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...linking the science and practice of Environmental Health

Environmental Health

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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

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enHEALTH

The Environmental Health Committee (enHealth) is a sub-committee of the Australian Health Protection Committee (AHPC) which reports to the Australian Health Ministers' Advisory Committee.

OUR MISSION

The quality of life and health of Australians are underpinned by having clean water and air, safe food and housing, protection from pollutants and a program to intervene in the environment to prevent and control disease. enHealth will identify the Australian environmental health sector's role in developing and supporting infrastructure for health protection.

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- providing nationally agreed health policy advice
- implementing the *National Environmental Health Strategy 2007-2012*
- consulting with key stakeholders and consumers
- developing and coordinating research, information and practical resources on environmental health matters at a national level

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- a focus on supporting environmental health initiatives in Aboriginal and Torres Strait Islander communities
- more courses on disaster response (in conjunction with Emergency Management Australia)
- new resources to assist environmental health practitioners in their day-to-day work
- targeted training to enhance professional capacity

For more information go to the enHealth website at http://www.health.gov.au/internet/main/publishing.nsf/Content/ohp-environ-enhealth-committee.htm or email enhealth.secretariat@health.gov.au

The Environmental Health Committee (enHealth) sponsorship of the International Federation of Environmental Health 10th World Congress on Environmental Health received funding from the Australian Government, and the State Governments of Victoria, New South Wales, South Australia, Western Australia and Northern Territory.

The 10th World Congress on Environmental Health is upon us and it promises to be an exciting Congress with a world class speaking program. For those of you who aren't aware the Congress is being held from May 11 - 16, 2008 at the Brisbane Convention Centre. Further information can be obtained from the website www.ifeh2008.org

This issue contains five quite different articles in regard to content but they are linked to the theme of our first article Evaluating the Actions towards Environmental Health using DPSEEA and Program Logic (Jordan, Dunt, Dunn & Verrinder) which examines environmental health program planning and the use of program logic or program theory, within the DPSEEA framework (Driver, Pressure, State, Exposure, Effect and Action), as a tool for evaluating and improving environmental health planning, and thereby improving environmental health outcomes. Apart from the description and analysis provided by the authors of program logic, a number of observations were made including the complexity of environmental health problems and the need for a range of interdisciplinary and multidisciplinary professionals who can provide the requisite knowledge and skills to assist in addressing the identified problem. In addition it requires the cooperation of policy makers and other stakeholders including the broader community.

Environmental health emergencies and environment disaster management are key functions of environmental health professionals particularly at the local level. The article, Environmental Health Emergency Response to a Natural Storm Disaster in NSW, by Main, Ansell, Durrheim, Herlihy, Porigneaux, Tange, and Williams demonstrates the role EHOs play in disaster response and recovery phases of emergency management and, importantly, the authors provide an in depth description and discussion of the response and capacity of local public health resources. The key tasks of risk assessment, communication and mitigation are highlighted. Clearly, there is a need to ensure that adequate planning and preparedness are performed but, as the authors point out, there is a need for ongoing investment in capacity building at the local level so that there are adequate skilled personnel to respond to these events. With predictions that extreme weather events will become more frequent the area of local emergency management capacity building becomes extremely important.

From planning and responses to the natural environment Earl examines the built and social environments associated with crowds and outdoor music festivals. In this article there is an emphasis on planning for the event so as to reduce the uncertainty, or unpredictableness, associated with crowds. The article describes the importance to the environmental health practitioner of understanding crowd psychology and key factors such as demographic characteristics, crowd movement, artists, performances, and alcohol consumption that all potentially affect collective behaviour within crowds.

The last two articles examine two fundamental services associated with local government environmental health services. The first is focused on swimming pools. The authors Lau, Caughey, Rogers and Deacon ask the question are New Zealand School and Municipal Swimming Pools Clean and Safe? Although the authors do not offer any conclusions from their survey

there are indications from their discussion of the results that in relation to chemical parameters generally there is a higher rate of failure for school pools compared to municipal pools. From the microbiological perspective actually only one school pool failed. In comparison to a study conducted in 2001 this study showed that the school pool results were the same for pH, alkalinity and free available chlorine and worse for combined available chlorine and cyanuric acid. Microbiologically the results were better for *Staphylococcus aureus* and the same for *Pseudomonas aeruginosa*. It would be interesting to ascertain the relationship between the chemical parameters and risk of illness. The authors also suggest that it is not only bacteria but also fungi that could prove dangerous to health in pools if they are not correctly maintained.

