job satisfaction. The EQS procedure is "by far the most user friendly of the programs" and "this is the program of choice when the data are non-normal" (Tabachnick & Fidell 1996, p. 767). The "robust" option in EQS maximum likelihood calculation reduces the sensitivity of the analysis to departure from multivariate normality.

Initially, the models were used to assess the factorial structure of the facet job satisfaction scale in the Australian sample. The best-fitting model was then compared for equivalence across the Australian and Scottish samples by testing for invariance using multisample analysis. Arbuckle (1997) describes multisample analysis as a "process of fitting a model to two sets of data at once" and "comparing the results from the two groups to see how equivalent they are by testing hypotheses about the two groups simultaneously" (p. 413).

Evidence of equivalence was based on tests of invariance of parameters in the two samples; that is, the estimation of parameters in the Scottish sample (n = 211) was constrained to be equal to the values of the unconstrained Australian sample. A series of "a chi-square difference test" (Bollen, 1989, p. 292) between two nested models was then performed.

Tests of invariance between two or more samples proceed in a hierarchical fashion, after establishing the best baseline model for each group separately (Byrne, Shavelson & Muthén 1989). Invariance is first sought between the baseline model, and a model that has item-factor loadings constrained in the replication sample(s). If the results of the comparison is not statistically significant (i.e., the constrained parameters are equal across groups), then a comparison between this model and one where the factor covariances are constrained, in addition, is performed (Bentler 1995). A non-statistically significant result between the two nested models may be taken as evidence that the model is invariant across samples.

Assessment of model fit

In order to deal with the multivariate non-normality of the two sets of data, the Satorra-Bentler scaled statistic (S-Bχ^2) in the EQS program was used (Bentler 1995). This program provides a "robust" chi-square statistic as well as robust standard errors. The S-Bχ^2 statistic has been shown to approximate more closely the usual test statistic and to perform as well as, or better than, the usual asymptotically distribution-free (ADF) methods, generally recommended for non-normal multivariate data, as noted by Chou, Bentler, and Satorra (1991). Both samples in this study had non-normal multivariate kurtosis, with Mardia's (1970) normalised estimate 16.027 and 11.551 respectively for the Australian and the Scottish samples.

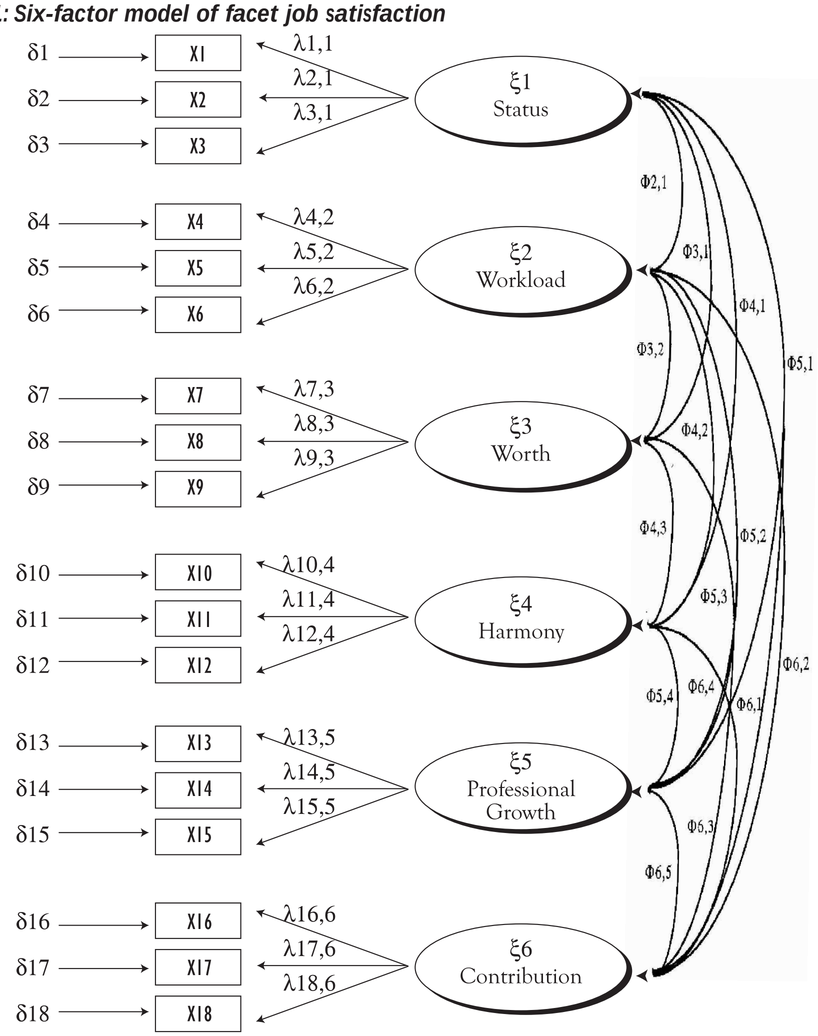
As reliance on the chi-square statistic alone for non-nested model evaluation is not recommended, because this statistic is dependent on sample size and likely to produce a significant result even in cases when there is a relatively good fit to the data (Bentler & Bonett 1980), EQS calculates several additional fit indices for the models. The following indices were used in this study: the Bentler and Bonett Nonnormed Fit Index (NNFI); the Comparative Fit Index (CFI) based on the Bentler-Bonett normed fit index, with an adjustment for degrees of freedom in the model; the robust Comparative Fit Index (robust CFI) that corrects for multivariate non-normality in the data; and the root mean square error of approximation (RMSEA). The NNFI and the CFI range from zero to 1.00 with values greater than 0.90 as an indication of acceptable fit (Marsh, Balla & Hau 1996). The RMSEA is relatively independent of sample size, and unlike other indices exhibits distributional properties that are known and, therefore, models may be tested on the basis of confidence intervals (CI). Point estimates of 0.05 or less indicate a good fit, while a value approaching 0.08 would represent reasonable errors of approximation (Steiger 1989). RMSEA values above 0.10 indicate poor fit. Point estimates, however, cannot capture the degree of imprecision in estimating this fit as MacCallum, Browne and Sugawara (1996) have observed. These researchers have presented a framework for evaluating model fit based on confidence intervals. When the entire CI of the RMSEA is below 0.05 the decision is made to reject the hypothesis of "not-close fit" but not of "close fit". By contrast, when the entire CI interval is above 0.05, the hypothesis of "close fit" is rejected but not that of the "not-close fit". When the CI "straddles" 0.05 the decision is more ambiguous. Both hypotheses of "close fit" and "not-close fit" cannot be rejected, that is both are plausible.

MacCallum, Browne and Sugawara, (1996), have provided calculations for power and determination of sample size when the null hypothesis is $\varepsilon \leq 0.05$, the alternative hypothesis is equal to 0.08, using an alpha level of 0.05, and a power of 0.80. In this study all model fit evaluations are based on the MacCallum, Browne and Sugawara (1996) framework, after demonstrating adequate power and sample size requirements.

Results

The Six-factor model of facet job satisfaction is presented in Figure 1. The means, standard deviations, reliability estimates, and intercorrelations for the three subscales for Samples 1 and 2 are presented in Table 1. Acceptable alpha reliabilities were obtained for four out of six constructs. Specifically, the constructs *status* and *professional growth* did not meet the 0.70 minimum acceptable threshold recommended (Nunnally 1976). The

Figure 1: Six-factor model of facet job satisfaction



intercorrelations among certain constructs were > 0.80, suggesting unidimensionality. This possibility was tested through a test of discriminant validity, reported later in the paper.

Statistically significant differences were found only in one of the six job satisfaction sub-scales between the Australian and Scottish samples, with the later group reporting higher mean values on satisfaction with *workload* (t = -3.582, df = 1031, $p < .001$).

Table 2 shows the convergent validities for the eighteen facet job satisfaction indicators. All t-ratios for the loadings in both samples were statistically significant, indicating that all items in the model were significantly related to their target constructs.

Because the intercorrelations among some constructs were high, as reported earlier and shown in Table 1, tests of discriminant validity were necessary. These tests were performed between each pair of constructs at a time (Anderson & Gerbing 1988), and they were based on a chi-square difference test (with one degree of freedom) comparing a nested model, where the covariance between a pair of constructs was fixed at one, with a model where the covariance was set free.

In all instances the difference between nested models for all pairs of constructs was statistically significant ($p < .05$), indicating discriminability among the job satisfaction facets. Difference chi-square tests with 1 degree of freedom, when the covariance was fixed at 1 (arguing for the unidimensionality of the constructs), ranged from 43.001 to 663.618.

Table 1: Means, Standard Deviations, Alpha Reliabilities, and Intercorrelations among Facet Satisfaction for the Australian (Sample 1) and Scottish (Sample 2) Samples

	Mean	SD	1	2	3	4	5	6
Sample 1 (n = 761)								
1. Status	3.018	0.827	0.635					
2. Workload	3.569	0.853	.508	0.788				
3. Worth	3.222	0.852	.787	.407	0.698			
4. Harmony	3.515	0.910	.675	.326	.685	0.763		
5. Professional Growth	2.974	0.833	.800	.493	.668	.633	0.626	
6. Contribution	3.499	0.913	.821	.272	.780	.656	.706	0.793
Sample 2 (n = 211)								
1. Status	3.039	0.781	0.624					
2. Workload	3.806	0.686	.352	0.748				
3. Worth	3.257	0.794	.754	.205	0.700			
4. Harmony	3.401	0.870	.822	.212	.691	0.738		
5. Professional Growth	2.973	0.718	.925	.362	.765	.871	0.550	
6. Contribution	3.434	0.911	.849	.127	.772	.714	.781	0.825

Note: Alpha reliabilities appear in the diagonal.

Tables 3 and 4 show the relevant fit indices for the null, the single, and the six factor models. As shown in Table 3, of the single factor and six factor models, the six-factor model was able to provide the most adequate fit to the data for the validation sample. In particular, in comparison to the six-factor model, the lower scores on the NNFI = 0.717, CFI = 0.751, RCFI = 0.753, as well as the point estimate of 0.109 for the RMSEA, with an unacceptable 90% confidence interval that ranges from 0.103 to 0.114, indicates that the single factor model does not fit the data well. By contrast, the point estimates on the NNFI = 0.935, CFI = 0.949, RCFI = 0.950, and the RMSEA with a 90% confidence interval

Table 2: Convergent Validity of Satisfaction Scales for the Australian Sample (n = 761) and the Scottish Sample (n = 211) Showing Standardized Factor Loadings

Items	F1	F2	F3	F4	F5	F6
V1 (Equity)	.736 (.669)					
V2 (Contin. Edn)	.624 (.632)					
V3 (Non-wages)	.486 (.496)					
V4 (Hours)		.814 (.852)				
V5 (Work v Outside)		.767 (.653)				
V6 (Control)		.675 (.725)				
V7 (Whole piece work)			.720 (.714)			
V8 (Feedback)			.693 (.636)			
V9 (Productivity)			.564 (.669)			
V10 (Prof. Interaction)				.832 (.809)		
V11 (Prof. Supervision)				.768 (.760)		
V12 (Harmony)				.591 (.473)		
V13 (Prof. Development)					.726 (.693)	
V14 (Security)					.547 (.470)	
V15 (Other Employment)					.520 (.522)	
V16 (Challenge)						.795 (.790)
V17 (Administration)						.785 (.775)
V18 (Accomplishment)						.680 (.774)

Note. Coefficients in brackets are from the Scottish Sample. Item labels correspond to survey questions

that straddles 0.05, give an indication that the six-factor model provides a reasonable fit to the data (MacCallum, Browne & Sugawara 1996).

Table 4 shows that in the single sample analysis, conducted in order to determine the best-fitting model for the Scottish sample, the six-factor model achieved the most reasonable fit to the data. All point estimates are above the minimum recommended values (NNFI = 0.908, CFI = 0.928, RCFI = 0.945, RMSEA = 0.062), while the confidence interval for the RMSEA straddles the point estimate of this index.

Power analysis and required sample size to test the RMSEA hypothesis of acceptable model fit was carried out for both samples. The minimum required sample size was

Table 3: Fit Indices for the Best Fitting Model for the Australian Sample (n = 761)

Model	χ^2	df	S-Bχ^2	NNFI	CFI	RCFI	RMSEA (90% CI)
Null Model	5014.517	153	--		--	--	--
One-Factor Model	1347.579	135	1180.838	0.717	0.751	0.753	0.109 (0.103 - 0.114)
Six-Factor Model	369.445	120	332.373	0.935	0.949	0.950	0.052 (0.046 - 0.058)

Notes: S-Bχ^2 = Satorra-Bentler Scaled Statistic, NNFI = Nonnormed Fit Index,
CFI = Comparative Fit Index, RCFI = Robust Comparative Fit Index,
RMSEA = Root Mean Square Error of Approximation, CI = Confidence Interval.
Minimum sample size required to test the RMSEA hypothesis = 117.
Power achieved for testing the RMSEA hypothesis for the Australian Sample = 1.

Table 4: Fit Indices for Three Competing Models for the Scottish Sample (n = 211)

Model	χ^2	df	S-Bχ^2	NNFI	CFI	RCFI	RMSEA (90% CI)
Null Model	1501.776	153					
One-Factor Model	476.018	135	392.100	0.713	0.747	0.785	0.110 (0.099 - 0.120)
Six-Factor Model	217.641	120	186.329	0.908	0.928	0.945	0.062 (0.049 - 0.075)

Notes: S-Bχ^2 = Satorra-Bentler Scaled Statistic, NNFI = Nonnormed Fit Index,
CFI = Comparative Fit Index, RCFI = Robust Comparative Fit Index,
RMSEA = Root Mean Square Error of Approximation, CI = Confidence Interval.
Minimum sample size required to test the RMSEA hypothesis = 117.
Power achieved for testing the RMSEA hypothesis for the Scottish Sample = 0.984.

calculated at N = 117, well below the actual size of both samples. Power requirements were also exceeded for both samples (1.00 and 0.984 respectively for the Australian and Scottish samples).

Invariance of the Facet Job Satisfaction Model across the two samples

To test whether the six-factor job satisfaction model was equivalent across the two samples, a multisample analysis was conducted. The order of constraints in evaluating equivalence across groups is an issue of some disagreement amongst researchers. Relevant to the six-factor model of job satisfaction tested in this study, Bollen (1989) recommends a testing hierarchy from a baseline model that includes in addition factor loading (lambda-x), error variances (theta-delta) and factor covariances (phi). However, Bentler (1995) suggests that the equality of error variances is least important, and Byrne (1994) argues that testing the equality of error parameters "represents an overly restrictive test of the data" (p. 161). It is, therefore, acceptable in testing across samples for invariance to report constraining only the factor loadings and factor covariances as a test of a model. In line with such recommendations, and the theoretical importance of the factor loadings and factor covariances in this study, the sets of parameters representing these parameters were constrained in testing the invariance of the six-factor job satisfaction model.

The majority of fit indices calculated for the single sample analysis were calculated by EQS in the multisample analysis. However, EQS 5.7 does not provide "robust" statistics for multisample techniques. For this reason the robust CFI and the S-Bχ^2 could not be reported. It should be noted, however, that the reported χ^2 values are likely to be substantially more inflated than those that the S-Bχ^2 statistic would have provided.

Table 5 shows the χ^2 difference tests with the associated degrees of freedom for nested models based on the multi-sample analysis. After imposing all constraints for the

Table 5: Invariance Analysis

Model	χ^2	df	$\Delta\chi^2$	Δdf	NNFI	CFI	RMSEA (90% CI)
Baseline Model	587.087	240	--	--	0.929	0.944	0.039 (0.035 - 0.043)
Loadings Invariant	610.999	258	23.912^{ns}	18	0.933	0.943	0.038 (0.034 - 0.041)
Loadings + Factor Covariances Invariant	630.586	273	19.587^{ns}	15	0.935	0.942	0.037 (0.033 - 0.040)

Notes: ns = $p > 0.05$; NNFI = Nonnormed Fit Index, CFI = Comparative Fit Index,
RMSEA = Root Mean Square Error of Approximation, CI = Confidence Interval.

invariance of loadings across groups, the χ^2 increment from the baseline model was not statistically significant ($\Delta\chi^2 = 23.912$, 18 df, $p > .05$). Holding the loadings cross groups invariant, and constraining the factor covariances to be equal in addition, did not result in a statistically significant difference between nested models ($\Delta\chi^2 = 19.587$, 15 df $p > .05$). For this final model the confidence interval for the RMSEA indicates that the model fits the data rather well. These results may be taken, therefore, as evidence that the six-factor job satisfaction model achieves invariance across the two samples.

Discussion

This paper has reported a multi-dimensional construct of job satisfaction for Environmental Health Officers. Specifically, we have developed measures for the assessment of six constructs of facet job satisfaction, by following a robust procedure of validation and cross-validation. In the validation procedure we have used a large Australian sample to refine the six-factor model of job satisfaction, by selecting the strongest indicators from a pool of items tapping into each target factor. For the cross-validation procedure we have used a Scottish sample and we have adopted the same model, and invariant loadings and factor covariances as the Australian model. The results of our analysis confirm the generalisability of the model to other populations. Researchers using the measures developed in this study ought to be confident that the meaning underlying each construct is the same across different groups.

Although the measures are valid and they show acceptable levels of alpha reliability, the items defining two constructs need to be reviewed in future studies as these dimensions are not adequately captured by the items loading on them. Two likely directions for further enquiry to improve the internal consistency include exploration of additional manifest variables for each of these dimensions. For example, within 'status' the variables 'perception of status within the organisation' and 'wages' load higher than 0.4 (0.700 and 0.590 respectively) in the original 27 element model. The second likely direction is the mediating effect of predictor demographic or biographical variables, for example "title" on the dimensions. The possibility that "title" influences satisfaction with the dimensions "status" and "professional growth" is consistent with the results of earlier aspects of this research (Pickett, Jackson & Phillips 1996). From this earlier paper, there is a significant association between the global measures of "overall satisfaction" and "title" ($\chi^2 = 109.6$, df = 4, $p < 0.001$), with the mean for the 'overall satisfaction' of the "directors" and "principals" as 3.2 and for the EHO is 2.8 on the 5-point scale.

The multi-sample analysis using the Australian and the Scottish samples as the two groups has produced a robust finding with invariance, thereby supporting the "generalisability" of the model. There is high correlation (> 0.8) between a number of the factors in the model (Tables 1 and 2 refer). Discriminant analysis determined that this was not identifying unidimensionality. This finding indicates that a second level higher order factor may be subsuming two or more of the factors from the model.

Conclusion

It has been demonstrated that the discrete elements that influence job satisfaction for the EHOs are not independent. Exploratory and confirmatory factor analysis of these elements has identified dimensions that summarise the main characteristics of the profile of job satisfaction for these practitioners. This initial measurement model was enhanced using structural equations modelling. The outcome was a measurement model as a facet job satisfaction scale that adequately defines these dimensions for EHOs in Australia.

The discriminant validity analysis has shown that although there is intercorrelation between the factors there is significant discrimination achieved by each factor and therefore the scale of the model "measures what it is intended to measure". The "reproducibility" and therefore the "reliability" of the model has been demonstrated with invariance shown following multisample analysis between groups from the Australian data set. The model has been successfully applied to data derived from identical questions to EHOs in Scotland, thereby suggesting that the model has general application.

This phase of the research has established the main dimensions of job satisfaction for EHOs. This outcome provides valuable information for the practitioners, the professional organisation and the managers of environmental health services. It is also significant that this research has also identified evidence of shared variance between the factors of the model. Therefore, in addition to factors that may display unique variance, important information may be lost if this shared variance is not taken into account. Canonical correlation and multivariate analysis of variance provide the opportunity to identify the relationship between the dimensions and the contribution of each dimension of the model, to the multivariate main effects when demographic and biographical influences (and interactions) on job satisfaction are being examined.

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Endnote

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Correspondence to:
Ron E. Pickett
Department of Environmental Health
School of Public Health
Curtin University of Technology
GPO Box U 1987
Perth, Western Australia, 6845
AUSTRALIA
Email rpickett@health.curtin.edu.au

Environmental Health Action in Indigenous Communities

Peter Stephenson

Indigenous Communities Environmental Health Program, University of Western Sydney

This paper explores the ways in which a mismatch between research purpose and local outcomes can significantly undermine the credibility of Indigenous health staff within their communities. The paper presents research findings and a case study that highlight the conflicting nature of the relationships and responsibilities that Indigenous environmental health practitioners have to their communities and to their health agency employers. This is particularly so with respect to research being conducted on environmental health conditions in communities. It follows earlier calls by Indigenous people for research conducted in, for and with their communities that goes beyond problem identification. The conclusion leads to a strong advocacy for new research norms with designs and protocols that work to support, rather than to undermine, the work of local Indigenous practitioners in community environmental health practice.

Key Words: *Indigenous Communities, Environmental Health, Action-Research, Social Change*

The research strand of the first professional program supporting Indigenous Environmental Health Officers in the field is currently generating more questions than answers. On one hand, there is a vast amount of data on the level of health (or, more properly, ill health) in rural and remote Indigenous communities. On the other hand, there is ample evidence to support the claim that still today, much of the research being undertaken in Indigenous communities is heavily weighted toward problem identification and not continuing to problem solution. Even less frequently do research findings prove either immediately available or beneficial to the local Indigenous health practitioners who collected the data, let alone the communities from which the data were taken.

This critique of the gap between professional practice and research addressing Indigenous health issues is not new. Since at least the 1970s, for example, it has been obligatory for any paper discussing Indigenous health to begin with statistics that reveal the severely negative relationships between all quality of life indicators for Aboriginal and Torres Strait Islanders and non-Indigenous Australians (from Borrie, Smith & Di Julio 1975 through to McLennan & Madden 1997). Whether it is a publication on the effectiveness of clinical screening programs (Mak & Straton, 1997); or drug and alcohol abuse (Gray et al. 1997); or lifestyle diseases like diabetes and hypertension (Reid & Trompf 1994; Saggers & Gray 1991), the figures clearly highlight the severe nature of this health disparity and the absence of any significant improvement. The combined data clearly define one of the greatest public health challenges facing Australia today as building healthy Aboriginal and Torres Strait Islander communities (Golds et al. 1997).

For more than 20 years there has also been research in rural and remote Aboriginal communities that demonstrates the importance of managing the physical environment in the protection of health and wellbeing (Gracey 1987; Hearn, Henderson & Houston 1993; House of Representatives Standing Committee on Aboriginal Affairs 1979; Munoz 1990; Scrimgeour 1989; Winch 1993). Despite this there remains ample evidence to show that poor environmental health conditions continue to exist in Indigenous communities (Environmental Health Needs Coordinating Committee 1998; Gracey, Williams & Houston 1997; Western Australia Health Department 1995) and that the health impact of such conditions on Australia's Indigenous populations is significant (Australian Bureau of Statistics & Australian Institute of Health and Welfare 1997; enHealth Council 1999; Stanley 1984).