The last article pertains to a comparative study by Moore, Dinnen, Saville and Ross of two methods of head lice treatment: a non-traditional method and treatment with a malathion based pediculicide. Of interest to those service providers who deal with head lice directly, or indirectly, the study found that using the extract/oil treatment was more effective than the 'traditional' malathion based treatment. The study reinforced how regular checking and immediate treatment has a major role in reducing the level of *pediculosis* in schools.

One of the important features underpinning these articles is that environmental health practice is a diverse field involving a wide range of disciplines.

Jim Smith
Editor

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Evaluating the Actions towards Environmental Health using DPSEEA and Program Logic

Helen Jordan[1], David Dunt[1], Louise Dunn[2], and Glenda Verrinder[3]

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This paper illustrates the integration of an approach used in program evaluation with an approach used by environmental health practitioners to provide a useful tool for program planning, evaluation and decision making for environmental health practitioners. A program logic approach that focuses on and links the 'actions' designed to improve environmental health with each of the components of the DPSEEA (Driver, Pressure, State, Exposure, Effect and Action) conceptual framework for indicator development is presented. Together, these approaches can be used to facilitate the evaluation of organised actions towards environmental health, and the effectiveness of these actions in attaining the goals that might be associated with any one or more components of the DPSEEA framework. These approaches also highlight the complexities of environmental health problems. They show the need for an interdisciplinary and multidisciplinary range of professionals to assist in addressing these issues. It is important to have an understanding that they are heuristic models, and can alter with improved knowledge of the mechanisms and conditions of the environmental problem and the intervention designed to address it.

Key words: *Environmental Health; Evaluation; Program Logic; Environmental Health Management; Environmental Health Planning*

Tools that can assist environmental health practitioners to evaluate actions towards environmental health need to be promoted. Many evaluation tools and approaches exist and are extensively described in the evaluation literature. Program logic, a systematic way of describing the logic underpinning a program, is one of these tools. It is used in the evaluation of programs across all disciplines from the planning stage to the step of interpreting and communicating the evaluation findings. It is used to illustrate the hypothesised or tested causal linkages between the processes, or organised set of actions, and the outcomes arising from these processes or actions. The United States Environmental Protection Agency (USEPA) promotes the use of program logic in recently developed guidelines for the evaluation of environmental programs (USEPA).

DPSEEA (Driver, Pressure, State, Exposure and Action) is a useful environmental health framework that allows practitioners to describe, heuristically, a logical conceptual sequence of events that leads to an environmental health problem. This framework can be integrated with the program logic approach to facilitate and strengthen evaluation of the actions towards environmental health.

The first section of this paper describes, separately, the DPSEEA framework, and the program logic approach that is often utilised in evaluation planning. The second section illustrates a number of applications in evaluation planning for these complementary frameworks. The paper then concludes by relating the use of these complementary approaches to policy development in environmental health.

DPSEEA Framework

The DPSEEA framework was developed and adopted as the conceptual framework for indicator development by the project HEADLAMP (Health and Environmental Analysis for Decision-Making, Linkage Analysis and Monitoring Project), jointly commissioned by the World Health Organization (WHO), USEPA and the United Nations Environment Programme (UNEP) (Corvalan, Briggs & Kjellstrom 1996). The DPSEEA framework was designed to support decision making in environmental health management, by describing environmental health problems from their proximal and distal causes to their health effects, and identifying areas for intervention (Pruss 2001).

The DPSEEA framework has three key applications within the wider HEADLAMP process described elsewhere by Corvalan and Kjellstrom (1996). First, DPSEEA can provide a framework for defining and validating the wider environmental health problem through the demonstration of known links between an environmental factor and its associated health outcome. Second, it can be used to guide the choice of data and indicators for compilation, assessment and quantification of the problem, and third, it can be a useful decision making tool for the formulation and implementation of policy toward improved environmental health. We propose and describe a fourth application. DPSSEA, when combined with a technique often used in the discipline of program evaluation, can be used as a tool to guide evaluation planning and interpretation, of the actions designed to address the environmental health problem, particularly when merged with the program logic approach.