It could therefore be argued that the provision of an effective, efficient and dedicated Indigenous environmental health service for Indigenous communities in Australia presents one of the single biggest workforce challenges for public health in this country. This might seem to be simply stating the obvious. However, creating and effecting such a service is far from a reality despite the best efforts of many in the communities, in local and state governments, and at the federal level.

Bridging the Gaps

Re-focusing the research emphasis toward the implementation of services and outcomes in the field could at least commence to bridge the gap. Initiatives generated over the past decade provide a foundation on which this type of collaborative research could be based. Significant interest has been generated in capacity building initiatives and support programs for Indigenous environmental health practitioners. These include:

- establishment of a third community-based training course in Australia through Cairns TAFE in 1996;
- upgrading of existing courses for Aboriginal Environmental Health Workers in Western Australia (Pundulmurra College in 1998) and the Northern Territory (Batchelor Institute in 1999);
- establishment in 1997 of an education and professional support program for Aboriginal and Torres Strait Islander students undertaking degree studies in environmental health through University of Western Sydney (Stephenson 1999);
- inclusion of Indigenous environmental health issues and programs in the National Environmental Health Strategy (enHealth Council, 1999) and Implementation Plan (enHealth Council 2000);
- development of an Indigenous Environmental Health Policy by the Queensland State Government Health Department (2000); and
- creation of Indigenous Environmental Health Special Interest Groups in National and State Divisions of the Australian Institute of Environmental Health (1999/2000).

Further, at regional, state and national levels, Indigenous practitioners have combined with other environmental health professionals and government decision makers in forums such as the annual Environmental Health Worker Seminars in Western Australia; a National Environmental Health Strategy Workshop in Alice Springs in 1997 (Brown, Stephenson & Mitchell 1997); National Practitioner Workshops in Cairns in 1998 (National Environmental Health Forum 1998), Broome in 1999 (enHealth Council 2000) and Alice Springs in 2000; and at regular Environmental Health Worker Workshops in the Torres Strait and North Peninsula Area of Far North Queensland. These forums have prioritised the needs of an environmental health workforce for Indigenous communities as follows:

- appropriate legislative powers, salaries, equipment, and career paths other than the Community

Development Employment Program (work-for-the-dole) for Indigenous Environmental Health Workers, for example, "Nurses at least have bandages; we don't even have spanners" (Remote Area Community Environmental Health Worker 1997);

- nationally consistent competencies for culturally-appropriate Environmental Health Worker training and development of articulation routes for upgrading to full professional status;

- adequate resources and professional support so that the emerging Indigenous workforce is able to implement the relevant recommendations of the National Environmental Health Strategy;

- development of National Environmental Health Standards and Guidelines for the Provision of Services to and by Aboriginal and Torres Strait Islander communities, and mentoring available to supervise the services;

- incorporation of "fixing funds and equipment" into budgets for environmental health and housing needs surveys, so the visits can supply direct help as well as take away information;

- access for remote communities to urban taken-for-granted technical solutions to food storage, preparation, cooking, temperature control, lighting, water harvesting, storage and re-use, water treatment; and

- development of rigorous inspection and certification procedures for all building works in communities undertaken by outside consultants as there is continual evidence of infrastructure malfunctioning even before construction teams leave, for example, Pholeros (1999) reports that 70% of failure of safety and health services within housing is due to poor initial construction.

The Indigenous environmental health workforce has also pressed for mechanisms for their representation within government and the profession, so that the needs and concerns of community practitioners are directly incorporated into decision making.

Acting on a recommendation of the 1999 National Indigenous Environmental Health Workshop, the Commonwealth government established a National Indigenous Environmental Health Forum to provide direct advice to the newly established national enHealth Council. Members of this forum have a vital role to play in the future of Indigenous environmental health policy, program planning, implementation and review. They, and their colleagues in the field, will need scientifically sound, culturally appropriate and locally effective research findings on which to base their work. This in turn requires Indigenous practitioners familiar with action-oriented research approaches in order to build on the previous problem identification research.

Limitations of a Problem Identification Approach

As with Aboriginal public health research before it, Aboriginal environmental health research has for the last decade been heavily weighted toward statistical treatment of data and issues identification (Gracey, Williams & Houston 1997; National Aboriginal Housing Strategy Working Party 1989). This work is valid, given that both governments and the public desire a clear and accurate account of the problems in communities before supporting the expenditure of special program funds. For example, in the 1995 Western Australian Aboriginal Environmental Health Survey, data were generated from a statewide survey of environmental health conditions in Aboriginal communities. The detailed and widely published findings (see Gracey, Williams & Houston 1997; Western Australia Health Department 1995) produced empirical data on the status of environmental health conditions on 155 rural and remote Aboriginal communities in Western Australia. These data revealed that:

- on-going design and maintenance problems prohibit the effective functioning of water supply and sanitation systems in just over one third of Western Australian communities;
- a staggering 70% of the total survey sample had significant or serious, and sometimes multiple, problems with various aspects of their housing;
- rubbish was not collected at all in over one third of communities and, in others, the methods of disposal were often inadequate;
- pests were problems in 44% of communities and the hygiene and maintenance of communal toilets were unacceptable in 25% of cases; and
- on-site environmental health workers could not be identified in 72% of communities surveyed and external environmental health worker support services were unavailable to 52% of communities.

These survey findings eventually produced action in some communities with the Western Australia Office of Aboriginal Health initiating a four-tier response. Responses included funding for the establishment of an Environmental Health Worker Training Program; 46 additional community-based worker positions; three million dollars being allocated to immediate capital works on sewerage systems in five priority communities; and a further 15 communities being identified for minor rectification works (Gracey, Williams & Houston 1997).

But while the data were used successfully to initiate project work in some 20 communities, the statistical results neither provided any clear directions for that project work; nor did they bring improvement to the more than 200 other communities given a lower priority. History tells us that the greater the lapse in time between the completion of a needs survey and the remedial work starting, the greater the likelihood that governments will defer funding decisions because of concerns for acting on outdated or inaccurate data. The sequence of surveys in the Western Australian case confirms that a regular bureaucratic response to this issue is to propose yet another survey. Indeed, the orchestrators of the most recent Western Australian survey, "The 1997 Environmental Health Needs Survey of Aboriginal Communities in Western Australia" (1998) themselves make this point.

The latest survey, conducted during the second half of 1997, collected data on environmental health conditions in 259 discrete Aboriginal communities. In the ‘Foreword’ to the survey report the Chair of the Environmental Health Needs Coordinating Committee (EHNCC) acknowledged that "positive consequences from the survey will not be immediately noticeable at the community level" (EHNCC 1998, p. 3). Yet the document still praises the survey for the administrative and bureaucratic efficiencies it brought to the task of data collection especially since a number of government departments share an interest in the same information. The Report is promoted as an "information pack" for decision makers, and one that can "assist them make justifiable and rational decisions about funding allocations for environmental health infrastructure in Aboriginal communities" (EHNCC 1998, p. 3). In this way the Report stops short of either recommending or generating immediate responses, and hands the responsibility for the management of findings over to agencies a step away from the communities.

The Western Australian Health Department's Office of Aboriginal Health (OAH), as one of the six members of the EHNCC, has taken up this challenge by producing an Action Plan (OAH 1998) aimed at addressing some of the survey findings. In this way the Office of Aboriginal Health has used the Report as leverage to initiate action in support of the Aboriginal Environmental Health Worker fraternity and bring about change and improvement where it is most needed – in the communities. Time will tell whether other agencies, which were interested enough in environmental health conditions in Aboriginal communities to support the survey design and administration, are equally as committed to supporting remedial action in the places where the data were collected.

Despite delivering a significant amount of detail on environmental health conditions in Western Australian Aboriginal communities and much needed confirmation in higher quarters, the findings of the 1997 survey were of no surprise to those whose everyday practice centres around environmental health work at the community level. Where an Environmental Health Worker is in place in the community, recognition of the extent of the problem neither ensures any improvement, nor does it assist them to do their work. As indicated above, this is particularly problematic for practitioners in communities that fall below the cut-off line for immediate financial assistance. These communities still require important improvement programs in a range of areas and must turn to their resident Environmental Health Worker or the regional coordinating office for advice and assistance.

Lack of continuity between "research into problem" and "research into practice" has led to pressure being exerted by communities on Environmental Health Workers administering the Western Australian needs survey. Their credibility has come into question when communities see them as the "face" of the survey and therefore as the person or people responsible for bringing about change and improvement. The more extensive the survey, the greater the expectations the residents placed on the local Environmental Health Workers and the Regional Coordinators for some positive and practical outcomes (Stephenson 1997-99).

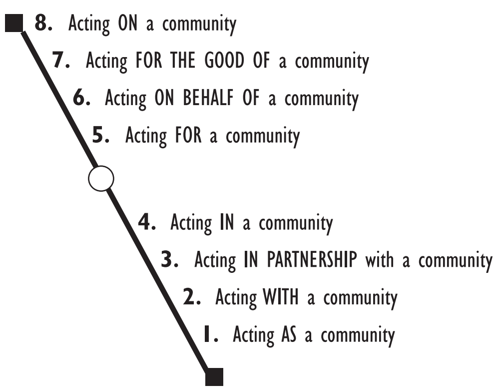
Beyond Problem Identification

Work with the first cohort of Indigenous undergraduate students remaining in their communities while undertaking a distance professional Environmental Health degree highlights this problem–practice gap. The efforts reported above have succeeded in establishing an expanding Environmental Health Worker workforce in Indigenous communities in most states and territories. It has also brought together a non-Indigenous professional workforce across Australia more attuned to the needs and issues of Indigenous practitioners and their communities, and national bodies interested in research, policy development and project funding in this field. Given these existing resources and the past documentation of the issues, the next logical step is collaboration in action-based research within the community context.

The project briefly described here is seeking to shift research objectives to support locally based improvement projects and change-evaluation studies. The research framework places at its centre Indigenous people in communities, their resident Environmental Health Workers and Regional Coordinators. In Figure 1, the range of possible researcher-researched relationships is presented as a continuum. The traditional roles are the outside researcher acting for the good of the community (position 7, and, it is hoped, not 8), while the local informants are in position 1, that is to say their community and cultural identity is indistinguishable from their work-based communications and actions in the community. Funding agencies and policy units are most likely to take up positions 6 and 7. These positions represent typical stakeholder roles for development and research programs connected to Indigenous communities.

In the research described here, the role of the outside researcher incorporates both No. 3 and No. 7 positions, that is, working in a partnership with the community and at the same time hoping that it is for their benefit. The co-researcher from the research community is acting at position No.1, where she or he lives and works as an integral part of the community and also in position No. 5, acting for his or her community, outside his or her expected community role. In most Aboriginal communities this is also outside the shared ethic of community consensus.

Figure 1. Community Action Scale: From Insiders to Outsiders



Source: Brown 1996

Such a clarification of roles could appear to be a simplistic analysis, if it were not that it can assist in overcoming the very barriers to action research identified in the forums described above. These barriers are:

- poorly defined roles of government and non-government sectors in the policy and practice of environmental health;
- use of culturally inappropriate environmental health indicators, standards, impact assessments and infrastructure;
- lack of participation and power for community leaders in policy development at the local, regional, state and national scale; and
- limited opportunities for education and training of the Indigenous members of the research team, with few prospects and support for career development (Brown, Stephenson & Mitchell 1997).

An example of where these barriers are being addressed through co-researcher roles is the work being done within the Anangu Pijantjatjara Lands of the far north west of South Australia. There, Nganampa Health Council has promoted an action orientation to "health hardware" research for over a decade (Nganampa Health Council 1987). Environmental health work is performed with the philosophy of "fix as you find" (Rainow 1998). Data are collected at a community level and through a continuous process, but unlike other data gathering exercises, the simple objective of this work is to repair acute or safety-related housing problems as they are identified. From their reports it can be observed that, when approached this way, the research process:

- results in immediate and potentially life saving repair work being done before the survey team leaves the community;
- generates a log of the environmental health problems that arise;
- improves understanding of the frequency of particular problems and areas that require particular vigilance in monitoring or maintenance;
- facilitates budgeting for regular

maintenance which, if left unattended, could result in more serious, resource demanding and expensive improvement procedures being necessary; and

- provides detailed data for program evaluation, including the nature of the problem, the response and the costs associated with improvement.

But while Nganampa Health's approach to research, surveys and evaluation programs has worked well in the Anangu Pijantjatjara Lands, Miller and Rainow (1997) acknowledge that their programs may neither be directly transferable to other Aboriginal communities around the country, nor is it the only model of collaboration between co-researchers. What works in the far north west of South Australia will not necessarily do so in Far North Queensland or Islands in the Torres Strait, or in communities in Western Australia and the Northern Territory.

With the successes of the Nganampa Health Council and the related Housing for Health Project (Pholeros, Rainow & Torzillo 1993) in mind and an awareness of the over-emphasis on researching problems, not solutions, the present research within the Environmental Health Program at University of Western Sydney[1] engages its Indigenous students in action-oriented research partnerships. It assists field based Aboriginal and Torres Strait Islander students and communities to undertake and review locally developed improvement initiatives. It enables communities to have command over the design, implementation and sustainability of projects and to have a say about what is important in the results. The following short case study illustrates such a research approach and its findings.

A Remote Area Environmental Health Service

This case study relates to an environmental health resource unit developed specifically to deliver support services to Indigenous communities and to provide training to community-based Environmental Health Workers across a remote part of mainland Australia. The resource unit is self-sufficient for equipment and staff, is headed by an experienced Environmental Health Worker and community leader with three full-time staff, and operates from its own light industrial premises.

A collaborative research program was designed to assist the co-researchers (a team of Indigenous environmental health practitioners) develop a stronger practical understanding of the nature of the challenges confronting them in their workplace and in their practice. The research is ongoing. Over the past two years the work has developed a history of the processes and events within the establishment of the first Indigenous-staffed environmental health service and seeks to provide:

- documentation of challenges in establishing Indigenous environmental health services for Indigenous communities, and of the successes and difficulties in overcoming those challenges;

- ongoing information on events and outcomes for the staff and sponsors of the unit in order to improve performance and identify future needs;

- a case study of the establishment of an Indigenous environmental health resource unit that can be useful for other areas seeking to establish such a service; and

- identification of future training and resource needs in the area of Indigenous environmental health.

The research shed some light on the implications of the interactions between the various positions along the Community Action Scale (Figure 1). The regional health agency supporting this remote service saw the role of the unit leader, and the conduct of his team, as acting more on behalf of the communities in the region – that is, at Position No. 6 on the Insider/Outsider Scale. Understanding that these different perceptions exist is important for managers of Indigenous environmental health staff and programs. After all, when Indigenous practitioners are required by management to "Act ON a Community", as they were in the 1995 and 1997 Western Australia Aboriginal Environmental Health Needs Surveys, it is clear that the practitioners' respect and credibility at the community level is under threat. Indigenous workers run the risk of being branded an outsider by the community; a position from which it may be extremely difficult to recover. But even when a better understanding of this dilemma has been generated among all the parties, there are still serious blocks to overcome.

As the Indigenous services in this study achieved public health recognition, expanded resources and community acceptance, new and unexpected role conflicts arose. The increased scope, acclaimed as a great success brought the need for administration, accounting and team leadership. These are all accommodated comfortably in an "outsider" model of a community service, but almost impossible to contain within traditional community relationships and obligations.

Without going further into the detailed results of the study, even this degree of analysis is of significance to managers of Indigenous practitioners who live or practice in, or have strong familial ties with Aboriginal and Torres Strait Islander communities. It helps us to understand how the position of Aboriginal and Torres Strait Islander practitioners in community settings can be compromised by the needs and demands of mainstream government agencies.

Conclusion

This paper has argued that for environmental health services for Indigenous communities to be effective and efficient in the estimation of outsiders or insiders, they need to be supported by research approaches that go beyond simply defining the extent of the problem. It advocates for a shift in research objectives to support Indigenous practitioners to engage in locally-based improvement projects and change-evaluation studies; projects that place the problems and practice of community Environmental Health Workers and Regional Coordinators at the centre of the inquiry. The paper identifies a host of material generated over the past decade on which this type of collaborative research could be effectively based.

Through one example taken from earlier field based research, three important issues for environmental health managers of Indigenous practitioners engaged in research activities in communities are highlighted. First, that the issue of "Insider" and "Outsider" to community is not only one for the non-Indigenous researcher to consider, it is also of very real concern to those being researched; that is, the Aboriginal and Torres Strait Islander environmental health practitioners themselves. Second, the case study highlights how Indigenous environmental health practitioners who have "Insider" status in the community have different professional relationships with community members than those of other environmental health professionals. It is hoped that this paper helps to increase awareness among agency and research managers about the conflicting relationships and responsibilities Indigenous environmental health practitioners experience across their community and government roles. Finally, the work here indicates that co-opting community-based practitioners into non-community roles, without supporting them with appropriate levels and forms of professional development, may in fact impede the application of research findings and therefore is counterproductive to bringing about environmental health improvement in community settings.

Endnote

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Correspondence to:
Peter Stephenson
School of Environment and Agriculture
University of Western Sydney, Hawkesbury Campus
Locked Bag 1797
Penrith South DC, NSW, 1797
AUSTRALIA
Email p.stephenson@uws.edu.au

An Overview of the Potential for Removal of Cyanobacterial Hepatotoxin from Drinking Water by Riverbank Filtration

M. J. Miller[1], J. Hutson[2], and H. J. Fallowfield[1]

Department of Environmental Health[1] and Department of Earth Sciences[2], The Flinders University of South Australia

Cyanobacterial hepatotoxins may pose a threat to public health when present in drinking water supplies. Traditional toxin removal techniques are not appropriate for remote Australian communities or developing nations. Bank filtration is potentially a low cost, low maintenance treatment option for the removal of the cyanobacterial toxins, nodularin and microcystin. Batch studies were conducted to determine the extent of hepatotoxin adsorption to a wide variety of soil types. Clay soils were found to be the most adsorbent. Desorption studies showed that nodularin and microcystin adsorption was reversible in the soils investigated. The mobility of the toxins in soil columns was also examined. Mobility was dependent upon the soil texture, with the highest mobility in the porous sand soil. The clay column became saturated and clogged, suggesting that soils high in clay would be inappropriate for bank filtration. Microbial degradation of the toxins was also investigated in batch experiments. Complete toxin removal was observed by Day 16 of the experiment in two out of the three soils examined. The calculation of toxin half lives suggested that microbial degradation would be the rate limiting step in toxin removal. It was concluded that bank filtration is a viable treatment option for the removal of hepatotoxins from drinking water, given that the hydraulic properties of the riverbank material allowed water flow and that toxin degrading populations of microorganisms could be established.

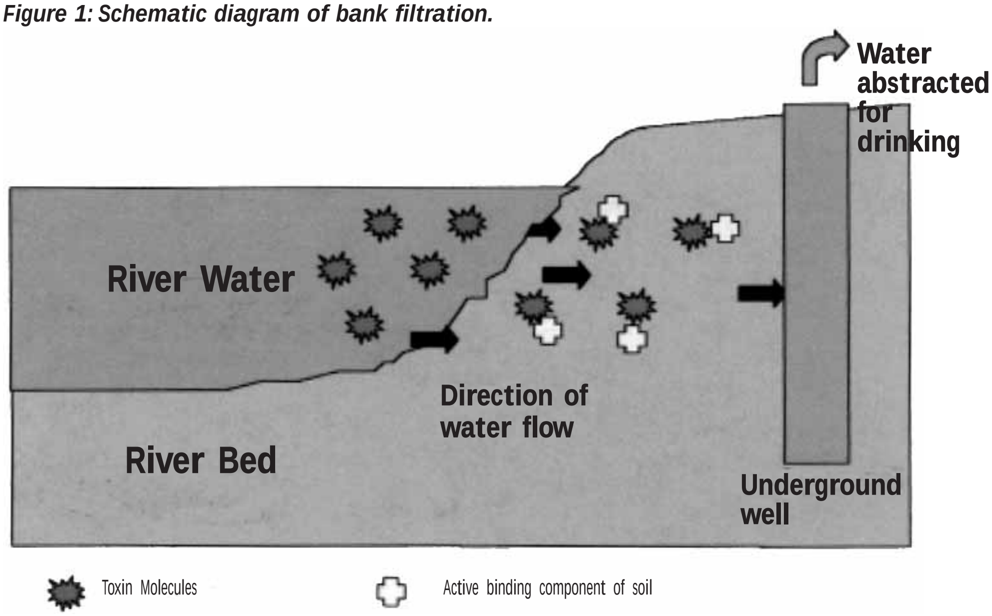
Key Words: *Cyanobacteria, Hepatotoxins, Drinking Water, Bank Filtration, Degradation, Aquifer*

Cyanobacteria are common throughout temperate regions of the world (Carmichael et al. 1985; Codd 1995). Public health concerns arise when cyanobacteria produce hepatotoxins that compromise the quality of drinking and recreational waters. Hepatotoxins are compounds that adversely affect the normal processes of the liver. There are two types of hepatotoxins; a cyclic pentapeptide, nodularin, and various cyclic heptapeptides termed microcystins. Microcystin and nodularin, are known to inhibit protein phosphatases 1 and 2A (Eriksson et al. 1990; MacKintosh et al. 1990; Yoshizawa et al. 1990), which can lead to tumor promotion in experimental animals (Nishiwaki-Matsushima et al. 1992; Ohta et al. 1994). Chronic adverse health effects may arise in populations that use hepatotoxin contaminated water for drinking (Hrudey et al. 1994). The potential for the hepatotoxins to affect adversely human health was demonstrated by the deaths of 50 patients in a Brazilian hospital who received microcystin contaminated water as a part of their haemodialysis treatment (Jochimsen et al. 1998). Recently, the World Health Organization (WHO) has moved towards implementing a guideline value for microcystin in drinking water (Chorus & Bartram 1999; WHO 1996). The suggested guideline value for microcystin-

LR, based mainly on results obtained from various animal experiments, was adopted at 1.0 μg L^{-1}. The guideline values for other microcystin variants and nodularin have not been set.

Conventional techniques for the removal of cyanobacterial hepatotoxins from water, such as chlorination and ozonation, are often expensive, highly dependent on existing infrastructure and technically demanding. There is a need in developing countries and in remote communities for a low cost, low maintenance, toxin removal technique. Bank filtration has the potential to remove cyanobacterial hepatotoxins from drinking water supplies. Bank filtration is the natural and/or artificial movement of water through riverbank material, as shown in Figure 1. This technique has been used to remove process is usually of high quality (Kühn 1999). However, some compounds can pass through the riverbank without being removed. An example is napthalene-1,5-disulfonate which was present in bank filtrate at detectable concentrations (1.5 μg L^{-1}) after 50-100 days filtration (Grischek 1999). A detailed understanding of the factors that influence the fate of a particular contaminant is required to enable the assessment of the efficiency of bank filtration as a removal strategy for cyanobacterial toxins. The retention of organic compounds by soil particles is dependent upon the functional groups of the compound and the characteristics of the soil. There are several soil properties, such as relatively high clay and organic carbon contents that effect the adsorption of organic compounds to soils (Hance 1988; Oliver et al. 1996).

Figure 1: Schematic diagram of bank filtration.



organic contaminants and nutrients from water of the River Rhine (Sontheimer 1980). The movement of toxic organic chemicals through soils governs their potential to enter the groundwater and/or food chains and cause adverse effects to humans and the ecosystem (Beck et al. 1993). Experiences in Europe have shown that the water at the end of the filtration

With regard to microcystin adsorption and mobility in soil, a research group in Finland has conducted preliminary investigations. Lahti et al. (1996) utilised sediment columns to determine the behaviour of microcystin-LR in lake water. Microcystin-LR at a concentration of 1.0 μg L^{-1} was pumped through the sediment at

0.91 m day^{-1} for 3 days and 1.8 m day^{-1} for the next four days, in an attempt to simulate *in situ* aquifer flow rates. Water leaving the columns was collected and analysed by high performance liquid chromatography. Microcystin-LR was detected at only a few ng L^{-1} (concentration not specified) representing a 99.5% reduction. No adsorption data were reported and the physico chemical properties of the sediment were not quantified. The broad aim of our research was to examine the adsorptive processes, transport and degradation of nodularin and microcystin-LR in a variety of different soils.

Batch Adsorption Experiments

Batch experiments are used to determine the type of adsorption processes occurring in soils. Known toxin concentrations are mixed with a soil and the amount of toxin adsorbed is plotted against the amount of toxin remaining in solution after mixing, to produce an adsorption isotherm. The type of adsorption processes occurring is reflected in the shape of the isotherm. The two simplest forms of adsorption produce linear (Eq 1) and non-linear (Freundlich; Eq 2) isotherms.

$$C_s = K_d . C_{eq} \qquad \text{(Equation 1)}$$

where,

K_s is the distribution coefficient (L kg^{-1})

C_s is the amount of toxin adsorbed per kilogram of soil (mg kg^{-1})

C_{eq} is the concentration of toxin in solution at equilibrium (mg L^{-1}).

For non-linear isotherms, where adsorption is dependent on concentration of the compound, the data are log normalised to allow the calculation of the Freundlich adsorption coefficient:

$$C_s = K_f . C_{eq}^{\,n} \qquad \text{(Equation 2)}$$

where,

K_f is the Freundlich adsorption coefficient (L kg^{-1})

n is the linearity exponent

The toxins used in the batch experiments were extracted from laboratory grown cultures and therefore, contained a level of organic carbon expected during a cyanobacterial bloom. The toxins were quantified throughout this project using reverse phase high performance liquid chromatography using the method of Miller et al. (in press).

Twelve soils of different physico-chemical properties were collected from the Willunga Basin and Lake Alexandrina regions of South Australia and used in the batch experiments (Miller et al. in press). Briefly, the soils were dried (~20°C) and sieved (1.405 mm) to remove small rocks, sticks and other material. The organic carbon (OC) content of the soil horizons and sediment was determined by the titrimetric dichromate redox method of Tiessen and Moir (1993). Particle size analysis was performed in triplicate on the soil samples using the pipette method of Sheldrick and Wang (1993) and soil pH was measured using the method of Rowell (1994). The bulk densities were determined using the core method of Blake and Hartage (1986a). A modified method of Blake and Hartage (1986b) was used for the quantification of the particle densities of the various soils. The 12 soils were mixed separately for 24 hours with each of the toxins at concentrations ranging from 0.1 to 2.5 mgL^{-1} as described by Miller et al. (in press). The time scale of the batch studies was such that it was unlikely that any degradation would have occurred and therefore, the toxin losses were attributable to adsorption alone.

Most of the sites displayed linear adsorption with low K_d values ranging from 0.2 - 2.59 L kg^{-1} indicating that the toxins were not strongly adsorbed to the soils. Regression analyses showed that the soils with the higher clay contents had higher adsorption coefficients and soils with a high sand content had low levels of toxin adsorption. The reason for this was the higher surface area available for adsorption in clay soils when compared with sands. From the twelve soils, three were chosen for detailed investigations. The three soils consisted of a high clay soil from Lakes Plains (high adsorption), a high sand soil from Hallett Cove (low adsorption) and a soil from McLaren Flat expressing intermediate adsorption.

Desorption experiments were conducted in the three texturally diverse soils using commercially available pure toxins. Desorption experiments were conducted to determine whether the hepatotoxins bind reversibly or irreversibly to soil particles. The McLaren Flat, Lakes Plains and Hallett Cove sites were used in the desorption experiments due to the diverse particle size distribution of these soils. Pure nodularin and microcystin-LR were mixed separately with the soils over a concentration range of 0.1 to 2.5 mg L^{-1} in distilled water. Soil (1 g) was added to 5 ml of the respective toxin solutions, in triplicate, and mixed using an end-on-end mixer. After the 24 hour adsorption period, the tubes were centrifuged (1600 g for 25 min), to pellet the soil. From the supernatant fraction, 1 ml was used to quantify the toxin. The remaining 4 ml of the supernatant was removed and 5 ml of distilled water was added to the soil pellet to initiate toxin desorption from the soils. The soils were re-suspended and were mixed for a further 24 hours. The procedure detailed above was repeated up to three times depending on the degree of desorption.

It was found that both nodularin and microcystin were completely desorbed within 48 hours in two out of the three soils. The Lakes Plains soil (high clay) retained the toxins over a longer time scale (120-144 hours), but mass balance calculations showed the binding of toxins to the soil was also reversible. This indicates that the toxins will be available for degradation by microbial populations in the soils.

The effect of solution properties, such as pH, salinity (measured as total dissolved solids) and dissolved organic carbon (DOC) were measured using the three different soils and extracted nodularin (Miller et al. in press). The pH effect was examined by mixing buffered and unbuffered nodularin solutions at pH 9, 7 and 4 with the soils. The final pH after the 24 hours mixing period of nodularin with soils provided the best indication of the effect pH had on toxin adsorption, rather than the initial solution pH. Solutions with final pH values ranging from 5.08 to 6.86 produced the highest adsorption coefficients of all solutions tested. Conversely, the lowest adsorption coefficients were observed in the buffer solution with final pH values greater than 8.80. As the pH became higher, it was postulated that the toxin molecules became more negatively charged and therefore more hydrophilic. This meant that the toxins were more likely to stay in the aqueous phase than partition into the soil. Dissolved organic carbon, pH and salinity have also been shown to influence toxin adsorption (Miller et al. in press). Where the ambient groundwater is brackish the design of a riverbank filtration system for removal of cyanobacterial toxins needs to be considered in relation to constraining the proportion of recovered water derived from a brackish aquifer. Modeling has shown that riverbank filtration schemes could meet the criteria of toxin removal and delivery of potable water except in locations where saline groundwater discharged to the river (Dillon et al. in press).

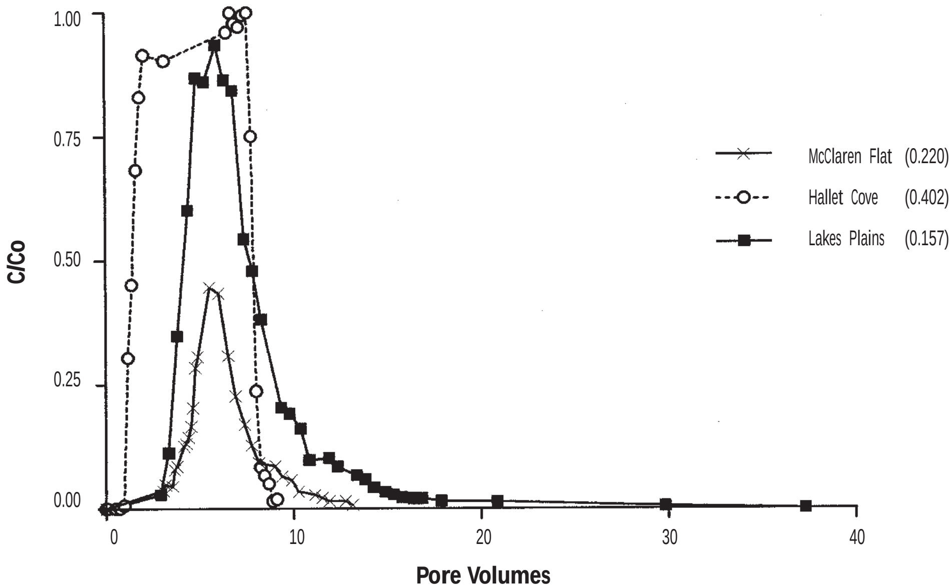
Contaminant Mobility in Soils

Batch studies are effective for preliminary investigations into the adsorption of organic compounds to soil particles. However, batch adsorption data alone cannot adequately predict the behaviour of toxin in the environment. Soil column experiments are used to examine the movement of compounds in conditions that are more applicable to environmental situations. Soil columns possess solution-to-soil ratios representative of the ratios in the field and the movement of the liquid through the column resembles the flow through soil (Bürglsser et al. 1993; Jackson et al. 1984), as observed during the process of bank filtration. Breakthrough curves (BTC) of contaminant outflow can be constructed from column experiments, which enables a retardation coefficient (R) to be calculated. Retardation is determined experimentally from BTCs where the concentration of contaminant leaving the column is equal to half of the concentration of contaminant entering the column. Low and high retardation values indicate high and low contaminant mobility respectively.

Perspex columns, 5 cm diameter and 9 cm length, were used. The columns had grooved end plates that enabled the flow to be dispersed evenly across the cross section of the column, allowing even flow throughout the entire column and eliminating preferential flow channels. The design of the columns ensured that there were no spaces containing dead volume in the end caps. In addition, the volume contained in the inlet/outlet was known and was factored into leaching calculations. The columns were packed by adding the air-dried soils and gently tapping the end on the bench. This method of packing was chosen to produce a homogenous mixture of adsorbing particles throughout the column and to ensure there were no preferential flow channels within the column that would result in toxin breakthrough sooner than expected. Preliminary column experiments with Lakes Plains soil, possessing a relatively high clay content, showed that the column became clogged and no outflow from the column was observed. To overcome this problem in subsequent experiments, Lakes Plains soil was pretreated with 0.1 M $CaCl_2$ before packing, to destabilise the colloidal material and allow flow through the column. Once packed the columns were leached with 0.005 M $CaSO_4$ for 24 hours to saturate the soil, check for leaks and ensure there were no air pockets. The 0.005 M $CaSO_4$ solution maintains the electrolyte balance of the soil (Dowling et al. 1994; Spurlock et al. 1995). The column was held vertical using a retort stand, and solutions were pumped from the bottom onto the column. After each soil column experiment was completed, the soil was collected and dried overnight at 105°C to enable the bulk density and volumetric water content of the column and the soil:solution ratio of the column to be determined.

In the current study, extracted nodularin and microcystin were pumped separately onto columns containing the three different test soils. The nodularin concentrations pumped onto the columns ranged from 1.2 to 2.15 mgL^{-1} and the microcystin concentrations ranged from 1.5 to 3.8 mg L^{-1}. These toxin concentrations are higher than would be expected under normal bloom conditions. However, once a bloom sinks and the cells lyse, the toxin concentrations could theoretically be 1 to 2 mgL^{-1}. The pulse of a high toxin concentration onto a soil column would best represent the conditions under which bank filtration would be expected to function. Pulses of toxin were pumped onto the respective soil columns and the concentration of toxin in collected fractions of known volume was quantified. Typical break through curves for microcystin at each site are shown in Figure 2. To enable the retardation coefficient to be readily determined the y-axis (Figure 2) is expressed as C/Co, where C is the toxin concentration of the fraction and Co is the toxin concentration of the solution pumped onto the column. When C/Co = 1, the concentration entering the column is equal to the concentration eluting from the column, which is indicative of toxin breakthrough. Microcystin was highly mobile through each of the soils, with retardation coefficients (R) of 1.07, 5.87 and 4.40 for Hallett Cove, McLaren Flat and Lakes Plains, respectively. The Hallett Cove site had the highest mobility, with the toxins flowing through the soil with the movement of the water. The highest

Figure 2: Microcystin breakthrough curves from the McLaren Flat, Hallett Cove and Lakes Plains soil columns. The flow rates of each breakthrough curve are given in parentheses (ml min^{-1}).



retention was seen in the McLaren Flat soil.

Toxin Degradation Experiments

Physical processes, such as adsorption and desorption, govern toxin transport, however, it is likely that the biological processes will determine the ultimate fate of the hepatotoxins in bank filtration systems. Degradation of microcystins by bacteria in aquatic environments has been well documented in the literature (Jones et al. 1994). However, there is a lack of information regarding the degradation of the hepatotoxins in the soil/water matrix. Lahti et al. (1998) examined the fate of microcystins from a cyanobacterial bloom in columns using soil from a bank filtration scheme in Finland. Desorption experiments were not conducted, nor were degradation rates calculated, making it difficult to determine if toxin losses were a function of degradation or irreversible binding to soil components.

It is difficult to isolate the chemical and physical processes of adsorption, desorption and diffusion from the biological processes of microbial degradation since the soil environment is extremely dynamic (Scow et al. 1995). Some of the factors that influence microbial degradation of organic compounds in soil include adsorption, diffusion and desorption of the contaminant (Scow & Hutson 1992) and the distribution of microorganisms and substrate throughout the soil matrix (Devare & Alexander 1995).

In the current study, microbial degradation was measured in the three different soils using batch experiments. Pure nodularin and microcystin were used in the degradation experiments to determine if the toxins could be removed without carbon and nitrogen additions to the soils. The starting concentrations of the toxins varied from 0.75 to 1.0 mgL^{-1}. Polypropylene tubes containing soil and toxin + azide were incubated concurrently with the soil + toxin in water tubes. Sodium azide was used to sterilise the soils, determined by plate counts, and represents a control in which there was minimal biological activity. Each of the tubes were sampled destructively and analysed for toxin concentration before the addition of the soils and then after 0.5, 1, 2, 4, 8, 10, 14, 16, 18, 22, 28 and 32 days incubation.

The results for microcystin are presented here, however, the nodularin results were comparable for all soils. The microcystin concentration in the azide and water tubes

Figure 3: Changes in microcystin concentration in toxin/water and toxin/azide solutions alone (soil absent from this experiment). Data points are the mean ± 1SD (n=3).

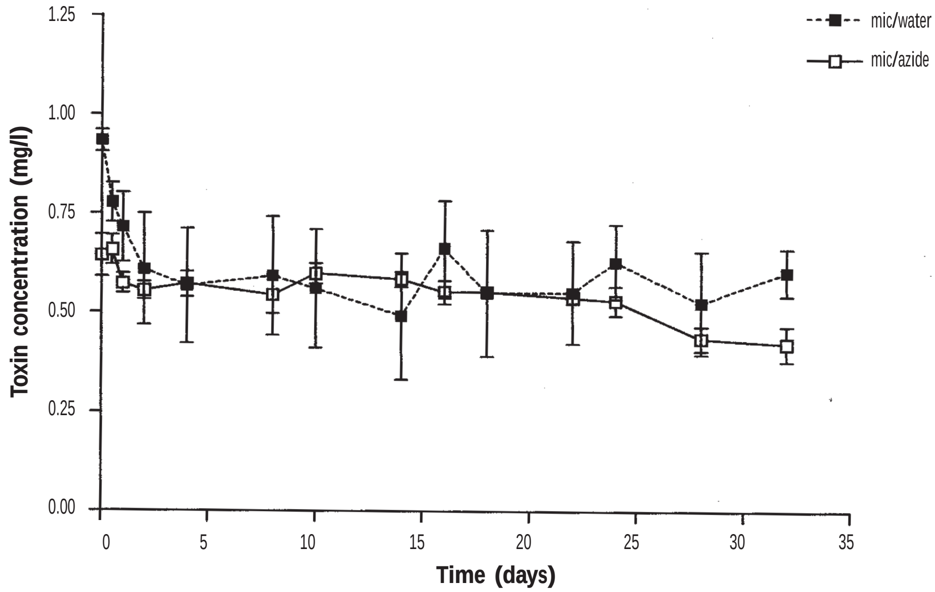


Figure 4: Difference between microcystin losses in azide solution and distilled water in Hallett Cove soil over 32 days. Data points are mean ± 1SD (n=3).

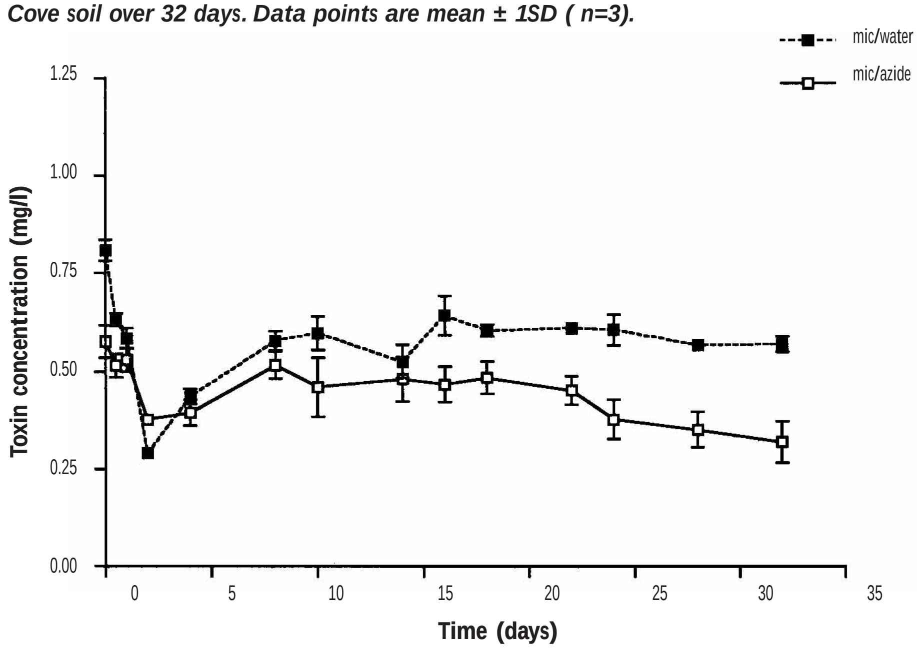


Figure 5: Microcystin losses in Lakes Plains soil in toxin/azide tubes and toxin/water tubes. Data points are mean ± 1SD (n=3).

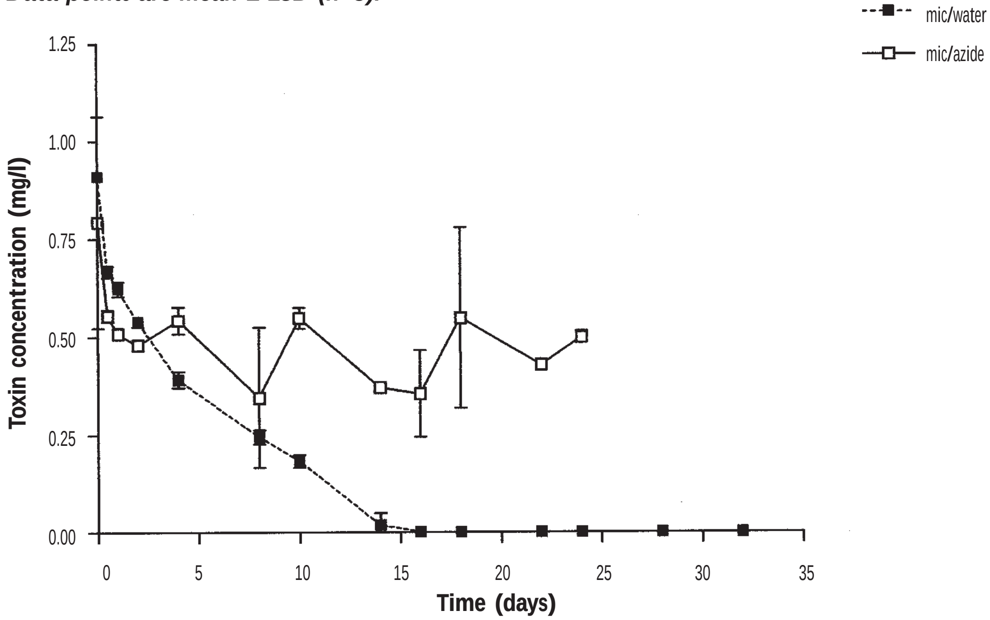
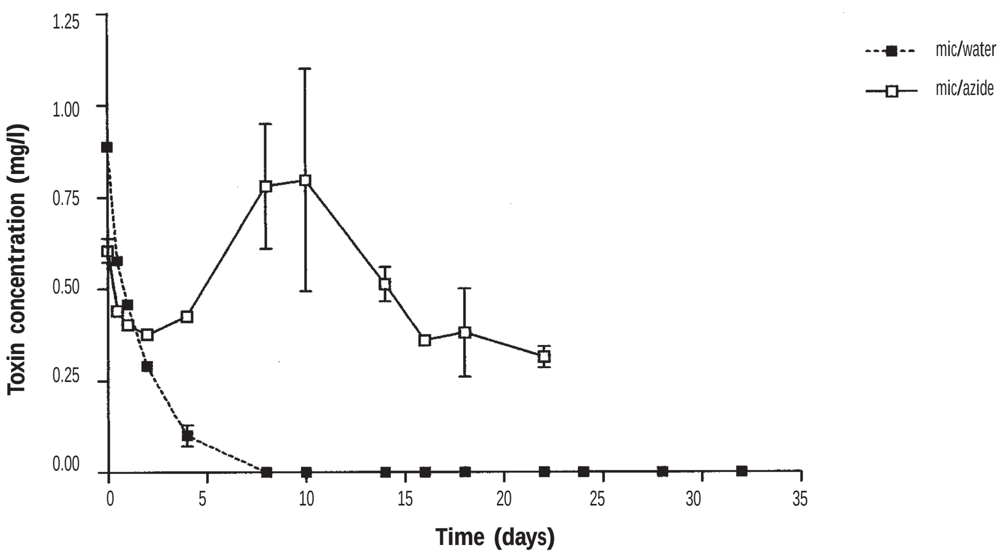


Figure 6: Degradation of microcystin-LR in McLaren Flat soil over 32 days in sterile (toxin/azide) and non-sterile (toxin/water) solutions. Data points represent mean ± 1SD (n=3).



where soil was absent decreased by approximately 0.25 mg L^{-1}, as shown in Figure 3. It appears from this result that the toxins were binding to the internal surface of the polypropylene tubes. After 5 days incubation, the toxin concentrations became stable at approximately 0.55 mg L^{-1}. In the absence of soil the difference between microcystin/azide and microcystin/water was not significant (t = 2.02, p = 0.054). A significant difference between toxin/azide and toxin/water solutions was observed

(Figure 4), however, in the presence of soil for microcystin (t = 3.4, p = 0.002), where toxin loss was greatest in the azide solutions. The reason for greater toxin losses in the azide solutions is not known, but it is clear that the azide is exerting an effect upon the hepatotoxins. Another effect observed at the Hallett Cove site was the increase in the microcystin concentration after Day 2 of the incubation. This was likely to be attributable to desorption and the lack of noticeable degradation in Hallett Cove soil.