The DPSEEA framework links the Drivers, Pressures, and State of the environment to Exposure and ultimately Effects on human health. Information on each of the links in the chain can inform decision makers of the mechanisms involving an environmental health problem, and consequently, assist them in choosing the most appropriate Actions or strategies to address the problem.

Within the DPSEEA framework, the D component of the chain refers to the Drivers, or driving forces, that "...motivate and push the environmental processes" that lead to detrimental health effects (Corvalan et al. 1996, p. 32). (See Box 1). The P component of the chain refers to the Pressures exerted on the State of the environment as a result of these Drivers. The Drivers and Pressures often relate directly to human occupation, exploitation or neglect of the environment.

Box 1:

Example 1	
Driver:	Use of coal to produce energy
Pressure:	Emission of greenhouse gases from power generators into the atmosphere.
State:	Increased global temperatures.
Exposure:	Exposure to vector borne diseases, reduced food productivity, weather disasters and extreme events, sea-level rise.
Effects:	Malaria, dengue, schistosomiasis, toxic algae and cholera, malnutrition, asthma, deaths and injuries due to extreme weather conditions, etc.

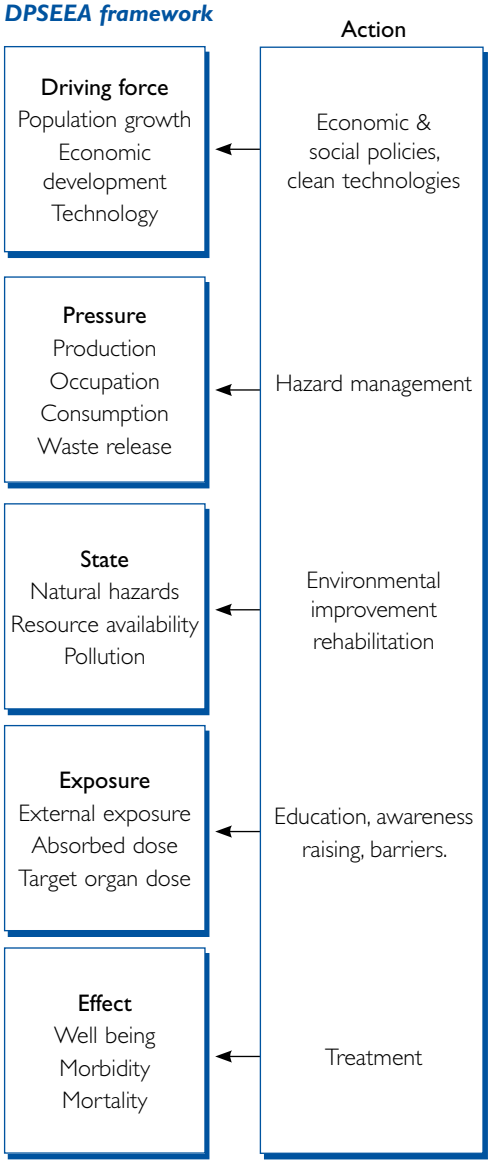
The S component of the chain refers to the State of the environment with respect to a physical or natural environmental hazardous situation, for example, floods, soil erosion, the presence of vectors, environmental pollution, or the availability and quality of natural resources (Corvalan et al. 1996).

The first E in the DPSEEA framework refers to Exposure. Exposure is "the intersection between humans and the hazards inherent in the environment" (Corvalan et al. 1996, p. 33). The second E in the chain refers to the health effects that result from the exposure to a hazard in the environment.

The A component of DPSEEA refers to the Actions. Actions depict those operations,

services, or programs that attempt to address any one or more of the five elements of the DPSEEA framework, which together define the environmental health problem. See Figure 1 for examples of actions and their relationship to the rest of the elements of the framework.

Figure 1: The linking of actions within the DPSEEA framework



Source: Modified from Corvalan et al. 1996. (Permission provided by World Health Organization 2007)

An action might directly address the Effects link in the chain, for example, the treatment of people who might be displaying the effects of arsenic exposure. Alternatively, an action or strategy might directly focus on the Exposure link in the chain, for example, by informing those living in areas with high soil arsenic concentrations to adopt behaviours to reduce their risk of exposure.