Microcystin was completely removed from the Lakes Plains soil + toxin in water solutions by Day 16. A rapid decrease in the microcystin concentration in solution was observed during the first 1-2 days, after which there was a steady decline in toxin levels. Microcystin was removed completely from solution by Day 16, as shown in Figure 5. Microcystin in Lakes Plains soil + azide solution remained constant at approximately 0.5 mg L^{-1} after a rapid initial decline in toxin concentrations. There was a significant difference (t = 2.5, p = 0.02) in microcystin concentration for the Lakes Plain soil incubations between microcystin in water and microcystin + azide.

The McLaren Flat soil showed the most rapid and complete toxin removal (Figure 6). Microcystin was removed from the soil + microcystin in water matrix by Day 8. The difference between the microcystin removal in soil + microcystin in water and soil + microcystin and azide solution was highly significant (t = 3.36 and p = 0.003). The McLaren Flat soil in the toxin/azide solution showed an increase in microcystin on Days 8-10, which was likely to be a function of desorption.

The fluctuations in toxin concentration over time observed in azide/toxin control tubes are likely to be due to the destructive sampling methodology, as opposed to any real effect. Destructive sampling can also explain some of the wide error bars, as each tube represents an isolated batch experiment.

The data shown in the Figures presented above (Figures 3-6) demonstrate that linear kinetics could not adequately describe toxin loss. There were generally two phases of loss; a rapid initial loss followed by a slower toxin loss over time. Regression analyses were conducted to determine the kinetics of gross toxin loss as it would be extremely difficult to separate adsorption/desorption from degradation, as these processes were probably occurring simultaneously. Two-phase exponential decay best described microcystin and nodularin losses for each soil. This supported the observation of an initial rapid loss of toxin due to adsorption and a slower degradative phase.

To indicate the rate limiting step of the interaction between adsorption and degradation, half lives were calculated for nodularin and microcystin in each of the three soils. The half lives ($t_{1/2}$) for adsorption and degradation in all three soils were calculated from the equation of the line that best fits from the non-linear curves. Table 1 details the half lives for nodularin losses in the three soils and Table 2 show the half lives for microcystin.

The $t_{1/2}$ of nodularin in the adsorption phase in Lakes Plains soil was 0.02 days,

Table 1: The nodularin half lives ($t_{1/2}$) in each of the three texturally different soils for adsorption and degradation

Site	Nodularin half lives (days)	
	Adsorption	Degradation
McLaren Flat	0.26	2.15
Lakes Plains	0.02	16.90
Hallett Cove	8.30	16.60

Table 2: Microcystin half lives ($t_{1/2}$) for the adsorption and degradation processes occurring in three soils collected from South Australia.

Site	Nodularin half lives (days)	
	Adsorption	Degradation
McLaren Flat	0.02	1.56
Lakes Plains	0.19	8.96
Hallett Cove	0.35	NA*

** NA- the toxin levels in solution actual increase in the degradative phase* while McLaren Flat had a $t_{1/2}$ of 0.26 days, suggesting nodularin was more rapidly adsorbed in Lakes Plains soil. The nodularin degradation phase had half lives of 16.9 and 2.15 days for Lakes Plains and McLaren Flat soils, respectively. Microcystin losses in Lakes Plains and McLaren Flat during the adsorptive phase were slightly different to the values recorded for nodularin. The Lakes Plains soil had $t_{1/2}$ of 0.19 days and the $t_{1/2}$ for McLaren Flat soil was 0.02 days, which suggests that microcystin was more rapidly adsorbed in McLaren Flat soil. The half lives for microcystin in the degradation phase in these two soils were approximately half that for nodularin. The McLaren Flat site had a $t_{1/2}$ of 1.56 days whereas a $t_{1/2}$ of 8.96 days was observed for microcystin degradation in Lakes Plains soil. The results from both McLaren Flat and Lakes Plains soils imply that microcystin is more readily biodegradable than nodularin in soils investigated. This observation is not unique. Jones et al. (1994) isolated an organism *(Sphingomonas* spp.) that could degrade microcystin-LR and -RR, but could not degrade nodularin in natural waters, during a six-hour experiment. However, it is not known whether nodularin would have been degraded perhaps over a longer experimental time frame. Further research found that the Adda-arginine peptide bond (common to both nodularin and microcystin-LR) was cleaved first in the degradative actions of *Sphingomonas* (Bourne et al. 1996). Takenaka and Watanabe (1997) isolated *Pseudomonas aeruginosa* from the surface water of a lake in Japan that degraded microcystin-LR to undetectable levels in 21 days. The alkaline protease from this bacterium attacked the Adda side chain as the first step in the biotransformation of microcystin-LR. Nodularin degradation by the alkaline protease was not examined. The molecular basis for the discrepancy between microcystin and nodularin degradation rates in surface waters and in the soil/water matrix requires further investigation.

Conclusion

The conclusions drawn from this study are as follows:

- Soils with a high sand content were the least adsorptive, while soils with relatively high clay contents were more effective at toxin adsorption.
- The toxins were highly mobile in all three soils, with the sandy soil having the greatest degree of mobility. A higher level of mobility means that a longer distance of filtration may be required to effectively remove the toxins from the water.
- Complete removal of nodularin and microcystin is possible by microbial degradation, in laboratory conditions, in less than 16 days. The kinetics of loss were bi-phasic, supporting the notion that there is an initial rapid phase of loss attributable to adsorption followed by a slower phase of loss due to degradation.
- Calculation of toxin half lives for adsorption and degradation indicated that degradation would be the rate limiting step in compete toxin removal in a bank filtration scheme.

Based on the results presented in this overview, bank filtration as a low-cost, low maintenance toxin removal strategy, offers a great deal of promise in the provision of toxin-free drinking water. The balance between the hydraulic properties of a soil and the behaviour of the toxins needs to be examined when considering a bank filtration scheme. For example, a clay soil may prevent flow and a high sand soil may not support toxin degradation. Each candidate site for bank filtration should be examined for the substrate and solution properties that will influence the adsorption, desorption and degradation of the hepatotoxins from the soil/water environment. This project represents the first step in an area of research important to public health officials, water authorities and academics alike.

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Correspondence to:
Howard Fallowfield
Department of Environmental Health
The Flinders University of South Australia
GPO Box 2100
Adelaide, South Australia, 5001
AUSTRALIA
Email Howard.Fallowfield@flinders.edu.au

Health Risk Assessment and Management of a Cyanobacterial Bloom Affecting a Non-Municipal Water Supply

Ian Marshall[1], Maree Smith[2] and Gerard Neville[1]

Public Health Services[1], and Public Health Sciences[2], Queensland Health

Queensland Health in collaboration with the Queensland Department of Natural Resources (DNR) and the responsible local government authority conducted a health risk assessment to determine whether a non-municipal water supply affected by a cyanobacterial bloom could be used as a potable water supply during an upcoming festival. Aphanizomenon *spp. and the potentially toxic species* Cylindrospermopsis raciborskii *were the dominant cyanobacteria initially present in the dam and treated water. Cylindrospermopsin, a hepatotoxic cyanotoxin was also detected in the dam, but not in the treated water. Artificial mixing of the water in the dam was implemented as a long-term solution to reducing cyanobacterial cell levels. Cell levels in the dam were significantly reduced after the method used to mix the water was implemented. However, the level of cells in the dam and treated water remained of concern and additional measures were taken further to reduce numbers. A copper-based algicide was used to treat the dam water, and a 5-micron filter was introduced to improve the capacity of the water treatment plant to remove organic matter. After the implementation of such measures the levels of cyanobacterial cells in the dam and treated water were reduced to levels that were unlikely to present a risk to human health. Monitoring of the water during the festival indicated that the level of cyanobacterial cells in dam and treated water remained at low levels. No health effects, which could be related to cyanobacteria, were reported during the festival.*

Key Words: *Risk Assessment, Water Treatment, Cyanabacteria,, Hepatotoxin*

Cyanobacterial blooms frequently affect recreational and drinking water supplies throughout Queensland. In terms of public health, the main concerns that cyanobacterial blooms present relate to the presence of intracellular and surface active toxins that may be produced by some genera. In addition, all cyanobacterial cells possess a lipopolysaccharide (LPS) component in their cell wall and this has potential to produce dermatological reactions.

Limited information is available on the toxicity of most cyanobacterial species. While many species are regarded as potentially toxic and may produce systemic (cyanotoxins) and surface active toxins, the levels of exposure required to produce adverse health effects for most cyanotoxins have not been well characterised.

There are no guideline values for the levels of cyanobacterial cells in drinking water. However, drinking water guidelines have been proposed by the World Health Organization (WHO) for microcystin-LR (Chorus & Bartram 1999) and microcystins generally, but not other cyanotoxins.

Dermatological reactions have been reported following recreational exposure to water containing cyanobacterial cells. It is likely that the LPS component of the cyanobacterial cell wall may be a possible cause for these reactions. Some species also have potential to produce other toxins capable of producing skin irritation. There is some evidence to suggest that at cell levels below 5.0×10^3 cells/mL irritant or allergenic effects would be unlikely to occur (Piloto et al. 1997).

The National Health and Medical Research Council (NH&MRC) through the rolling revision of the Australian Drinking Water Guidelines (ADWG) has recently endeavoured to establish acceptable levels for saxitoxins, cylindrospermopsin, nodularin and microcystins. In view of the limited information available for saxitoxins, cylindrospermopsin and nodularin, drinking water guideline values were not established for these toxins. However, for microcystins a draft drinking water guideline value of 1.3μg/L expressed as microcystin-LR toxicity equivalents was proposed. This level was based in part on a No Observable Adverse Effect Level (NOAEL) of 40μg/kg bodyweight/day established in a 13-week oral feeding study in mice in which affects to the liver were reported (Chorus & Bartram 1999). The expression of the guideline value as toxicity equivalents accounts for the presence of other isomers of microcystin to be present in the water and their toxicity relative to that of microcystin-LR. The WHO has set a provisional drinking water guideline level for microcystin-LR of 1μg/L.

Although there is no drinking water guideline value for cylindrospermopsin, research conducted at the National Research Centre for Environmental Toxicology (NRCET) suggests that a guideline level of 1 μg/L would be protective of health (Moore et al. 1998). In addition, on the basis of animal studies conducted using other cyanotoxins, acceptable levels for various toxins have been proposed for drinking water (Duy et al. 2000). Although assumptions regarding bodyweight and daily water intake vary, the acceptable levels derived for other cyanotoxins are of the same order as for microcystin-LR.

When a cyanobacterial bloom affects a water supply, a health risk assessment may need to be undertaken to determine whether the water supply is suitable for its intended use. Such an assessment needs to consider the type of hazards the bloom presents and the potential for exposure to occur.

This paper outlines the assessment that was undertaken to determine whether treated water from a non-municipal drinking water supply affected by a cyanobacterial bloom could be used as a source of potable water during a five day period and the subsequent management of such a bloom.

Background

In November 1999, approximately eight weeks before a large festival was to commence, a notable increase in the odour and turbidity of water from the festival's on-site water treatment plant was detected. Concerns were raised that algae in the dam may be affecting the quality of the treated water. Preliminary testing of water samples indicated the presence of several cyanobacterial species, notably, *Aphanizomenon* spp. and the potentially toxic cyanobacterium *Cylindrospermopsis raciborskii*. (Table 1). This indicated that further testing was necessary to identify and enumerate cells in the dam and treated water, and to characterise the distribution of cyanobacterial cells in the dam water. As *C. raciborskii* has the potential to produce the cyanotoxin, cylindrospermopsin, the presence and level of this toxin in the dam and treated water would also need to be determined. Cylindrospermopsin is a hepatotoxin, but also has potential to affect a number of other tissues.

Table 1: Cyanobacteria identified in dam and treated tank water

Dam water:	*Cylindrospermopsis raciborskii, Aphanocapsa* spp., *Aphanizomenon* spp., *Planktolyngbya* spp., *Oscillatoria* spp., and *Chroococcus* spp.
Tank water:	*Cylindrospermopsis raciborskii, Aphanocapsa* spp., *Aphanizomenon* spp., *Planktolyngbya* spp., *Snowella* spp., and *Chroococcus* spp.

Note: Water samples were examined using phase contrast microscopy.

The festival's organisers approached Queensland Health to advise them whether treated water from the on-site water treatment plant was suitable as a potable water supply during the festival. This was a matter of particular public health significance as the festival was likely to attract over 80,000 patrons, some of whom were likely to camp on site. There was a relatively short period of time before the festival was to commence and the bloom affected the only on-site drinking water supply.

A working party comprising representatives from the festival organising committee, Queensland Health, DNR and the responsible Local Government was established. The working party undertook a site assessment and agreed upon a strategy whereby the risks the water supply presented could be characterised and a determination made as to the suitability of the treated water as a potable water supply.

Site Assessment

The site assessment involved inspecting the water treatment and storage facilities, and the dam water and its catchment, to identify potential hazards.

The water treatment plant comprised slow sand filtration with pre-chlorination. The intake point from the dam was approximately 1-metre at depth in the centre of the dam. Treated water was pumped to storage tanks situated on-site and then reticulated throughout the site. On the basis of the colour and clarity of the treated water, it was apparent that the water was being adversely affected by the presence of cyanobacterial cells in the dam water.

Details relating to the maintenance and performance of the water treatment plant were not available. Given that the efficiency of slow sand filtration to remove cyanobacterial cells is reported to be as high as 99% (Chorus & Bartram 1999), it was clear that the filtration system was not operating efficiently. This was attributed to the overloading of the filter with cyanobacterial cells. In view of the high organic load of the pre-filtered water, pre-chlorination was unlikely to provide effective disinfection of the source water.

Water storage tanks were estimated to hold sufficient water to meet daily water requirements during the festival (approximately 0.5mL). Tanks were in the process of being cleaned in preparation for the festival.

Fencing around the dam prevented cattle, but not native fauna, gaining access to the dam water. The position of the dam indicated that there was little potential for the water to be contaminated with agricultural chemicals. There was no evidence of cyanobacterial scum on the surface of the water. However, the clarity of the water was reported to have diminished in recent weeks.

Exposure Assessment

There was significant potential for oral and dermal exposure to cyanobacterial cells including the toxin, cylindrospermopsin. Treated water was to be used for drinking, cooking and showering. Access to the dam was secured and it was unlikely that patrons at the festival would use the dam for swimming. Drinking water was also to be available through a commercial operator providing tanked water from an off-site source. The extent to which this source of water would supplement the on-site treated water was not determined.

As the festival was only held over five days, exposure to any contaminant in the treated water would be of short duration. Therefore, adverse health effects resulting from cumulative exposure was unlikely.

The absence of performance data on the water treatment plant meant that the capacity of the water treatment plant to remove cyanobacterial cells, toxins and other contaminants was not known. Therefore, there was considerable uncertainty with respect to the potential for patrons to be exposed. A water monitoring program was needed to characterise the quality of dam and treated water over the weeks leading up to the festival. This would provide some indication of the potential for patrons to be exposed.

On the basis of the site assessment and exposure assessment, the following issues were identified as key issues that needed to be addressed:

- the festival organisers would need to implement a water quality management program aimed at improving the performance of the water treatment process;
- on the basis of the results of the monitoring, measures need to be implemented to reduce cyanobacterial cells in the dam water, as well as the treated water;
- the health risks presented from other contaminants present in the dam and treated water needed to be determined; and
- if measures to reduce cyanobacterial cell numbers and to improve the performance of the water treatment plant proved ineffective, alternative arrangements would need to be made with respect to the provision of potable water during the festival.

Monitoring and Management Program

The aim of the monitoring program was to provide results sufficiently representative so that the risks associated with the use of the water could be reliably characterised. The program was designed to monitor trends in cyanobacterial cell numbers and cyanotoxin levels, and to determine whether other microbiological and chemical parameters of concern were present in the dam and/or treated water and, if so, whether the levels detected complied with relevant standards or guidelines.

In addition to determining the level of cyanobacteria and associated toxins in the dam water, other issues that needed to be addressed in relation to potability of the water were examined. These issues were:

- in view of the potential for native animals to access the dam water, the presence of *Escherichia coli* (*E. coli*) (the most specific indicator of faecal contamination), *Cryptosporidium* and *Giardia* needed to be determined. The presence of *Cryptosporidium* and *Giardia* in the dam water would indicate that further assessment would be required. This could effectively preclude the use of the water for drinking purposes during the festival;
- the physical characteristics and inorganic content of the dam and treated water needed to be determined. The history of the dam suggested that the water was unlikely to be contaminated with agricultural chemicals such as pesticides.

Results of initial monitoring

Results of initial monitoring indicated that total cyanobacterial cell counts in the dam and treated water were unacceptable (Table 2). A total cell count of 97,900 cells/mL was reported for the treated water and total cell counts in the dam water ranged from 221,000 to 467,000 cells/mL. Total cell counts in seven of the eight dam water samples exceeded 250,000 cells/mL.

The levels of cyanobacterial cells in the dam water exceeded Alert Level 2 of the WHO guidelines (Chorus & Bartram 1999). The threshold for Alert Level 2 is 100,000 cells/mL and is for an established and toxic bloom that may produce local scums. Levels of cyanobacteria in excess of 100,000 cells/mL in the dam water were considered to present a significant risk to human health, particularly as the water treatment system was ineffective. At this level, the WHO recommends that the following actions should be implemented (Chorus & Bartram 1999):

- toxin testing should be initiated and/or continued on a weekly to fortnightly basis;

- an alternative supply should be considered if available; and
- weekly sampling for cyanobacterial counts should be conducted.

At the off-take site, samples taken at the surface and at two and four metres indicated that of the dominant species present, the total cell count for *C. raciborskii* was highest at two metres (58,000 cells/mL) than at the surface (38,800 cells/mL) or four metres (28,700 cells/mL). Total cell count for *Aphanizomenon* spp. decreased with increasing depth ranging from 254,000 cells/mL at surface to 128,000 cells/mL at four metres.

At other sites, the total cell counts for *C. raciborskii* and *Aphanizomenon* spp. ranged from 24,500 to 172,000 cells/mL and from 141,000 to 227,000 cells/mL, respectively. In the treated water, *C. raciborskii* and *Aphanizomenon* spp. were present at 28,600 and 65,400 cells/mL, respectively.

Cryptosporidium and *Giardia* were not detected in a 10-litre composite sample taken from the source water. *E. coli* was also not detected in samples of treated water. However, a low count of coliforms ($\leq$ 12 cfu per 100mL) was detected in samples from treated water.

On completion of the initial monitoring it was apparent that measures were required to reduce the current bloom and the potential for future bloom formation to occur in the dam water. The potential for bloom formation for some species, particularly scum forming species such as Aphanizomenon spp., is partly dependent on the stability of the water column. This is due to the capacity of cyanobacteria to regulate their buoyancy and migrate up and down water columns, thereby enabling cells to move into a stratum where conditions for growth are more favourable. Artificial mixing of a water column has been reported as a means to destratify the column, thereby reducing the potential for cyanobacterial cells to attain optimum conditions for growth. Given the limited time available to resolve the issue of provision of potable water before the festival began and the need to look for a long-term solution to the control of cyanobacteria in the dam, it was decided to attempt to artificially mix the water in the dam.

For artificial mixing to be effective, three conditions must be satisfied. At least 80% of the water volume should be mixed, a mixing rate of 1 m h^{-1} should be attained and the water body must be sufficiently deep so that the light carrying capacity of the water body can be reduced (Chorus & Bartram 1999). It should be noted that this information is based on experience in temperate reservoirs in Europe, which may or may not be applicable to sub-tropical conditions in Australia. Unfortunately, there was insufficient time and resources available to assess properly whether these conditions were satisfied.

Table 2: Levels of cyanobacterial cells and cylindrospermopsin in raw and treated water at different times over the monitoring and management program

	Raw Water				Treated Water			
	Total Cyanobacteria (cells/mL)	*C. raciborskii* (cells/mL)	*Aphanizomenon* spp. (cells/mL)	*Cylindrospermopsin* (µg/mL)	Total Cyanobacteria (cells/mL)	*C. raciborskii* (cells/mL)	*Aphanizomenon* spp. (cells/mL)	*Cylindrospermopsin* (µg/mL)
Baseline monitoring	221,000 to 467,000	24,500 to 172,000	128,000 to 254,000	8.2	97,900	28,600	65,400	ND
After mixing	54,200 to 171,000	1480 to 9030	9200 to 34,000	4.3	32,900	6740	18,900	ND
Post algicide treatment	9690	ND	ND	2.7	9540	20	ND	ND

To mix the dam water festival organisers were advised by DNR to install a 100mm main pipe along the length of the dam. The pipe was attached to a centrifugal pump. The intake point for the pump from the dam was located approximately 1.5 metres beneath the surface of the water. Three to four 50mm outlet pipes were then fitted along the main pipe in a way that would circulate water around the dam.

To determine whether artificial mixing was successful in reducing cell numbers, cyanobacterial cell levels were determined before and approximately two weeks after artificial mixing was implemented. If artificial mixing reduced cell numbers sufficiently, it was anticipated that the organic load on the water treatment plant would be reduced thus improving the efficiency of the plant. If artificial mixing did not significantly reduce the number of cyanobacterial cells in the treated water, the use of an algicide was considered to be an alternative, but short-term solution.

Results of monitoring after implementation of artificial mixing

Approximately nine days after artificial mixing of the dam water had been implemented, lower total cyanobacterial cell counts were reported at all sampling sites (Table 2). Total cell counts ranged from 54,200 to 171,000 cells/mL in the dam water and in the treated water a total cell count of 32,900 cells/mL was reported.

On the basis of the total cell counts in the dam and treated water, the water treatment plant had only reduced the level of cyanobacterial cells in the treated water by approximately 30 to 45%. Only two of eight dam water samples exceeded 100,000 cells/mL. At the off-take site, total cell counts decreased with depth with 88,900 cells/mL reported at the surface decreasing to 69,200 cells/mL at four metres. The highest level of *C. raciborskii* in the different samples at this site only marginally exceeded 5000 cells/mL and levels of *Aphanizomenon* spp. did not exceed 18,000 cells/mL. Levels reported for *C. raciborskii* and *Aphanizomenon* spp. in the treated water indicated that the water treatment plant did not significantly remove either of these species.

At this time cylindrospermopsin was detected in a surface water sample taken from the off-take area (4.3mg/L), but was not detected in treated water (limit of reporting was 0.2μg/L; HPLC MS/MS). The absence of toxin in the treated water was most likely attributed to pre-chlorination. On the basis of the reports available, residual free chlorine levels determined for the treated water ranged from four to five ppm (pH 8.2).

Additional management strategies

To reduce further cyanobacterial cell numbers a copper-based algicide was applied to the dam. The suggested rate of application was 0.2-0.5mg/L copper. It was not known if this regime was followed. Two days following this treatment, the cyanobacterial cell count in a composite sample taken from the off-take site was 9690 cells/mL and for treated water was 9540 cells/mL (Table 2). A low total cell count was reported for *C. raciborskii* (20 cells/mL), but neither cylindrospermopsin nor *Aphanizomenon* spp. were detected in the treated water. The level of cyanobacterial cells in the dam water only marginally exceeded Alert Level 1 of the WHO guidelines (Chorus & Bartram 1999). The threshold for Alert Level 1 is 2000 cells/mL. At this level, the WHO guidelines recommend that an assessment needs to be made as to whether the concentration of cyanobacteria in the raw water can be reduced or whether the water treatment system is effective in reducing cell and toxin concentrations.

Due to the potential for toxin to be released from lysed cyanobacterial cells and for copper levels to be increased, toxin and copper levels were also determined.

Cylindrospermopsin was detected in dam water (2.7μg/L), but not in the treated water. Copper levels in the treated water (0.12mg/L) did not exceed the ADWG health-based guideline value (2.0mg/L).

In view of the comparable levels of cells in the dam and treated water, steps were taken to improve the performance of the water treatment plant. To improve colour and turbidity, and to reduce the level of chlorination required to degrade the toxin and disinfect filtered water, a five micron filtration unit consisting of four SSX100 Bag Filter vessels was installed distal to the existing sand media filters. In addition, post-filter chlorination was introduced as an alternative to the pre-chlorination previously used.

Samples taken after these measures were introduced indicated that the total cell count in the treated water was less than 2000 cells/mL. *C. raciborskii* and *Aphanizomenon* spp. were not detected in the treated water. Visual inspection of water from the water treatment plant after the filtration unit had been introduced indicated that the colour of the water had improved. However, subsequent analyses of water samples indicated that both colour (50 to 60 Hazen units) and turbidity (12 to 14 NTU) exceeded the guideline values recommended in the ADWG (15 Hazen units and 1 NTU, respectively). The colour of the water was further improved by the addition of a flocculent. Residual free chlorine levels of treated water ranged from 0.05 to 0.7ppm (pH ranged from 7.85 to 8.0).

Final Assessment

On the basis of the measures taken to reduce cyanobacterial cell levels in the dam water and to improve the performance of the water treatment plant, patrons at the festival would be exposed to low levels of cyanobacteria in the treated water. The information available on the potential for cyanobacteria to induce adverse health effects suggested that exposure to cyanobacterial cells in the treated water at the low levels reported was not considered to present a risk to human health.

No cylindrospermopsin was detected in the treated water. Cylindrospermopsin is degraded by chlorination and the removal of toxin by the water treatment plant was most likely due to chlorination. Residual chlorine concentrations of 0.5 mg/L have been shown to degrade greater than 99% of cylindrospermopsin within a pH range of 6 to 9 (Senogles et al. 1999). The presence of coliforms in the water supply, but not *E.coli*, suggested that the coliforms were not of faecal origin, but most likely were from vegetative matter and in this respect not considered to present a risk to human health.

On the basis of the results obtained it was concluded that the treated water was unlikely to cause any adverse health effects during the festival. To ensure that the quality of the treated water was maintained during the festival, the dam and treated water were inspected on a daily basis to ensure that there was no odour or reduction in the clarity of the drinking water.

Contingency Planning

In preparation for the festival, festival organisers were required to prepare a contingency plan. Contingency planning needed to consider two scenarios. The first was where the water can be used for showering and domestic use, but not as a drinking water source, and the second where the water is not suitable to be used for any purpose. The contingency plans relied on formal notification of patrons concerning the permitted uses of the water as well as appropriate signage (consistent with Australian Standard 1319). In addition, if the water was found to be unacceptable for drinking or other purposes, six tanks were to be installed around the festival site. Tanks would be refilled as needed with water supplied from the local municipal water supply.

Discussion

On occasions cyanobacterial cells are detected in drinking water supplies. An alternate water supply may not be readily available and consequently the risk the water supply presents to human health needs to be assessed. In view of the various factors that may impact on such an assessment, it is understandable that no drinking water guideline level has been established for cyanobacterial cells in drinking water. Nevertheless, at times, a decision may need to be made with regard to the likelihood that a particular level of cyanobacterial cells in treated water presents a risk to human health. Despite the paucity of information concerning the level of cyanobacterial cells in drinking water required to produce adverse health effects, the limited information that is available suggests that levels less than 2000 cells/mL would be unlikely to adversely affect human health.

The ADWG provide an overview of key issues that need to be considered when managing a water treatment system and measuring the performance of the system. For small water supplies with infrequent use, such as presented here, it is unrealistic to expect festival organisers to adopt the comprehensive monitoring program as outlined in the ADWG. However, organisers of such festivals should allow for sufficient lead-time to enable the water treatment system to be assessed. Therefore if changes to the system need to be made, sufficient time would permit a more complete assessment of such changes.

Conclusion

Where the water supply is to be used to provide water to the public, the assessment needs to consider the likely hazards to be encountered and the capacity of the treatment plant to remove potential contaminants. If there is concern regarding the capacity of the water treatment system to provide drinking water of an acceptable quality, contingency planning plays an important role in mitigating any risks to human health. Contingency planning should be undertaken well in advance of the event and advice should be sought from government on issues to be considered.

When assessing the health risks that an affected water supply presents it may be necessary for those charged with the responsibility of the assessment to work in collaboration with others from diverse backgrounds. A multidisciplinary approach is recommended with input from relevant government, research and industry bodies.

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Correspondence to:
Ian Marshall
Public Health Services
Queensland Health
Brisbane, Queensland, 4001
AUSTRALIA
Email Ian_Marshall@health.qld.gov.au

Sentinel Foodborne Disease Surveillance in Australia: Priorities and Possibilities

Craig B. Dalton and Leanne E. Unicomb

Hunter Public Health Unit, New South Wales

The incidence of foodborne disease in Australia is estimated at 2.2 to 4.2 million per year, however, the accuracy of estimates is uncertain and the major causes are largely unknown (Australia New Zealand Food Authority [ANZFA] 1999; Sumner et al. 2000). The Australian federal government's Public Health Division's funding of sentinel foodborne disease sites nationally presents a unique opportunity to advance our understanding of foodborne disease in Australia to inform prevention programs (Communicable Diseases Intelligence 2000). The protocols for the program are yet to be finalised, however, negotiation between sites will be required to develop a protocol that can be standardised across the nation and through which national collaboration can be achieved. The program has the potential to achieve four basic objectives: 1) to document the prevalence and burden of common foodborne diseases, 2) to determine the causes of foodborne disease by pathogen, vehicle and food production, processing, and handling errors, 3) to enhance the detection, investigation and centralised standard reporting of foodborne disease outbreaks, and 4) to provide epidemiological information to inform risk assessment and HACCP program development. The project offers an opportunity for a concerted effort to examine the extent, burden and causes of foodborne disease.

Key Words: *Foodborne Disease, Pathogens, Food Production, Risk Factors*

The incidence of foodborne disease in Australia is estimated at 2.2 to 4.2 million per year, however, the accuracy of estimates is uncertain and the major causes are largely unknown (ANZFA 1999, Sumner et al. 2000). The Australian federal government's Public Health Division's funding of sentinel foodborne disease sites nationally presents a unique opportunity to advance our understanding of foodborne disease in Australia to inform prevention programs (Communicable Diseases Intelligence 2000). This initiative meets the challenge of earlier proposals for a "state of the art" surveillance system (Voetsch et al. 2000) which will see a central coordinating group and sentinel foodborne disease sites in six states. The protocols for the program are yet to be finalised, however, negotiation between sites will be required to develop a protocol that can be standardised across the nation and through which national collaboration can be achieved.

Sentinel surveillance using the USA FoodNet model has been piloted at the Public Health Unit in the Hunter Area of New South Wales for 18 months. This period has provided opportunities to refine our research strategies. This article is intended to raise some potential priorities and possibilities for the new sentinel surveillance program rather than to pre-empt final protocol development which must occur as a national collaboration.

The program has the potential to achieve four basic objectives: 1) to document the prevalence and burden of common foodborne diseases, 2) to determine the causes of foodborne disease by pathogen, vehicle and food production, processing, and handling errors, 3) to enhance the detection, investigation and centralised standard reporting of foodborne disease outbreaks, and 4) to provide epidemiological information to inform risk assessment and HACCP program development. A range of surveillance and case-control methods will be used to achieve these objectives and many of these have been discussed in previous publications (Crerar et al. 1996; Voetsch et al. 2000). Briefly, these could include education of general practitioners, hospital-based medical practitioners and the community to report suspected foodborne outbreaks, population-based surveys of diarrhoeal disease incidence, enhanced laboratory surveillance, and surveillance for clinical syndromes associated with foodborne disease.

Within these broad objectives, this article discusses the opportunities for sentinel sites to effect national case-control studies that focus on major foodborne disease, and to forge links between epidemiological surveillance and laboratory science.

Case-control Studies of Major Foodborne Disease Threats

Case-control studies are of potential value to investigate risk factors for foodborne disease due to specific pathogens. The method allows the attributable fraction (relative contribution) of food vehicles and other risk factors for foodborne diseases to be determined to allow prioritisation of prevention programs. In the Hunter, we conduct case-control studies on *Campylobacter* and *Salmonella*. Cases are interviewed by telephone, and unmatched controls are selected by alternatively adding or subtracting a digit from case telephone numbers until a control is found. Information is obtained on five types of exposures (travel, water for consumption and recreation, food storage and preparation practices, food consumption, and contact with domestic and farm animals), and demographic details. Analyses compare the ratio of the odds of exposure to a range of foods between cases and controls (Schlesselman 1982).

In the development of a coordinated national program, it will be important to prioritise selected pathogens and high-risk food vehicles of public health importance for inclusion in case-control studies. Further assessment of risks faced by Australian consumers will be needed, however, some vehicles and pathogens can be proposed for prioritisation at this stage. The pathogens in Table 1 are proposed based on their incidence in Australia and/or their virulence.

Table 1:* *Candidate foodborne pathogens for national or regional case-control studies.

- Campylobacter species
- *Salmonella Typhimurium*
- *Salmonella Enteritidis*
- *Listeria monocytogenes*
- Shiga toxin producing *Escherichia coli* (STEC) and/or Haemolytic Uraemic Syndrome (HUS)
- Antimicrobial resistant Salmonella and Campylobacter
- *Yersinia enterocolitica*

Prioritisation of pathogens

Campylobacter infection has the highest reported incidence rates nationally of pathogens associated with foodborne illness. There have been between 10-13,000 cases per year nationally since 1994, without including cases from New South Wales, which are likely to add another 3000 to 4000 cases (Communicable Diseases Network-National Notifiable Diseases Surveillance System, pers. comm.). Preliminary analysis of the Hunter case-control study is defining food vehicle-specific risk factors for infection (Hunter Public Health Unit, unpub).

Salmonella Typhimurium should be prioritised for investigation as it is the most common serotype of *Salmonella* reported in Australia and in each state or territory, except the Northern Territory in 1999 (National Enteric Pathogens Surveillance Scheme 1999). Of the 5000 to 8000 cases of

Salmonella reported annually, approximately 2000 to 3000 cases of serotype *Typhimurium* are reported nationally each year. (National Enteric Pathogens Surveillance Scheme 1999). A case-control study of this serotype may shed light on the causes of the more common phage types (PT) of *S. Typhimurium* which are PT 135, 64 and 9.

Salmonella Enteritidis is the third most frequently identified salmonella serotype in Australia with 368 cases being reported in 1999 (National Enteric Pathogens Surveillance Scheme 1999). While most cases of *Salmonella Enteritidis* are acquired overseas the ever-present risk of introduction of this bacterium into egg laying flocks requires vigilant monitoring.

Listeria monocytogenes is reported to cause approximately 60-70 invasive infections nationally per year (Communicable Diseases Network- National Notifiable Diseases Surveillance System, pers. comm.) and is associated with a high case fatality rate (Farber & Peterkin 1991). *Listeria* infection is particularly severe among the elderly, immune compromised people, pregnant women and neonates.

Shiga toxin producing *Escherichia coli* (STEC) and Haemolytic Uraemic Syndrome (HUS) cases are rare, however, the sequelae and case fatality rate for these infections demand that the risk factors for STEC infection in the Australian setting be defined as early as possible. Thus far, foods have only been implicated in STEC outbreaks on two occasions during outbreaks in Australia. In each case smallgoods were implicated (Centers for Disease Control and Prevention 1995a, McCall et al. 1996).

It might be worthwhile to include antimicrobial resistant *Salmonella* and *Campylobacter* in case-control studies. It will be important to conduct surveillance that is sensitive enough to detect the arrival of important new antimicrobial resistant organisms such as the emergence of *Salmonella Typhimurium* DT 104, as seen in the UK (Threlfall et al. 1997) and USA (Glynn et al. 1998). Of the 3762 strains of *Salmonella* tested for antimicrobial resistance at the Microbiological Diagnostic Unit in Melbourne in 1999, 516 (13.7%) were resistant to at least one antibiotic. Of these 516 isolates, 313 were known to be associated with overseas travel (almost certainly an underestimate), 77 (24.6%) were resistant (National Enteric Pathogens Surveillance Scheme 1999). These figures suggest that there are up to approximately 200 cases of domestically acquired antibiotic resistant *Salmonella* infection annually which may be sufficient to commence case-control studies nationally. Case-control studies have identified consumption of beef as a risk factor for antibiotic resistant *Salmonella* infection in the USA (Davies et al. 1996) and the UK (Wall et al. 1994).

Initial scoping studies will need to be done to determine how frequent resistance is among *Campylobacter* isolates. If resistance is too infrequent to commence case-control studies, it will be necessary to test a sample of isolates annually so that any emerging resistance can be detected. Overseas travel is likely to be the major risk factor for antimicrobial resistant infection at the moment so to focus on prevention of foodborne disease in Australia, the case-control study should probably be restricted to domestically acquired infection.

While *Yersinia* is not a priority nationally it has been a problem in some jurisdictions such as South Australia and Queensland (Communicable Diseases Network- National Notifiable Diseases Surveillance System, pers. comm.) It may be appropriate for some jurisdictions to focus on pathogens of interest to their state alone.

A number of other pathogens are responsible for foodborne illness which are not included in our priority listing for case-control studies of sporadic disease because they are transmitted primarily person-to-person (*Shigella*, *Calicivirus*), require expensive or nonroutine testing (*Clostridium perfringens*, *Staphylococcus aureus*, *Bacillus cereus*), or are extremely rare (*Clostridium botulinum*, *Vibrio* sp.). In addition, most of these organisms are not notifiable so it would be difficult to elicit reports from laboratories for sporadic cases. However, these organisms should be looked for in outbreak situations to help inform prevention for these pathogens.

Prioritisation of foods

The foods in Table 2 are candidates for inclusion in case-control studies because the method of production, processing or handling is inherently hazardous or because they have been implicated as vehicles of foodborne disease in Australia or overseas. The foods are proposed as core vehicles for inclusion, however, we must be careful not to limit studies to these foods or new and emerging vehicles may be missed. Over time, foods that are not found to be associated with disease should be replaced by new candidate foods. Foods, suggested by their new production methods or their association with disease in outbreaks or other case-control studies, can be added.

Table 2: Candidate high-risk foods for inclusion in case-control studies

• processed meats	• sprouts
• ground meats, especially beef	• "ground-grown" salad vegetables
• chicken	• unpasteurised milks
• shellfish	• eggs
• soft cheeses	

Case-control study questionnaires should continually evolve and must respond to emerging associations. For example, if an emerging association is found with "food x" then further questions pertaining to "food x" should be added to the questionnaire to define better whether the method of preparation, heat treatment, storage, level of consumption (dose), or brand of product is associated with illness or protective of illness. This will help identify prevention strategies.

Processed meats that do not involve a simple cooking "kill" step or other post-cooking processing, or may be subject to post-processing contamination, carry a greater foodborne disease risk (Lyytikainen et al. 2000). Organisms present on carcass surfaces can be mixed throughout ground meat lots, and in the absence of sufficient cooking ("kill" step), are capable of survival through to consumption. Ground meats have been implicated in outbreaks of *E. coli* O157:H7 (Centers for Disease Control and Prevention 1996, Cieslak et al. 1997) and Salmonella (Centers for Disease Control and Prevention 1995b; Roels et al. 1997), among other pathogens.

Repeated outbreaks of *E. coli* O157:H7 and Salmonella attest to the hazardous nature of sprouts (Centers for Disease Control and Prevention 1997b, Doyle 1999a; National Advisory Committee Criteria for Foods 1999; Ponka et al. 1995; Van Beneden et al. 1999). To prevent infection, contaminated sprouts could potentially be treated, however, *Salmonella* within the sprout can be protected from disinfection processes so there are no simple control steps for this food (Doyle 1999).

Minimally processed vegetables and fruits that will not be cooked before consumption are increasingly recognised vehicles for foodborne outbreaks. (Hedberg et al. 1999; Mohle-Boetani et al. 1999). Vegetables and fruit grown directly in or on the ground constitute the greatest risk due to the risk of contamination with soil bacteria or fertilisers contaminated with manure. Studies have shown that once fruit and vegetables are contaminated it is very difficult to sanitise them even with rinses containing high levels of chlorine (Doyle 1999b). Hence, it will be important to include horticultural products such as melons, lettuces, tomatoes, shallots, and strawberries in the case-control studies.

Chicken has been repeatedly implicated in foodborne outbreaks in Australia and elsewhere (Brennan et al. 1999; Eberhart-Phillips et al. 1997; Kenny et al. 1999; Victorian Department of Health and Human Services 1999). Chicken has been implicated as a cause of *Campylobacter* in case-control studies in New Zealand (Eberhart-Phillips et al. 1997) and in our preliminary analysis of case-control data in the Hunter (unpub.).

Unpasteurised milk from cattle and goats and their products can transmit a wide range of pathogens including *E. coli* O157:H7, *Listeria monocytogenes*, Salmonella, and Campylobacter (Hedrick et al. 1998; Keene et al. 1997; Villar et al. 1999; Wood et al. 1996). Soft cheeses also pose a risk of transmitting infection from Listeria, *E. coli* and Salmonella (Altekruse et al. 1998).

Consumption of oysters has resulted in foodborne disease outbreaks due to Calicivirus in Australia (Stafford et al. 1997) and elsewhere (Berg et al. 2000). The possibly greater concern is the risk of hepatitis A as occurred in the Wallis Lake outbreak of 1997 (Conaty et al. 2000). Because oysters are predominantly eaten raw and they are often grown in waters intermittently contaminated by sewage, they are likely to continue to be a foodborne disease hazard.

There have been several outbreaks of salmonellosis associated with eggs in Australia (Hanna et al. 1997; Millet et al. 1999), however, we have not experienced the epidemic of *Salmonella Enteritidis* seen in Europe and the United States. *Salmonella Enteritidis* Phage Type 4 in Europe and the United States and *Salmonella Enteritidis* Phage Type 8 and 13a in the United States have been responsible for egg-associated outbreaks of foodborne illness (Sobel et al. 2000).

With the recent confirmation of *Salmonella Enteritidis* phage type 4 in egg laying flocks in Hawaii in 1998 with associated human illness (Tauxe, R. 2000, CDC, pers. comm., November), we should not be surprised should *Salmonella Enteritidis* emerge in Australia in the next few years. Given that risk assessments predict that only one in 20,000 eggs need to be contaminated to present a significant public health problem (FSIS 1998), case-control studies may be the most sensitive way of identifying egg-associated *Salmonella Enteritidis* in Australia.

Early evidence will be crucial in limiting the impact of egg- related outbreaks as there are obvious needs to improve the handling of eggs from farm to plate. It is surprising to find that cartons of eggs labelled "keep refrigerated" are still displayed at room temperature for sale in supermarkets in Australia. Preliminary analysis of Hunter sentinel surveillance data suggests that raw or runny egg consumption (21%) is slightly more frequent than in the United States (Centers for Disease Control and Prevention 2000), which is approximately 16% and suggests that significant consumer education will be required in this country.

As the sentinel sites evaluate the timeliness of their *Salmonella* serotyping and phage typing and response to this information it will become clear whether the recruitment of cases is feasible once phage typing results are available, or whether recruitment should be initiated based on serotyping information to minimise delay.

Additional to information on consumption of prioritised foods, data on how thoroughly the foods were cooked should be collected. For example, participants could be asked "were the eggs hard-boiled or runny?", and "was the chicken pink?". Insufficient cooking of hamburgers, and eggs, among others, have been implicated in outbreaks of foodborne illness (Berg et al. 2000, Centers for Disease Control and Prevention 1995b, 1996).

From the case-control studies conducted in the Hunter, data on consumption of high-risk foods has been obtained. Preliminary information is available on adults without disease (controls) interviewed regarding 7-day food history. Approximately 10% ate alfalfa sprouts, 24% ate undercooked meat, 7% ate undercooked poultry, 4% ate raw seafood, 21% ate runny egg, 66% ate processed meats and 1% drank unpasteurised milk (unpub.). This compares with the US, where in 1998/99 8% ate sprouts, 7% ate undercooked hamburgers, 2% ate undercooked roast chicken, 1% ate raw oysters, 16% ate runny eggs and 4% consumed unpasteurised milk (Centers for Disease Control and Prevention 2000).

Non-food risk factors such as contact with animals, overseas travel, and consumption of unprotected water, must be included to help to define the relative contribution to these infections of food compared to non-food factors. Inclusion of non-food risk factors allows for better definition of foodborne risk factors by removing the non-food "noise" from the data through stratified or logistic regression analysis. Host-based risk factors such as age, immune-compromise, and therapies that may predispose subjects to infection, such as cancer chemotherapy, immunosupressive drugs, antacids or prior antibiotic therapy, should also be included to establish the relative contribution of foods to disease.

Integration with Laboratory Science

The commencement of the new national sentinel program seems an appropriate time to consider the introduction of innovative and improved laboratory detection methods. It will be important to ensure that cutting edge laboratory science is integrated within the surveillance methodology. Some suggested laboratory methods for consideration are given in Table 3.

Table 3: Laboratory methods that could be integrated into sentinel surveillance programs

Enhanced detection:

- Shiga toxin
- Caliciviruses (formerly known as Norwalk-like viruses)

Standardised subtyping:

- Listeria (PFGE*, ribotyping)
- Salmonella (ribotyping, PFGE)
- Campylobacter (PFGE, RAPD**)
- *Clostridium perfringens* (PFGE)
- Caliciviruses (sequence analysis)

Antimicrobial resistance:

- Salmonella (on-going)
- Campylobacter
- Listeria

**Pulse field gel electrophoresis, **Randomly amplified polymorphic DNA*

Enhanced detection

STEC infections, the most common precursor to HUS, appear to be rare in Australia (Sintchencko et al. 1998), however, not all jurisdictions test systematically for STEC infection. The rate of HUS among children <15 years of age in Australia is reported to be 0.8/100,000 (Elliot et al. 1998) compared to 1.1/100,000 among those <16 years of age in the US, based on FoodNet data (Dunne et al. 2000). If it is assumed that for every HUS case there were 20 symptomatic STEC infections then there would be approximately 600 symptomatic STEC infections per year in Australia. The 1 in 20 ratio is based on US data where O157:H7 may be more common than in Australia. Non-O157:H7 serotypes appear to be more frequently detected in Australia (Goldwater & Bettleheim 1995). Of 21 strains collected from 1994-1998 causing HUS in children only three were O157:H- and none were O157:H7 (Australian Paediatric Surveillance Unit 2000). The multiplier of 20 may overestimate the incidence of STEC infection in Australia, however, it is almost certainly higher than the 107 cases reported to the National Notifiable Diseases Surveillance (NNDS) since 1997.