In most cases, it is expected that an impact on any link in the Driver, Pressure, State, Exposure or Effects elements of the chain will in turn impact on all successive linkages. For instance, an action that acts directly on the Driver, for example, Action 1, Figure 2, is also expected to impact on the Pressure, State, Exposure and subsequent Effect of the chain. While an action that directly addresses the Exposure link in the chain, for example, Action 2, Figure 2, is expected to impact on the Exposure and Effect.

Program Logic

According to Bickman (1987), the program logic, sometimes referred to as the program theory, is a "plausible and sensible model of how a program is supposed to work" , and is a description of the inputs, activities, and causal pathways that justify and describe the efforts put towards achieving a strategic outcome, and can include the conditions or factors necessary for those pathways to progress.

An outcome hierarchy is a component of the logic model that focuses on the outcomes expected to arise from the actions. Suchman (1967), Patton (1997) and Funnel (1997) along with other evaluation practitioners and theorists, promote the use of outcome or objective hierarchies as tools in evaluation.

To construct an outcome hierarchy, outcomes are described by their expected order of manifestation. By illustrating them in a hierarchical manner according to their means-end causative linkages, it becomes clear which are the proximal and which are the distal outcomes in relation to the program activities, and their expected order of manifestation in relation to each other, as illustrated in Figure 3.

Figure 2: An example of an action flow on the Driver, Pressure, Exposure, Effect pathway

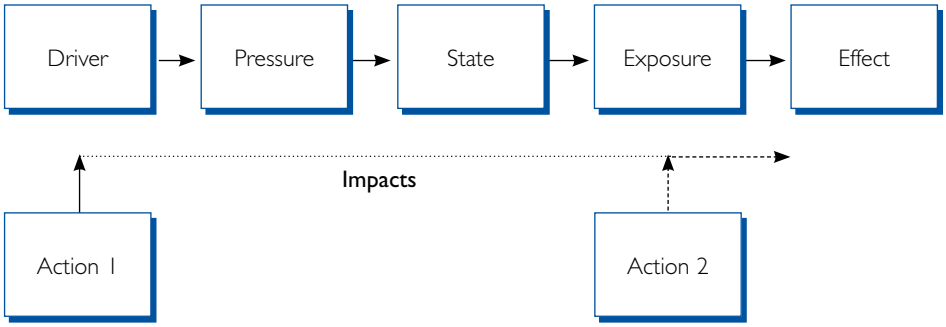


Figure 3: An outcome hierarchy for a service or program of actions aimed at reducing the transmission of blood borne diseases through unhygienic tattooing practices