To improve our ability to identify point source outbreaks and perform useful case-control studies we will need a systematic approach to screening stool for Shiga-toxins. The two most likely methods are Polymerase chain reaction (PCR), or a commercial Enzyme-linked immunosorbent assay (ELISA) for STEC. The ELISA may be the best option as it is technically less complicated and will cost approx $2200 to screen 94 specimens, however, commercial PCR tests may prove cheaper and more sensitive. Because of the rarity of STEC infection in Australian studies thus far, it may be efficient to only screen bloody stools that are negative for other bacterial pathogens.

Caliciviruses (formerly known as Norwalk-like viruses or small round structured viruses) are increasingly being recognised as one of the most common foodborne disease pathogens. This pathogen was rarely detected in outbreaks in the past because diagnosis relied on electron microscopy of stool within the first few days of onset or serological tests that were not widely available. With the advent of PCR for Caliciviruses they are being increasingly recognised as a major cause of outbreaks, and sequencing is allowing epidemiological links between seemingly disparate outbreaks to be identified and the detection of similar sequences in humans and epidemiologically implicated food (Glass et al. 2000). Since significant morbidity is associated with Caliciviruses it will be important better to define the epidemiology of this pathogen in Australia. Calicivirus infections in the community are spread through person-to-person contact. The small infectious dose of this pathogen leads to dramatic outbreaks when infected food handlers contaminate food (Fankhauser et al. 1998) or when oyster beds become contaminated (Stafford et al. 1997). Because of the frequent person-to-person transmission it would not be worthwhile (from the perspective of a foodborne disease research program) to include Calicivirus infections in case-control studies. However, it will be essential to test stool for Calicivirus (by PCR) in foodborne outbreaks that are not caused by common bacterial pathogens. In particular, when the prevalence of vomiting is greater than 50% and the incubation period is 24 to 48 hours, testing for Caliciviruses should be considered (Hedberg 1993).

Standardised subtyping

Molecular typing will be important for identifying clusters, enhancing analysis of case-control studies (to allow restricted analyses of like-strains rather than comparing "apples with oranges"), and investigating outbreaks (Table 3). Methods such as pulse field gel electrophoresis (PFGE) (Ahmed et al. 2000), RAPD (Landers et al. 1998) and ribotyping (Harrington et al. 1999) can allow differentiation of strains. In recognition of the possibility that nationwide outbreaks of listeriosis could be missed without the aid of a standardised subtyping system, the National Public Health Laboratory Network is planning to implement standardised subtyping with central reporting of *Listeria monocytogenes* strains. PulseNet, the prototype system in the USA, has successfully identified multistate outbreaks that would have gone unrecognised had PFGE not been performed (MMWR 1998).

Investigation of *Campylobacter* infection should benefit from subtyping technology. While *Campylobacter* case-control studies in the Hunter have identified some risk factors, such as eating out of the home during the week before illness, other risk factors would be likely to be elucidated if a subtyping system could be used. One can imagine how inefficient studies of salmonellosis would be without the benefit of serotype and phage typing to differentiate between strains.

Clostridium perfringens still appears to be a frequent cause of foodborne outbreaks, but can be difficult to confirm because of the need to collect stool samples rapidly and have spore counts confirmed before they decrease. The use of PFGE to show that all cases involved in an outbreak are the same subtype (rather than a mixture of background strains) can help identify a common source outbreak long after spore counts have decreased below the level of accepted significance of 10^5; (Maslanka et al. 1999). Subtyping of *Clostridium perfringens* in epidemiologically implicated food can further strengthen the link.

Sequence analysis of Calicivirus strains detected from outbreaks has allowed the linkage between outbreaks. An example of the usefulness of the technique was the detection of a multistate outbreak of gastroenteritis following consumption of raw oysters (Berg et al. 2000). Sequence analysis has also permitted the trace-back of the cause of an outbreak in the US to a contaminated food item (Daniels et al. 2000).

Antimicrobial resistance

As described earlier, antimicrobial resistance among *Salmonella* isolates is routinely determined. Antimicrobial resistance of *Campylobacter* strains is not routinely performed and resistance among these organisms has emerged in the US and UK (Smith et al, 1999, Thwaites et al. 1997).

The above list of pathogens is not exhaustive and, in addition, sentinel sites will need to have access to tests for *Staphylococcus aureus*, Enterotoxigenic *E. coli*, and Bacillus species and their toxins; otherwise the epidemiology of foodborne disease will be biased by the limitation of our testing modalities.

Links with Food Science Laboratories

Outbreak investigations have identified, and will continue to identify, failures in HACCP programs. To understand why an outbreak has occurred and what can be done to prevent future outbreaks it will be important for food scientists to add value to epidemiological investigations. Quantification of bacterial load in food vehicles responsible for outbreaks can help inform quantitative risk assessment. Inoculation and challenge studies can help define which control points are "critical" and identify new controls. By simply determining the number of cells of *Salmonella napoli* in chocolate required to cause infection in a single outbreak, it was recognised that previous assumptions that large inocula were required to cause salmonellosis, were incorrect (Greenwood & Hooper 1983). Such findings have considerable implications for HACCP programs and quantitative risk assessment.

Conclusion

Without reliable surveillance data, anecdote and politics could drive food safety policy. The stakeholders in this project are many, they include Australian consumers, federal and state health, food safety, and agricultural departments, the food industry at multiple levels, and our trading partners. The stakeholders need to have the best estimates of foodborne disease burden possible. They need to know which foods and processes are most hazardous and what can be done to reduce the hazard. They need to know which sectors most need HACCP programs and when HACCP plans fail, as some inevitably will, they need to know why.

The project offers an opportunity for a concerted effort to examine the extent, burden and causes of foodborne disease. Routine surveillance activities will be undertaken, as will aggressive investigation of outbreaks with centralised reporting. Obviously, all of the projects suggested in this paper cannot be incorporated into a program that will only run for two years. However, we hope the range of options for case-control studies in conjunction with enhanced laboratory capabilities outlined in this paper will provide 'food for thought' and a stimulus for discussion.

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Correspondence to:
Craig Dalton
Hunter Public Health Unit
PO Box 466
Wallsend, New South Wales, 2287
AUSTRALIA
Email cdalt@doh.health.nsw.gov.au

The Intergovernmental Context in Reforming Public Health Policy: The Introduction of a New Food Safety Policy in Victoria

James C. Smith

JCS Public Health Planning, Victoria

The relationship between the Victorian Department of Human Services and local government for the delivery and coordination of public health services is longstanding, and the nature of the relationship is grounded in the hierarchical models of control. In this model of control the central authority formulates policy and legislation, and local government authorities implement the legislation at their own cost. Despite the longstanding hierarchical model of control the effectiveness of this intergovernmental relationship is open to question. The recently developed State government food safety reform, the Victorian Food Hygiene Strategy, is in difficulties. Part of the difficulty originates from the poor understanding of what makes a reform different from the usual organisational changes, the process used to develop and implement the policy, and poor management of the intergovernmental relationship.

Key Words: *Food Safety, Intergovernmental Relationships, Local Government, Food Policy*

The 1997 changes to food safety policy in Victoria signaled a new approach to achieving safe food. The changes were consistent with national and international trends in food safety. This paper examines the introduction of the new food safety policy within a public health system that is based upon a longstanding intergovernmental relationship between state and local governments. It also considers the ways that changes at the national level impact on state arrangements. This paper has a focus on the state and local government intergovernmental and policy implementation issues, and the implications these issues have for the development of public health policy.

Background

In 1854 the then Colony of Victoria passed the first Health Act which closely reflected the 1848 English Public Health Act (Bidmeade & Reynolds 1997; Cumpston 1989; Gordon 1976). Importantly, although the colonial government undertook the development of legislation, the implementation of the sanitary reforms was delegated to local government. Thus was established the public health administrative system which exists to the present day and consists of two organisations, the central Department of Health and the 78 local government authorities which collectively make up the local government sector.

In Victoria, the roles and responsibilities of local authorities are controlled by state legislation, and, in the case of public health functions, by the provisions of the Health Act 1958 and the Food Act 1984: "In some cases, as with the health regulations, they [local councils] are virtually policing standards determined by the States" (Neutz 1974, p. 79). Historically, the Health Act and its various amendments, has provided the central authority with controls over the resources, reporting, implementation, administrative decisions, and regulation making powers of the local authority (Smith 1995). Bidmeade and Reynolds (1997) also point out that the 19th century public health laws were developed using a top down process and were, as a consequence, prescriptive and draconian. However, in the late 20th century there has been a move away to less draconian legislation. Nonetheless, it was within this top down, or hierarchical, context that the basis of the relationship between local and central government in public health was firmly established.

In 1905 Victoria proclaimed the first Pure Food Act in Australia (Cumpston 1989). Since that time, the federal and some state governments have been attempting to establish a national agreement and a working legislative framework, for uniform food hygiene and safety legislation (National Food Authority 1993; National Food Authority 1994). Eventually, agreement was reached on food composition and labeling standards. For the last six years attention has been focused on uniform food hygiene standards. The establishment of the National Food Authority (Australia New Zealand Food Authority [ANZFA]) was stimulated because of concerns about the lack of uniformity of food safety legislation and its administration, international trends in food hygiene reform, and the need to reduce the reported incidence of food borne illness in Australia (National Food Authority 1994).

The most significant aspect of the national approach to food hygiene and safety was a change in the style of regulation used by the state and territory jurisdictions. The current style of regulation consists of prescriptive food standards with a reliance on state, territory and local governments for enforcement (ANZFA 1996b). Generally, the activities associated with the prescribed standards included registration of food premises, random hygiene inspections of food premises and food handling, investigation of consumer food safety and quality complaints, and, in the case of Victoria, the acquisition of food samples for analysis. ANZFA (1994, p. 17) argued that these "command and control" type of food safety activities should be emphasised less and replaced with less prescriptive regulation, and with a greater emphasis on industry responsibility. The ANZFA's approach was described as "co-regulatory". It argued that the trends in many other countries were to remove the prescriptive requirements of legislation and replace these with general goal or outcome orientated legislation (ANZFA 1994, p. 19). Over regulation actually takes responsibility away from industry and often creates a culture of meeting bare minimum requirements in food safety (ANZFA 1996a).

Of importance, however, was an argument grounded in both a public health and an economic rationale, that the prescriptive regulatory approach was in itself not a preventative approach:

Importantly, however, the reforms are designed to transfer the often substantial costs of failure of the current end-product inspection and testing approach to an investing in substantially enhanced preventative measures to improve food safety (ANZFA 1996b, p. 9).

The costs of failure are the increasing incidence and cost of food borne illness outlined in Table 1.

Table 1: Incidence and cost of food borne illness in the USA and Australia 1992-1994

	USA	Australia
Estimated number of illness per year	6.5M to 33M	0.46M to 2.3M
Estimated number of deaths per year	Up to 9,000	Up to 630
'Cost of illness' per year (for seven specific pathogenic bacteria) i.e. resources the community would save by avoiding food borne illness	$5600M to $9400M	$487M to $825M
'Willingness to pay' per year (for five specific pathogenic bacteria) i.e. the value people would put on safe foods	$6600M to $22000M	$575M to $1900M

Source: ANZFA 1996b, p. 8

It should be noted that the Australian values were derived by the ANZFA through the extrapolation of the data from the United States on a per capita basis (ANZFA 1996b) that may or may not reflect the situation in Australia. In addition, ANZFA (1996b) observed that the bad publicity and consumer anxiety associated with food recalls and food poisoning incidents negatively affected an industry employing 700,000 people and with a turnover in excess of $80 billion.

The ANZFA's specific preventative measure to improve food safety is the food safety program (FSP) that is based on the Hazard Analysis Critical Control Point (HACCP) risk management approach. It is proposed that all food businesses with one or more hazards in their operations be required, over the next six years, to develop and implement a FSP.

The Victorian Food Hygiene Strategy

For well over 120 years the State of Victoria has had a food safety control system designed to prevent the sale of food that is harmful or injurious to health. The mechanism for achieving food safety standards was based upon the performance of food hygiene surveillance activities by local government authorities. Under the provisions of the legislation each local government authority has had the responsibility of ensuring that food businesses comply with the legislation and that food sold in the municipality is safe for human consumption. The legislative mechanism used for food safety control was initially the Health Act, but because of the public health and economic importance of the food industry, a Food Act specifically addressing food safety standards was proclaimed in 1984.

The specific food hygiene surveillance activities of local government rested on sets of prescriptive regulations made under the Health Act and Food Act which pertained to the physical cleanliness of food premises, food handler behaviour, and the construction, fittings and maintenance of the food premises. An oversight by the then Department of Health and Community Services in 1994, whereby a regulatory impact statement was not prepared for replacement regulations, saw the automatic expiration of these sets of food safety regulations. Consequently, local government has had to rely on the general and non-prescriptive provisions of the Food Act 1984 and hastily developed, but non -mandatory, Codes of Practice.

The well publicised outbreaks of food borne illnesses in Victoria in late 1996 and in early 1997 sparked the development of the Victorian Food Hygiene Strategy by the state government. The Strategy was based on the ANZFA's proposed national standard with its underpinning risk management approach and Food Safety Programs. The Food (Amendment) Act 1997 (Vic) required the development of a food safety program by all food business owners in the State estimated to number around 40,000 premises. Local government was required to assess and approve the Programs and, thereafter, ensure that the Program implemented in each food business was adequate (Victoria, Legislative Assembly, 6th May 1999). Victoria was the first Australian jurisdiction to apply the risk management approach in food safety that had been advocated by ANZFA. As part of the Strategy the government established within the Department of Human Services a specific administrative unit, Food Safety Victoria, and a Food Safety Council to advise the Minister for Health on strategic issues of food safety (Department of Human Services 1997a; Victoria, Legislative Council, 19 November 1997).

In terms of implementation it was the government's intention to schedule the introduction of FSPs so that by the end of 2000 all businesses would have a FSP. This schedule attempted to categorise food businesses on the basis of public health risk. Class A food businesses were seen to be the highest risk category as they provided food to vulnerable groups such as the elderly and the very young. Consequently, these businesses were required to comply with the earliest timeline. The other classes (B, C and D) reflected risks associated with the type of food sold, whether it was potentially hazardous food, packaged or non-packaged, and whether it would be cooked prior to consumption. The schedule also reflected a notion held by Food Safety Victoria that a food safety program could be divided up into four elements: a training program; hazard analysis; hazard control; and a recall procedure. Each of these would have a corresponding milestone date.

Numerous issues associated with the interpretation and application of the legislation together with regulatory implementation issues resulted in a revised schedule for the introduction of food safety programs.

Table 2: Revised Implementation Schedule for Food Safety Programs

Class	Business profile	Compliance date
A	Business selling food to vulnerable groups	31 March 1999
B1	A food premises or food vehicle employing 20 or more Full Time Equivalent Employees and selling unpacked potentially hazardous foods which are not intended to be consumed as cooked or otherwise treated immediately prior to consumption OR a charitable or community group's food selling events involving 20 or more volunteers	31 Dec 1999
B2	A food premises or food vehicle employing 19 or fewer Full Time Equivalent Employees and selling unpacked potentially hazardous foods which are not intended to be consumed as cooked or otherwise treated immediately prior to consumption OR a charitable or community group's food selling events involving 19 or fewer volunteers	31 March 2000
C1	A food premises or food vehicle employing 20 or more Full Time Equivalent Employees and selling potentially hazardous foods which are intended to be consumed as cooked or otherwise treated immediately prior to consumption OR a charitable or community group's food selling events involving 20 or more volunteers OR a food premises or a food vehicle or a charitable or a community group selling non-potentially hazardous food which is unpacked	30 June 2000
C2	A food premises or food vehicle employing 19 or fewer Full Time Equivalent Employees and selling potentially hazardous foods which are intended to be consumed as cooked or otherwise treated immediately prior to consumption OR a charitable or community group's food selling events which involve 19 or fewer volunteers OR a food premises or a food vehicle or a charitable or a community group selling non-potentially hazardous food which is unpacked	30 Sept 2000
D	Businesses selling packaged foods only	31 Dec 2000
E	A fundraising body for a charitable or community group which: • intends to conduct 12 or fewer food selling events per year OR • had a turnover of less than $15,000 in the previous financial year for the same activity	31 Dec 2000

Source: Adapted from Victorian Government Gazette 1998, 20 August

The revised schedule reflected a substantial change in policy in that the milestone dates and the sequence of food safety program development were omitted from the schedule. There was a re-categorisation of food businesses that was based on employee numbers and the type of food sold, and the recognition of fundraising activities by charitable groups. The rationale for the re-categorisation thus moved from public health risk to a mixed rationale reflecting, inter alia, the size of the food business, and, in the case of Class E businesses, the motivation for selling food including the frequency and amount of food sold. The new schedule did not affect the Class A food businesses as the compliance date for this Class had already passed when the new schedule was gazetted. Interestingly, the overall time frame for the introduction of food safety programs still remained at 31st December 2000.

A survey undertaken by Food Safety Victoria indicated that only 47% of Class A food premises had submitted their food safety programs as required by 31st March 1999 (Department of Human Services 1999). A further survey by the Australian Institute of Environmental Health (AIEH 1999) indicated that compliance by Class A premises with the time frame at the end of May 1999 (two months after the legislated compliance date) was approximately 78%, with only 3% of these being assessed and approved by local authorities.

Clearly, the results of both surveys indicated that the implementation of the reform was only marginally successful. It was critical that there was 100% compliance by the Class A businesses as they were not only the first test of the Strategy but they were considered to have a better capacity, compared with the other classes of businesses, to comply with the legislative requirements. The level of assessment of the food safety programs by local authorities also tended to be a critical indicator of the success of the reform given that local government has the key enforcement role under the legislation. An assessment rate of only 3% as at the end of May clearly underscored a serious problem with the implementation of the reform.

Reform and Implementation of the Food Safety Policy

The difficulties associated with the development of the Strategy, within a reform process, may be understood in a number of ways. Administrative reform is essentially a political process (Alaba 1994; Painter 1990), and is best understood from a political perspective. However, unlike other forms of organisational change, administrative reform is characterised by comprehensive rather than incremental change (Alaba 1994). Painter (1990, p. 77) observed that administrative reform is a political process in that "… societal values impinge on and ultimately shape the nature of administrative systems" and that the motivation for:

> *… making changes in administrative structures or procedures within public services, [is] because they have become out of line with the expectations and values of the social and political environment* (Chapman & Greenaway cited in Painter 1990, p. 76).

The initiation of the Victorian Food Hygiene Strategy came at a time when the government was facing increasing pressure for action both from the broad community and the media regarding a spate of food borne illnesses and food contamination incidents (Department of Human Services 1997a). The reaction of the government was to develop a food safety reform strategy. However, the strategy development process excluded the local government sector and thus indicated a top down approach.

Comprehensive changes associated with reform are described in a number of ways in the literature. Sometimes change is described as a deliberate attempt to change the goals, structure and procedures of the bureaucracy (Abueva cited in Alaba 1994). Other descriptions include changes that attempt to induce new rather than to modify existing bureaucratic behaviour (Backoff cited in Alaba 1994; Leemans cited in Alaba 1994). The introduction of a risk management approach to food safety through the Food Hygiene Strategy was the first attempt in Australia to introduce such an approach in the entire food service area within a whole state jurisdiction (Department of Human Services 1997a). It represents an attempt to induce new behaviours within the bureaucracy.

Importantly, although the overall goal of achieving safe food remained unchanged, the structure and procedures of local government had to change in response to the new legislation and the ambitious timetable set for its application. Local government was now charged with assessing and approving programs that were required by legislation to contain several elements including the identification of all risks to food safety, the means by which these hazards were to be controlled, the means by which the controls would be supervised, details of how staff would be made competent in handling food safely, and the records that would be kept to demonstrate the adequacy of the program.

The legislation also required local government authorities to be satisfied that a program was adequate before granting the registration and renewal of annual registration of the premises and, additionally, to perform a specific inspection of the premises (Food (Amendment) Act 1997[Vic]). These new legislative requirements were in addition to the existing food safety responsibilities of local government (Municipal Association of Victoria 23 October 1998). Significantly, of the two organisations constituting the administrative system only local government was undergoing a reform process.

A critical policy issue arising from the development of the Strategy was the absence of an impact assessment of the proposed legislation on government and industry. Consequently, assumptions were made by the government regarding the capacity of the system, in particular, the capacity of local government to manage and implement the Strategy. The specific action strategies released at the time for the Food Hygiene Strategy make no mention of local government and the costs associated with implementing the legislation, although state government costs were both identified and quantified (Department of Human Services 1997b). The response by local government was to raise registration fees to cover the costs associated with assessing programs, managing risk, and developing management systems. The response by the Department of Human Services was to question the need for increasing fees and the expressed view that the Department "… does not believe that Councils' responsibilities under the Food Hygiene Strategy add significantly to those responsibilities under the previous legislation" (Department of Human Services 1998). Further, the Department requested that councils justify the rise in fees and if found unreasonable and counterproductive to the state's aims would recommend to the government capping of the fees (Department of Human Services 1998).

Given that local government was the focus for significant organisational change, the Food Hygiene Strategy may also be considered a reform due to the presence of significant levels of resistance that tends to be a feature of reform and not of other forms of organisational change (Alaba 1994). Reform can have a non-collaborative and coercive nature and tension may be associated with the proposed reform itself if, for example, there is an apparent contradiction in goals and values such as those goals associated with central control and with devolution (Leemans cited in Alaba 1994). Interestingly with this example, conflict between central agencies and operational organisations would appear to be inevitable (Aberbach et al. cited in Alaba 1994).

Backoff (cited in Alaba 1994) also commented that resistance can be triggered when there is incompatibility between the values associated with the reform and with the system being reformed, perceived irrelevance of the reform and the needs of the organisation, lack of participation, and high costs and risk. Problem tractability, the appropriateness of the implementation strategy, and the general support within the environment also determine the level of resistance to the reform (Sabatier et al. cited in Alaba 1994).

Carroll (1993) in discussing the Queensland government's reforms of all policy, legislation and regulations affecting business, asserted that such a reform would not be successful unless there were defined capacities within the government and the public service to perform such a reform. Specifically, these capacities pertained to undertaking a widespread and detailed policy analysis of the relevant policies and legislation, extensive policy and program design and redesign, and effective and efficient implementation.

As seen above, there were opposing views held by the Department of Human Services and local government on the subject of responsibilities under the legislation and no impact assessment of capacity as recommended by Carroll (1993). A low level of commitment by local government to the Strategy would seem to have arisen from the absence of an implementation plan for the Food Hygiene Strategy, the increased workload and legal liability, the lack of participation in implementation decision making, and inconsistency between the espoused partnership approach of the Department and the operational reality. The culmination of these issues was articulated in a Departmental memorandum:

> *Many stakeholders have not shared the Department's expectations about the implementation of the Act. Departmental interpretation of the intention and wording of the Act and the relatively simple changes in practices that were anticipated is not reflected in the behaviour or expressed expectations of stakeholders and interest groups* (Department of Human Services 1999).

Clearly, there was recognition that

values, perspectives and expectations were not shared. Despite this recognition, the Department continued to make decisions and make recommendations to the Minister to amend the legislation to simplify implementation for local government (Department of Human Services 1999; Victoria, Legislative Assembly, 6 May 1999), without any acknowledgment of or systematic consultation with local government.

Conclusion

The public attention and criticism associated with the outbreak of food borne illness in 1996-97 galvanised the state government into developing and launching, in the presence of the invited media, the Food Hygiene Strategy. This is consistent with the idea that reform is a political process (Alaba 1994; Painter 1990) initiated, in this instance, when the then existing food safety strategies were not consistent with the expectations of the social and political environment (Painter 1990).

The Strategy itself constituted what in the literature is described as an administrative reform (Alaba 1994) whereby the Strategy was a comprehensive rather than an incremental change in food safety. The comprehensive change involving the Strategy was an attempt to induce new behaviours within the local government bureaucracy (Backoff cited in Alaba 1994; Leemans cited in Alaba 1994). In terms of structure, changes included the creation of Food Safety Victoria (FSV) within the Department of Human Services that was charged with the responsibility for all food safety matters across the whole of government, including coordination through local government.

Although the overall goal of reducing food borne illness had not changed with the introduction of the Strategy, reshaping of aims rather than transforming predetermined aims (Brunsson et al. 1993), the procedures and objectives by which this goal was to be achieved changed completely. The changes in approach and procedure were captured under the 'co-regulation' banner whereby industry had to demonstrate compliance using a specified technical tool (food safety program), and local government had to assess and approve such programs. Currently, Victoria is the only state in Australia to have introduced this co-regulatory approach.

Surveys undertaken by Food Safety Victoria and the Australian Institute of Environmental Health indicated a decided slowness in industry compliance and local government assessment processes. This tends to support the notion that the Strategy is a reform requiring comprehensive change.

The notion of resistance to reform being a feature of a reform and not necessarily a feature of organisational change (Alaba 1994) is particularly pertinent to this paper. The Strategy itself caused tension in that the associated legal liability and costs were borne by local government and attempts to recoup the additional costs were met with threats by the state government, seemingly in contradiction with the espoused business principles of the state government (Leemans cited in Alaba 1994).

Probably the most outstanding feature of the Strategy, in terms of reform, was its essential non-collaborative and coercive nature (Leemans cited in Alaba 1994). The outcome was conflict between two parts of the system, the local government sector and the Department of Human Services, which was inevitable according to Aberbach et al. (cited in Alaba 1994). Apart from the non-collaborative and coercive nature of the development of the Strategy, other triggers for resistance associated with the Strategy were the lack of participation, high costs, high legal risks, and the appropriateness of the implementation strategy.

Has the Food Hygiene Strategy reform been a success? Although it is early in the implementation phase, the literature and evidence to date indicate that there is high resistance and low commitment to the Strategy. This is a critical indicator of success within a public health administrative system that relies on positive intergovernmental relationships for the implementation of central policy.

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Correspondence to:
James C. Smith
JCS Public Health Planning
PO Box 278
Rosanna, Victoria, 3084
AUSTRALIA
Email jcs@optushome.com.au

A Shady Profile: A Community Perspective

Melissa J. Stoneham, Cameron P. Earl, Diana Battistutta and Donald E. Stewart

School of Public Health, Queensland University of Technology

Australia has the highest incidence of skin cancer in the world increasing at a rate by around 5% each year (Gies et al. 1998). There is ample evidence to associate skin cancer with exposure to ultraviolet radiation from the sun (IARC, 1992). To address this issue, the implementation of comprehensive, integrated strategies is required. Local governments adopting shade creation policies to complement current action to increase shade at public facilities is one such strategy to improve the environment and ensure sustainable public health outcomes. Community support for local government shade creation projects can influence the development of local shade creation policies. To explore this notion in more depth, community consultation through a random telephone survey of residents from three local governments that have adopted shade creation polices was undertaken. The survey revealed that almost all respondents considered shade a high priority both for themselves and from a community perspective, and this was influenced by factors such as being a parent and personal or family experience with skin cancer. Despite this high priority for shade creation, the study identified limited involvement by the community in the local government policy development process. A further finding was the low level of community awareness that a shade creation policy existed within their local government. The results from this project assisted local government authorities by allowing reflection on past performances in policy development, and has the potential to contribute to future planning from policy interventions.

Key Words: *Skin Cancer, Policy, Shade Creation, Local Government, Community Participation*

Australia has the highest incidence of skin cancer in the world and the rate of skin cancer has been increasing by around 5% each year with the most recent Australian Bureau of Statistics figures attributing 1281 deaths to skin cancer in 1996 alone (Australian Bureau of Statistics 1998; Gies et al. 1998). This is despite substantial efforts to improve sun safe behaviour through various health promotion interventions.

There is ample evidence to associate skin cancer with exposure to ultraviolet radiation (UVR) from the sun (International Agency for Radiation Control 1992). Exposure to UVR accounts for approximately 70% of all skin cancers (Hoffman 1987). Avoiding excessive sun exposure can reduce the risk of a number of diseases including skin cancer (Giles, Marks & Foley 1988). To reduce the rates of skin cancer it is necessary to change the behaviour of the community. This requires the implementation of comprehensive and integrated strategies.

The development of healthy public policy in a local community setting is one such strategy. Incorporating an ecological view of health including factors from the economic, social and physical environments, healthy public policy has the potential to influence the individual and collective decisions that people make (Draper 1988). In this way, personal preventive measures can be complemented by environmental and structural change. This reduces the onus on the individual, and creates sustainable and healthy environments within local communities.

Local government authorities are well placed to influence local communities in Australia as they are the only locally based structure with a mandate to influence the natural, man-made, social and economic environments in which people live (Harris & Wills 1997). Local government action to increase shade at public facilities is one method of improving the environment, similarly, adopting formal shade creation policies is one way of stimulating structural change to ensure sustainable outcomes.

However, it appears that local governments have been slow to develop formal policy relating to the creation of shade. Queensland University of Technology has been investigating why local governments differ in the adoption rates of shade creation policies. The research has already identified barriers and facilitating factors associated with the adoption of shade creation policies and has included a focus on three local governments that have formally adopted shade creation policies (Stoneham & Harrison 1997).

Healthy public policy requires informed public participation in the process of priority setting, strategic planning and decision-making. Public participation aims to ensure accountability to the public interest, or to the general interests of the consumers affected by the programs (World Health Organization [WHO] 1988). Community support for healthy public policy developed by local government such as shade creation policies can have a major influence on the policy development process. To explore this notion in more depth, community consultation through a random telephone survey of residents from each of three local governments was undertaken. The aims of this telephone survey were to identify the level of input of the community in policy development, adoption and implementation processes, and secondly, to ascertain the community's support for shade creation as a skin cancer prevention strategy.

Methods

Questionnaire

The questionnaire was designed to be completed over the telephone in a relatively short period of time (5-10 minutes) and included basic demographic data, gender, age group, parental status and personal and family experience of skin cancer.

The main component of the questionnaire involved a number of key questions that related to the policy development process and included:

- Were the community members aware that their local government had adopted a shade creation policy?
- What level of input did the community have into the policy development process?
- Was there potential for future input from the community into the policy cycle?
- Was local government the best placed agency to create shade at public facilities?
- What value did community members place on shade from an individual and community perspective, and
- Had the community seen any evidence of shade creation within their communities?

The sample

A survey of Queensland and Northern New South Wales identified only three local governments who had formally adopted shade creation policies. The local government areas included in this survey were Kingaroy Shire Council, Banana Shire Council and Lismore City Council. Both Kingaroy and Banana are rural Shires in Queensland, with agriculture being the primary source of income. Lismore is a coastal city that has become a major tourist destination based on the beauty of its environment.

The sample was randomly selected from each of the three local government areas, using the electronic white pages (EWP). The telephone calls were made between the hours of 4.30pm and 7.30pm, Monday to Thursday and each number attempted was contacted a maximum of five times. Each interviewer was given training using a package developed specifically for this project and initial calls were conducted in the presence of the trainers to assist with reliability of the data collected.

A logistic maximum of telephone numbers contacted for the three Shires was 1120 resulting in a final response from 483 residents (43%). The response rates for the individual local governments included 201 for Banana Shire (51%), 166 from Kingaroy Shire (45%) and 116 from Lismore City (32%). The response rate of the households approached was affected by the inability to contact residents after repeated attempts (31%) or refusal to participate in the survey (26%).

Statistical methods

Associations between categorical variables were summarised in tables showing counts and percentages. This study was conceptualised as an exploratory study so no formal hypothesis testing was performed on the data.

Results

Representativeness of the sample

Data collected on age and gender were compared with the Australian Bureau of Statistics census data (1999) to ascertain the representativeness of the samples. The sample for Kingaroy Shire Council was considered representative of the general population but Lismore City and Banana Shire Councils were over represented. Females (Table 1) over represented the distributions of respondents in all three Shires.

Table 1: Representativeness of the sample respondents to age and gender distributions of their respective Shires.

	Kingaroy		Banana		Lismore	
	Survey	ABS	Survey	ABS	Survey	ABS
Gender %						
Female	63.6	51.6	64.0	46.8	62.9	52.0
Male	36.4	48.4	36.0	53.2	37.1	48.0
Age Group (Years)						
18 –35	33.7	32.1	30.8	37.0	19.0	36.4
36-45	19.3	21.4	28.9	22.3	21.6	22.3
46-55	19.3	16.5	22.4	15.6	26.7	15.6
56-65	11.4	11.8	9.0	10.4	12.1	10.4
>65	16.7	18.2	9.0	15.2	20.7	15.2

The distribution of respondents indicating that they were parents was similar across all three local governments: Banana 87.1%, Kingaroy 82.5% and Lismore 84.5% respectively.

Experience with skin cancer

About one third of the respondents in the survey had self-reported personal experience with skin cancer, varying from 28.2% in Lismore, to 42.9% in the Banana Shire area. Similar results were noted for family history with skin cancer, with the Banana Shire area citing 43.9% through to Lismore which cited 25.3% (Table 2).

Table 2: Previous experience with skin cancer

Local Government Area	Personal experience (%)	Family experience (%)
Kingaroy Shire Council	28.9%	30.8%
Banana Shire Council	42.9%	43.9%
Lismore City Council	28.2%	25.3%
Total	100%	100%

** A further two respondents were aware of the policy but no response was recorded against this question*

Public involvement in the adoption and implementation of the policies

Of the 60 respondents aware of a policy, five (8.6%) were involved in the adoption process by either completing a consultation questionnaire (n=2) or through advocating for the policy (n=3). Further, from the 60 respondents, 10 (16.9%) were also involved in the implementation process of the policies, with the planting of trees (n=5) being the most common involvement cited. There were only two respondents involved in both the adoption and implementation of the policy and both were residents of Banana Shire Council. From the data collected, all the respondents involved in the adoption process (n=5) and nine of the ten respondents involved in the implementation were parents.

Recognition of council's role in shade creation

Forty six percent (46%, n=220) of the respondents identified that Council had a role in shade creation for public places. This response is based on asking whether the respondents associated their Council with the provision of shade at public facilities. The respondents (n=220) identified the three most common facilities to be parks (25%), swimming pools (18%) and natural and built shade in the central business districts (12%).

Community perspectives on shade as a cancer prevention strategy

Overall, individuals placed a high personal priority on shade. The total percentage of respondents who nominated shade as a priority, high or very high priority was 93.5%. The respondents were also asked to comment on the general community's priority for shade, and most indicated considerable priority for shade with a total of 97.5% of responses indicating a priority, high, or very high priority.

Seventy-two percent of the respondents who considered shade a very high priority both from an individual and a community perspective were women. No significant differences were identified in the responses from males and females for the other categories.

Forty percent of the respondents who indicated shade was a low or no personal priority were aged between 18 and 35 years.

Table 4: Comparison of three Local Government areas and value placed on shade from an individual and community perspective

Priority for Shade	Very high	High priority	Priority	Low priority	No	Total
Personal						
Banana	57.2%	30.3%	8.5%	3.0%	1.0%	100% (n=201)
Kingaroy	51.2%	33.7%	8.4%	5.4%	1.2%	100% (n=166)
Lismore	58.2%	19.8%	12.1%	8.6%	0.9%	100% (n=116)
Community						
Banana	59.2%	28.9%	9.0%	0.0%	2.0%	100% (n=201)
Kingaroy	45.8%	41.0%	12.0%	1.2%	0.0%	100% (n=166)
Lismore	57.8%	28.4%	10.3%	3.4%	0.0%	100% (n=116)

Personal = Respondents were asked to identify their personal priority for shade.

Community = Respondents were asked to identify the community's priority for shade.

Reasons for identifying shade as a priority

The respondents were also asked to identify the reasons why shade was a priority. Having children (36.5%), the hot climate (23.0%) and protection from UVR (9.0%), were prominent in the community priority for shade, and these were similar for the personal reasons. Some reasons varied from the respondents' personal priority for shade. These included elderly people who enjoy shade (9.0%), children who like to use shade while playing (9.0%), and within a farming community there is so much cleared land that any shade is appreciated (4.5%).

Table 5: Reason Identified for Personal Priority for Shade

Reason Identified for personal priority for shade	% of Responses (N = 54)
Protection from UVR	24.7%
The hot climate	21.5%
Having children	20.5%
Having fair skin	15.4%
Have fair skin	9.2%
Work outdoor	6.2%
Family history of skin cancer	1.5%
I like trees	1.5%
Total	100%

Discussion

Almost all respondents across the three local government authorities indicated that shade was a high priority both for themselves and for the community. This was influenced by factors such as being a parent, and personal or family experience with skin cancer. Despite the high priority for shade creation, the study identified limited involvement by the community in the policy development process. A further finding was the low level of community awareness that a shade creation policy existed within their local government area.

The inclusion of the community in all phases of health related policy formulation and the dissemination of relevant information is considered important in the development of healthy public policy (WHO 1988). Health promotion research indicates that when the community has input into the development of strategies, there is greater acceptance, awareness, ownership and compliance (WHO 1986, 1988). There is little evidence from the survey that these factors had any impact on the process used to develop shade creation policies in any of the local governments. This is further confirmed by the low percentage of awareness of the policy (12.4%), indicating that the consultation processes used by local governments involved in this study were unsuccessful in consulting with the community during the development of their shade creation policies. Effective diffusion requires many strategies and the use of formal and informal communication channels (Orlandi et al. 1990). The findings from this research indicate that one of the most successful forms of disseminating information about policy development to the community, was through local government initiated contact such as council newsletters and personal contact with council officers.

Attempts were made by local governments to inform the community of the policy development process, however, they appear to have generated little reaction from the community. This is demonstrated by the low percentage of residents involved in the adoption (8.6%) and implementation (16.9%) phases.

Although input into the policy process was limited, 46% of the respondents confirmed that their local government was actively creating shade at public places in the local community, with swimming pools and parks being the most reported venues for shade creation activities. Parliamentary debate (Rogers 1995) recognised this type of activity and described the success of local authorities as being measured not by their size, but by the quality of services delivered and by the value that is gained from taxpayers' money. The challenge for local governments is twofold. First, local governments must find ways to include community participation in decision making processes, and second must instigate potential measures to identify whether the community values activities such as the creation of shade.

The survey indicated that being a parent has had considerable influence on the involvement in the development process of shade creation policies. This is supported in the literature where research has indicated that awareness of sun safety is heightened once becoming a parent (Robinson 2000). This was evident by parents comprising the majority of the respondents (87%) who were aware of the shade creation policy. One hundred percent (n=5) of the respondents involved in the adoption, and 90% (n=9) of the respondents involved in the implementation, of the shade creation policies were parents.

Over 87.5% of the respondents who were able to identify local government's role in shade creation, were parents. Ninety percent (90%) of the respondents who indicated they had a very high personal priority for shade and 88% of the respondents who indicated their local community had a very high priority for shade were also parents. All respondents in the Kingaroy sample group who were aware of the shade creation policy were parents, and had at least a priority for shade with 50% indicating that shade was a very high priority. Over 87.8% of the respondents who were parents in Lismore had a high or very high priority for shade compared to 65.8% of the respondents who were not parents.

Conclusion

The community based telephone survey demonstrated that gaining useful data from the public could be a relatively simple and effective way of gaining evidence to support local health promotion interventions. These data assist local governments when reflecting on how past performance in the policy development cycle can assist future planning for policy interventions. Specifically, the data indicated trends in the effectiveness of councils' communication dissemination channels, the level of community participation in the policy development process, local self-reported incidence of skin cancer, the value placed on shade creation, and whether the community acknowledged an increase of shade within their local government areas.

Anecdotal evidence suggests that there is a lack of evaluation data on comprehensive programs that address individual and environmental approaches to sun safety. Further research is needed to identify barriers to the development, adoption and implementation of shade creation policies in community settings. This study focused on local governments, being the closest form of government to the people. There is a need to continue these types of studies, as local governments are key organisations that can positively influence many outdoor facilities where people gather.

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Correspondence to:
Melissa Stoneham
School of Public Health
Queensland University of Technology
Victoria Park Road
Kelvin Grove, Queensland, 4059
AUSTRALIA

What Do Environmental Health Officers Need to Know About Native Title? Adopting a Precautionary Approach

Ed Wensing

One of the misconceptions surrounding native title is that it only arises in an area if there is a native title claim or determination. Nothing could be further from the truth. Native title is an existing right that originates in indigenous law and custom (as opposed to a Crown grant). As such, it pre-exists European settlement and, in certain areas, continues to the present day. Native title is a common law right that may already exist over areas of Crown and other land or waters owned, controlled or held in trust by local councils, state/territory and federal governments, irrespective of whether there are any native title claims or determinations in the area.

Environmental Health Officers (EHOs) working for local councils or other government agencies may be responsible for approving or authorising activities on land or waters where native title exists or may exist, such as the issuing of licences to conduct camel rides on a public beach. Under the *Native Title Act 1993* (Cwlth), these are called future acts.

As decision makers on matters affecting Crown land and other areas where native title exists (co-exists) or may exist (co-exist), Environmental Health Officers may be responsible for complying with the requirements of the *Native Title Act 1993* (Cwlth), and complementary state/territory legislation. The *Act* provides for the recognition and protection of native title, and such rights and interests cannot be extinguished contrary to the *Act*. EHOs with land or water management responsibilities should therefore, know how to work effectively and competently with native title.

Acts affecting (extinguishing, impairing or limiting the enjoyment and exercise of) native title rights and interests are known as 'future acts' under the *Native Title Act 1993* (Cwlth). In order to ensure that future acts are valid in so far as native title is concerned, certain processes under the *Act* must be followed. This means that some EHOs will need to become familiar with the processes in the *Act* to ensure that whatever activities are carried out in an area where native title exists or may exist, is valid in so far as native title is concerned.

The effects of invalidity are less certain. Native titleholders may be entitled to damages or other common law remedies for any activities that invalidly impact on their native title rights and interests. Following the correct native title processes and adopting a precautionary approach to native title matters will ensure that:

- everyone's legal rights are recognised;
- the agency's exposure to any claim for damages is minimised if not eliminated; and
- following the proper procedures will ensure that development outcomes are lawful and valid in so far as they affect native title.

A Precautionary Approach

So, what is involved in adopting a precautionary approach? The Australian Local Government Association (ALGA), with the assistance from the Aboriginal and Torres Strait Islander Commission (ATSIC) and the National Native Title Tribunal (NNTT), has developed a six-step action plan that local Councils can adopt to implement a precautionary approach to native title matters. Indeed, the Action Plan is suitable for use by any non-native titleholder, not just local councils.

Step 1 Search

For Step 1, examine the Registers and the Schedule of Applications held by the National Native Title Tribunal or the equivalent state/territory body to establish whether there are any determinations of native title, registered Indigenous Land Use Agreements (ILUAs), registered claimant applications or unregistered native title determination applications in an area in question. If the search reveals the existence of an application, a determination or an agreement, then the registered claimants or common law native title holders will be entitled to certain procedural rights under the *Native Title Act 1993* (Cmwlth) for acts that affect their native title rights and interests.

As an existing right, native title may exist in an area irrespective of whether or not there is an application or determination of native title.

Step 2 Analyse

For Step 2, analyse what you should do where there are any registered native title bodies corporate, registered native title claimants, or unregistered native title applicants on the Registers or the Schedule of Applications, or where there are no native titleholders or claimants entered on the Registers or the Schedule. Registered native title claimants, registered native title bodies corporate and Native Title Representative Bodies will be entitled to be notified and may be entitled to either the 'right to negotiate', the 'right to be consulted', the 'opportunity to comment' or the same procedural rights as an ordinary or freehold titleholder in relation to certain future acts that are to take place in areas where native title exists or may exist.

Remember that native title may exist in an area whether or not there are any applications or determinations in an area.

Step 3 Becoming a party

Your agency may need to decide whether or not to become a party to any native title applications in the area, and, if it chooses to become a party, whether the best method of resolving the matter is by negotiation of an agreement or by litigation. According to Lane and McRae (1999, pp. 412):

> …*litigation is not an efficient method for determining the existing rights and obligations of negotiating parties. The primary interest in the question of whether to litigate or negotiate, from an economic perspective, should be, which alternative produces the greatest possibility of satisfaction of a party's interests at the least cost? Even on an intuitive level, the balance comes down firmly in favour of negotiation.*

Experience internationally, and in our short history of native title, indicates that agreement is the most economically and socially efficient way of resolving uncertainties about land title, access and the doing of future acts.

Step 4 Identify

This step is divided into three parts and by carrying out each part sequentially, you or your agency will be able to identify where native title may exist or has been extinguished in relation to all land or waters owned, controlled or held in trust by your agency or the local council.

First, the requirements to maintain inventories of all land and waters that are owned, controlled or held in trust by any particular agency will vary within and between jurisdictions in Australia. So it may be necessary for you or your agency to begin by establishing such an inventory.

Second, it may be necessary to conduct a tenure history search. The purpose of such a search will be to establish from s23 of the *Native Title Act* 1993 (Cmwlth), and state/territory legislation enacted pursuant to s23E of the *Native Title Act* 1993 (Cmwlth), whether there have been any extinguishing events in any of the land or waters owned, controlled or held in trust by your agency.

Third, examine all tenure histories and site inspection reports to identify any acts that took place in the past and that may have extinguished native title by being completely inconsistent with its continued existence or co-existence. An alternative approach is to reach an agreement with any native title holders/claimants for the relevant areas.

This is a complex step and it may be necessary to seek independent professional advice.

Step 5 Future acts

Your agency may be proposing to carry out an activity in relation to an area where native title exists or may exist. If so, it should do so validly and follow the correct processes.

Activities that take place in relation to land or waters are referred to as acts under the *Native Title Act 1993* (Cmwlth). Any act that a government agency carries out in an area where native title exists or may exist may impact on native title rights or interests. Acts affecting native title that take place after 1 January 1994 and do not fall within the definition of intermediate period acts or past acts, are referred to as future acts. To carry out a future act validly in an area where native title may exist, the correct processes must be followed irrespective of whether there are any native title determinations or applications in the area.

For each kind of future act, there will be specific processes to follow under the *Native Title Act 1993* (Cmwlth) or, in some cases, under state/territory legislation. By following the correct processes under the *Act* and/or complementary state or territory legislation, you or your agency can ensure that any future acts in relation to an area are valid in terms of their effect on native title. An agreement may also be reached with native titleholders and/or claimants to validate future acts.

For a future act to be valid to the extent that it affects native title, it must come within one of the provisions in the future act hierarchy in the *Native Title Act 1993* (Cmwlth). If not, it will be invalid to the extent that it affects native title (s24OA of the *Native Title Act 1993* (Cmwlth)). If a future act does not fall within any of the provisions in the future act hierarchy the only way of ensuring validity is to negotiate an Indigenous Land Use Agreement.

This is also a complex step and it may be necessary to seek independent professional advice.

Step 6 Negotiate agreements

In a native title context there will always be a need for agreements.

The 1998 amendments to the *Native Title Act 1993* (Cmwlth) strengthen the status of local and regional agreements between native title holders and other parties, including local councils and state/territory governments, by providing flexibility, certainty and mechanisms for enforcement. These amendments were widely supported by all stakeholders. The amendments mean that agreements about the use of land between native title holders or claimants and other interest holders remain the most important way of resolving native title matters. Indeed, the more complex processes can be avoided by negotiating an agreement with native titleholders and claimants.

There is ample opportunity for the parties to resolve native title matters by agreement in the interests of good governance, in a way that maintains and promotes community cohesion as well as providing certainty. Local councils, state and territory governments, infrastructure agencies, private companies and private individuals can also benefit from a productive working relationship with Aboriginal peoples and Torres Strait Islanders, especially where the parties are able to work together for a common purpose or purposes.

Agreements between Indigenous and non-Indigenous Australians can be about any matter or matters the parties choose and they can be negotiated at any stage.

Conclusion

At the very least, EHOs with land and water management responsibilities need to:

- identify the areas where native title no longer exists, for example areas covered by private freehold, grants of exclusive possession or public works;
- highlight the areas where native title may continue to exist;
- keep an inventory of where native title has been determined by the Federal Court;
- consult with registered native title bodies corporate, registered native title claimants and/or unregistered native title applicants to obtain a better understanding of native title matters; and
- have a reasonable understanding of what can and cannot be done in terms of native title rights and interests in areas where native title exists or may exist.

As a prudent management strategy, native title should be included as a consideration in all dealings involving land where it cannot be established beyond doubt that native title has been extinguished. Adoption of a precautionary approach in relation to native title matters will ensure your agency meets its obligations under the *Native Title Act 1993* (Cmwlth) and complementary State or Territory legislation. This can only be done by following the correct processes.

Disclaimer

This information is provided as guidance only. It does not constitute legal advice. It should not be relied upon as a substitute for independent professional advice on any particular matter.

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Note: Copies of the Australian Local Government Association Guides can be obtained by contacting the Australian Local Government Association on Tel: 02 6281 1211, Facs: 02 6282 2110 or by email on alga@alga.com.au or visit the ALGA web site at <www.alga.nativeTitle.htm> Summaries and order forms can be accessed on the web site.

Ed Wensing is an independent planning and land management consultant and is a co-author of *Working with Native Title: A Practical Guide for Local Government* and the author of *Working out Agreements: A Practical Guide to Agreements between Local Government and Indigenous Australians*, published by the Australian Local Government Association. Ed can be contacted on 02 6241 6361 or by email on edwensing@ozemail.com.au, or web site at <www.auspics.com>

Nationally Consistent Food Safety Standards for Australia

Tania Martin and Liz Dean

Australia now has national food safety standards. The Australia New Zealand Food Authority worked on the development of these standards in conjunction with the State and Territory health authorities, local government and industry representatives and experts on food safety.

Three of the new standards are mandatory. The fourth standard is voluntary. This paper introduces the new standards and then discusses the implications of the three

Existing State and Territory food hygiene regulations differ between jurisdictions. They are often prescriptive and inflexible in nature. They include requirements related to food quality rather than food safety and in some cases they are out-of-date. In addition, they generally rely on the inspection of a food business by an enforcement officer to identify any breaches of the legislation and situations that need remedial action.

These shortcomings were recognised in 1995 when State and Territory health ministers asked the Australia New Zealand Food Authority (ANZFA) to develop nationally uniform food safety standards for Australia.

Australian health ministers approved three of the four new standards when they met, as the Australia New Zealand Food Standards Council, in July 2000. The Council had previously deferred consideration of the fourth standard for food safety programs, and requested further study of the efficacy and costs of these programs for a range of food businesses.

Pending the results of this work, but taking into account decisions by some States and Territories to proceed with the introduction of food safety programs, in November 2000 health ministers agreed that the standard for food safety programs should be adopted as a voluntary standard. This means that where States and Territories do implement a requirement for food safety programs, the requirement must be consistent with this voluntary standard.

The four new standards form Chapter 3 of the Food Standards Code. The standards are:

Standard 3.1.1 *Interpretation and Application*
Standard 3.2.1 *Food Safety Programs*
Standard 3.2.2 *Food Safety Practices and General Requirements*
Standard 3.2.3 *Food Premises and Equipment*

The new standards are less prescriptive than the old regulations, and can also be justified on food safety grounds. They are based on a preventative approach that should serve to reduce the incidence of food borne illness in Australia. They also reflect international best practice and the standards of Australia's trading partners.

Standards 3.1.1, 3.2.2 and 3.2.3 are mandatory. Standard 3.2.1 *Food Safety Programs* is the only voluntary standard.

The New Mandatory Food Safety Standards

Table 1 sets out some key points of difference between the existing hygiene regulations and the new mandatory food safety standards.

The new measures set out the food safety outcomes that a business must achieve, and outline safe food handling practices in ways that should help businesses to assess the safety of their own operations. Businesses will have more direct responsibility for the safety of the food they handle and sell, but they will be able to achieve this in different ways.

Table 1: Some differences between the existing hygiene regulations and the new food safety standards

Points of contrast – the new against the old	Existing food hygiene regulations	New food safety standards
Consistency vs inconsistency	The hot water sanitising temperature for eating and drinking utensils varies considerably–70°C, 74°C, 75°C, 77°C, or no temperature is specified.	Sanitising processes for eating and drinking utensils must be effective.
Outcome based vs prescription	The surface in contact with food must not, when treated with a 2% citric acid solution … contain a metal in a greater concentration than specified …	Only packaging material that is fit for its intended use and not likely to cause food contamination is permitted.
Flexibility vs inflexibility	A person must not sell potentially hazardous food if it is below 60°C or above 5°C.	Potentially hazardous food can be at temperatures between 5°C and 60°C, provided a food business can demonstrate that the safety of the food will not be compromised.
Modern vs out-of-date approach	Any appliance used for washing clothes must not be used for preparing food or for cleaning packages or appliances used for containing food.	Equipment must be fit for its intended use.
Food safety vs food quality	Frozen food must not be held above –15°C for longer than two hours in any period of 24 hours.	If potentially hazardous food is intended to be stored frozen, it must remain frozen during storage.

The New Requirements

The majority of the new requirements for food businesses are set out in Standard 3.2.2 *Food Safety Practices and General Requirements*. They are summarised in Table 2. Businesses operating safely now should find that compliance with these new requirements is a straightforward exercise.

Table 2: New requirements in Standard 3.2.2 Food Safety Practices and General Requirements

Requirement	Summary of the new obligations placed on food businesses
Skills and knowledge	Ensure that food handlers and supervisors have skills and knowledge in food safety commensurate with their responsibilities within the business.
Notification	Provide the appropriate enforcement agency with contact details and information on the nature and location of their food business.
Food receipt	Take steps to ensure food received into the premises is safe and suitable.
Food processing	Where a process step is needed to ensure the safety of a food, use a process step that achieves this outcome.
Food recall	Food businesses engaged in the wholesale supply, manufacture or importation of food must have a written recall system.
Health and hygiene	Food handlers are to be informed of their health and hygiene obligations.
Temperature control	If handling potentially hazardous food, businesses must have a thermometer accurate to +/- 1°C to measure the temperature of the food.

Standard 3.2.2 *Food Safety Practices and General Requirements* also includes specific temperature requirements for potentially hazardous food. These apply when food is received, stored, cooled, heated, displayed and transported. At the same time, the standard recognises that it is not always practical or necessary for potentially hazardous food to be maintained continuously at or below 5°C, or above 60°C. It introduces a new mechanism whereby businesses will be able to vary the way in which they meet the specified temperature control requirements for potentially hazardous food by using time as a control. However, they must be able to demonstrate that any alternative approach does not compromise the microbiological safety of the food. See Box for example.

Enforcement of the new requirements

Standards 3.1.1, 3.2.2 and 3.2.3 become enforceable from February 2001, depending on the regulatory situation in the different

A catering company working with potentially hazardous food decides that it is easier to use time control to limit the growth of food borne pathogens in food, instead of temperature. The company may do this if the total period of time without refrigeration will be no more than four hours, and if it has a process in place to demonstrate that this is so.

For example, the company keeps the total time for preparation and delivery to two hours, and keeps records of this. It labels the food before delivery with instructions to use it within two hours of delivery, or to refrigerate it on arrival and use it within two hours of its removal from the refrigerator.

NOTE: If the preparation and delivery time exceed two hours the food cannot be re-refrigerated and the food must be used immediately.

States and Territories. The requirement that food handlers and supervisors have food safety skills and knowledge commensurate with their duties within the food business and the notification provision in Standard 3.2.2 both come into effect from February 2002, to give businesses time to comply with these requirements. The notification provision does not duplicate existing registration systems and will affect only those food businesses not already covered by these existing systems.

Assistance with the new requirements

In August 2000, ANZFA published the first edition of an interpretative guideline to the food safety standards, entitled *Safe Food Australia*. This guide has been written primarily for the government agencies and environmental health officers responsible for enforcing food safety standards, as an aid to support the consistent interpretation and enforcement of the standards. The revised second edition of *Safe Food Australia* will be distributed to environmental health officers in the first part of 2001, through the State and Territory health authorities.

Safe Food Australia will also be available through the ANZFA website as a point of reference, in addition to the standards themselves, for food businesses and others who may have a more detailed interest in the intent behind the standards. This will include members of the many different professions with an interest in food safety, such as food safety trainers and food safety consultants.

Environmental health officers will be a key source of advice for businesses as they adapt to the new requirements in the standards as these are phased in through 2001 and 2002. In addition, there is industry and government recognition of a need for additional advice that is tailored to the needs of different food businesses, and in particular the smaller ones.

ANZFA has been working with State and Territory governments to identify these additional information needs and the best ways of meeting them. ANZFA's present plans include the development of additional material on subjects such as temperature control and the skills and knowledge and notification requirements, as a further resource for environmental health officers and to assist food businesses with the adoption of the standards. A separate guide will be prepared to support the introduction of the voluntary standard, Standard 3.2.1 *Food Safety Programs*, in those States and Territories that choose to adopt this standard.

Tania Martin and Liz Dean are Senior Food Scientists in the ANZFA Food Safety Program. They led the project team that worked on the development of Standard 3.2.2 *Food Safety Practices and General Requirements* and Standard 3.2.3 *Food Premises and Equipment*. They are the primary authors of *Safe Food Australia*.
Australia New Zealand Food Authority
P O Box 7186, Canberra MC, ACT, 2610, AUSTRALIA Telephone: 02 6271 2222,
Email: food.safety@anzfa.gov.au, Fax: 02 6271 2278 , ANZFA website: www.anzfa.gov.au

Agenda for Action 2000

Australian Institute of Environmental Health 27th National Conference - Cairns

Asian & Pacific Partnerships: Alliances for Action in the 21st Century
Local Issues within the Global Context
including the
Singapore AIEH/SOCEH Satellite Workshop on
Regional Environmental Health Perspectives

Conference/Workshop Resolutions and Actions

Prepared by Workshop Convenors: Martin Webb, President AIEH (Queensland Division), Peter Davey Vice President AIEH (Queensland Division), Mr Koh Geok Beng President Singapore Society of Environmental Health (SOCEH) and Anne Outram – Anne Outram & Associates – Consultant to the Australian Institute of Environmental Health, Queensland

This is the third conference that this Institute has been involved in the formulation of an Agenda for Action for the purpose of identifying strategic directions in the future. The satellite workshop held in Singapore after the national conference also elicited further action for collaboration in the Asia-Pacific region.

The Cairns conference delegates recommended that:

1. *There was a need for continued research, education and workforce development in the Environmental Health field*

   Action 1. Build public health partnerships to meet the global challenges in the 21st century through the process of improving action research.

   Action 2. Conduct a needs assessment for research and educational capacity building in the profession of Environmental Health and that the recommendations be assessed by the Institute's National Board.

   Action 3. Improve the environmental health workforce capacity to deal with local issues within the global context.

2. *Sustainable development should be an integral component of the everyday activities of the Environmental Health practitioner*

   Action 1. The Institute establishes a Special Interest Group called Sustainable Development for Environmental Health and formulate Policy Statements and Action Plans and that every Special Interest Group's Policy Statement and Action Plan incorporate the concept of sustainable development.

   Action 2. Assist the development of an agreed set of community environmental health action guidelines to help all members of local communities to work together confidently to a shared goal of security in their living environment, now and in the future.

Action 3. The Institute investigates ways to link sustainable development into the practice of environmental health across Australia and the Pacific Rim.

3. *Environmental Health practitioners should be cognisant with the principles of the Social Determinants of Health when planning programs*

Action 1. Develop partnerships and alliances to create holistic policies in environmental health that build on the physical, social, economic and cultural components of quality of life in communities.

4. *Activities in the Environmental Health profession move from a response role to that of health planning and prevention*

Action 1. The Institute encourages Environmental Health practitioners to build healthy and sustainable communities, using integrated Public and Environmental Health Planning models to develop healthy cities and community action, healthy public policy, programs and interventions.

Action 2. Integrate the outcomes of environmental health community needs assessment into both health planning strategies and town planning schemes in communities.

Action 3. Develop working partnerships and integrate the policies and programs of the health, environment and transport sectors to build health-promoting environments.

Action 4. Convene a workshop in 2001 to address ways of forming partnerships and alliances for public and environmental health, breaking down the barriers between the sectors, and discovering new ways to work with the 'organisational silos' that have environmental health outcomes outside of the health sector.

5. *The future profile of Environmental Health Practitioners within Local Government needs to be assessed*

Action 1. The Institute holds a symposium with other professionals working in the field of Environmental Health to look at ways we can work together to produce better health outcomes – the symposium should also look at building trust amongstthese professionals and information sharing.

Action 2. The Institute encourages Environmental Health practitioners to promote their skills at both the operational and strategic levels.

Action 3. The Institute promotes alliances across the sectors that have environmental and public health outcomes.

6. *The role of Environmental Health Practitioners involvement in disaster management needs to be profiled*

Action 1. The Institute promotes available training courses and the strategic involvement that Environmental Health practitioners and Local Governments have in that role.

Action 2. The Institute conducts an audit with those professions working in emergency management to ascertain their understanding of the public health implications and the number of people who are trained in the community

7. *Indigenous Health should be a major focus of Environmental Health activity in the profession*

   Action 1. Continue to work in partnership with communities and the key stakeholders in improving the living conditions of indigenous people in Australia.

   Action 2. Assist in the continued success of the environmental health workers education and training programs in Australia and provide practical experience for environmental health workers in local and state government and industry workplaces.

8. *Institute policies should reflect the conference outcomes*

   Action 1. State and National Special Interest Groups need to review and develop relevant policies and action plans consistent with the conference theme and outcomes.

The Singapore AIEH/Singapore Society of Environmental Health Satellite Workshop - Regional Environmental Health perspectives

Conference delegates noted:

1. That Environmental Health professionals consider local and regional environmental health issues within a global context and where possible work together in partnerships across the region to improve environmental health outcomes.

2. That a process of environmental health information sharing across the region be further developed.

3. That the environmental health profession engages more with industry and the non-government sectors in partnership to improve environmental health outcomes in communities.

4. That environmental health action be promoted as 'good business' in communities.

5. That there is a need to build capacity to undertake research and develop action on priority regional issues such as the following:

   - the food safety challenge
   - health planning
   - exotic mosquitoes and disease
   - managing waste
   - flexible education for environmental health professionals
   - regional partnerships
   - indoor air pollution, and
   - risk assessment and air pollution

6. That the awareness of environmental health values in communities needs to be raised.

7. That professionals need to recognise the importance of "mutual respect" when working in partnerships with other nations across the region.

The following Actions were agreed:

Action 1. That member nations of the International Federation of Environmental Health (IFEH) work in partnership to establish a Pacific Rim Regional Office of the IFEH and address regional environmental health issues in partnership.

Action 2. To administer this proposed office, that the AIEH agreed to establish a web-site within the existing AIEH web-site and provide links to the IFEH web-site. The web-site would be the first stage in providing an avenue to build networks, continue discussions and share information.

Action 3. That a Regional Meeting of the IFEH Pacific Rim Group be held at the next National AIEH Conference in Perth 14-19 October 2001.

For further information contact:

Australian Institute of Environmental Health
National Office
PO Box 77
Deakin West ACT, 2600.
AUSTRALIA
Email national@aieh.org.au

Population Health: Concepts and Methods

T. Kue Young

Oxford University Press, 1998, 315 pp. $99.95 (hardback)

My first impression of this book was 'why do we need yet another epidemiology textbook?' However, on further reading, I found my view changing to one of interest and enthusiasm. As an environmental health practitioner with some training in epidemiology and having dabbled a little in this field, I found that what held my interest was the way in which the author explained a range of epidemiological principles, and then weaved these into real-life public health situations. As the author describes in Chapter 1, population health is an area that has epidemiology as its core discipline, but uses these principles in conjunction with the disciplines of demography, sociology, geography, economics and anthropology to study the health of the population.

The book contains nine chapters. Chapter 1, the Introduction, sets the stage for what is population health. Chapter 2, Measuring health and disease in populations (I), describes concepts for measuring the frequency of occurrence of disease in populations, for example, incidence or prevalence, while in Chapter 3, Measuring health and disease in populations (II), the author overviews health status indicators. Chapter 4, Modelling determinants of population health, discusses the reasons why some populations are healthier than others, including the complex interaction of determinants, for example, genetic susceptibility or the physical environment. Chapter 5, Assessing health risks in populations, discusses risk assessment and disease causation. Quantitative and qualitative research methods are reviewed in Chapter 6, Designing population health studies, including an overview of bias, confounding, and other sources of error. Chapter 7, Planning population health interventions, looks at strategies for improving the health of populations. Evaluating health services for populations, Chapter 8, provides an overview of evaluation methods, and in Chapter 9, Improving the health of populations, the author proposes as an exercise for the reader that he or she uses the information provided in the previous chapters and applies this to a select population.

This is a single author text and benefits greatly from the consistency this method of authorship provides. What I found most beneficial was the way in which the core concepts were illustrated and explained through the extensive use of Boxes to explain terms and add supplementary information, and Case Studies that illustrated the concepts through discussing relevant published studies. Each chapter also contains Exercises further to challenge the reader. All statements of fact, direct quotations and numerical data are fully referenced in the Notes for each chapter, and these also discuss in more detail the concepts mentioned in the text.

Overall, this book did an excellent job in relating theoretical concepts to everyday practice, particularly through the use of actual data and published studies. As such, I would recommend this book to students and practitioners who are interested in population health and are looking for a text that is both instructional and reader-friendly.

Thomas D. Tenkate
Brisbane North Side Public Health Unit
Queensland Health
PO Box 1507
Fortitude Valley, Queensland, 4006
AUSTRALIA
Email Thomas_Tenkate@health.qld.gov.au

Environmental Health Risk Perception in Australia: A Research Report to the enHealth Council

Gary Starr, Andrew Langley and Anne Taylor

Commonwealth Department of Health and Aged Care, 2000, 94 pp.

This report presents a wide-ranging and detailed analysis of the perceptions of health risks of a representative sample of the Australian population. The survey reports on the perceived risks to health from a large number of environmental hazards, both to the Australian public as a whole, and to individual respondents and their families.

The study design and questionnaire were influenced by a similar study conducted in Canada in 1992. Telephone interviews were conducted in all states and territories during February 2000. A total of 2008 interviews were completed from an initial eligible sample of 3255 (a minimum of 2000 interviews were needed). Most of the losses in response were from refusals to be interviewed (454) or non-contact after six attempts (596). An overall response rate of 61.7% was achieved. Surprisingly, only 10 interviews were terminated. Due to the length of the questionnaire (114 questions), I would have expected more interviews to be terminated, and I am sure that the interviewers would have had to work hard at the latter stages of the interview to keep the respondents interested and maintain data integrity. Perhaps this shows that the Australian public is more interested in environmental health than we sometimes give them credit.

The top six issues perceived by the general public as having the highest risk were (in descending order): cigarette smoking, illegal drugs, suntanning, nuclear waste, crime and violence, and stress. The top six issues perceived as a high risk to the respondents' families were (in descending order): misuse of chemicals and poisons, food poisoning, chemicals in drinking water, mercury in fillings, and chemical termite treatments.

In general, people paid close attention to warning labels, felt that the greenhouse effect was a serious problem, tried hard to avoid chemicals in daily life, and smoking was rated as a high risk even by current smokers. The most used sources of information were the media (newspapers and magazines, followed by television and radio), however, confidence in the quality of information from these sources was not as high as that shown in information from medical doctors and government departments of health or environment.

Overall, the survey found that the public have a high level of concern about many environmental health issues. The results of the survey should assist government policymakers and agencies to more appropriately address public concerns, and provide insights into the best ways of distributing information about environmental health issues.

Thomas D. Tenkate
Brisbane North Side Public Health Unit
Queensland Health
PO Box 1507
Fortitude Valley, Queensland, 4006
AUSTRALIA
Email Thomas_Tenkate@health.qld.gov.au

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Environmental Health

The Journal of the Australian Institute of Environmental Health

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Each table and figure must be produced on a separate page, double spaced, numbered consecutively, and given a title. Tables should not duplicate information in the text. Each table and figure must be cited in the text and its position indicated.

Acknowledgments

Acknowledgments should be typed on a separate page, following the text. Where appropriate give credit to grantors, sponsors, technical assistants, and professional colleagues.

Endnotes

Notes which are in addition to references should be used sparingly. They can be numbered in superscript in the text and then listed as Endnotes before the Reference List at the end.

References

References should conform to the Australian Government Publishing Service 1994, *Style Manual for Authors, Editors and Printers*, 5th edn, AGPS, Canberra. Examples of referencing can be obtained from the Editor.

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