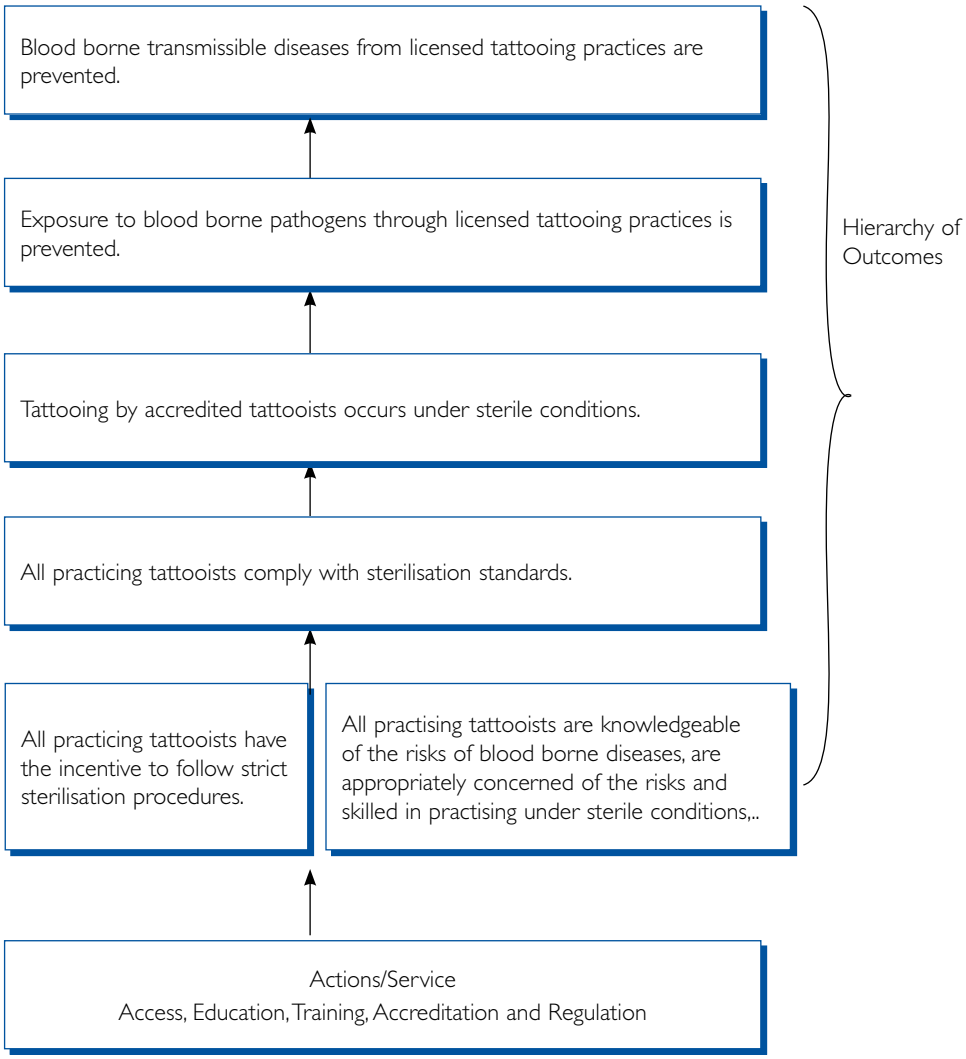
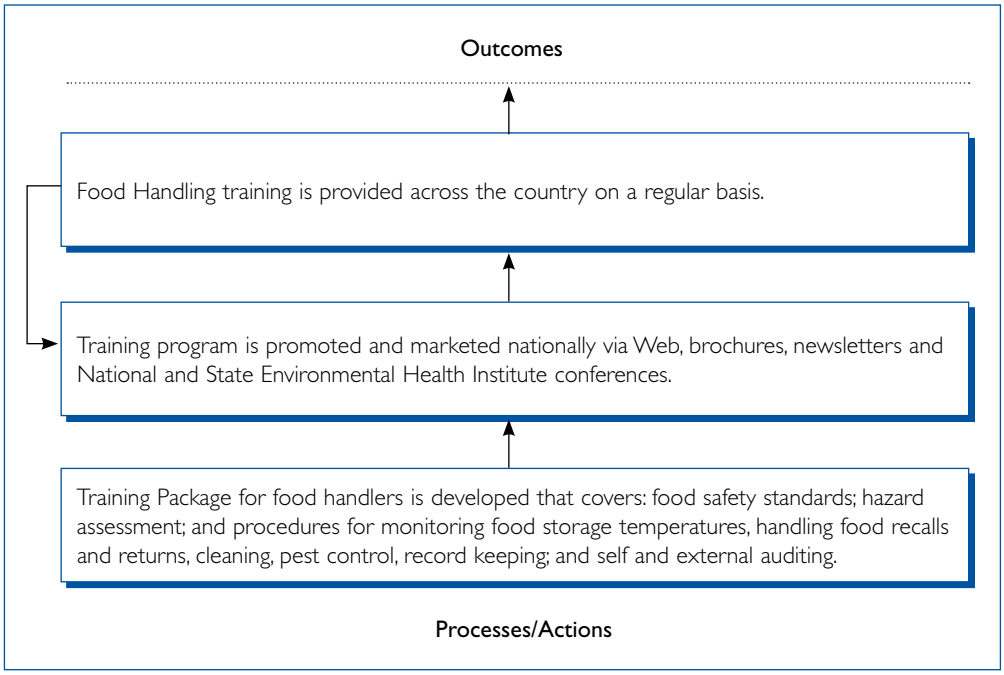


Figure 4: Pathway diagram illustrating the processes of a food safety training program and their linkages



The outcome hierarchy depicted in Figure 3 is unilinear, although programs often have a number of goals and associated streams of objectives or expected outcomes, and might have alternative causal pathways (Rogers 2008) or feedback loops as described below. In these cases, a multi-linear and multi-directional flow diagram could be used to illustrate the various arms of outcomes and how they may interact with each other.

In addition to outcomes, a program logic can illustrate the processes or actions as depicted in Figure 4.

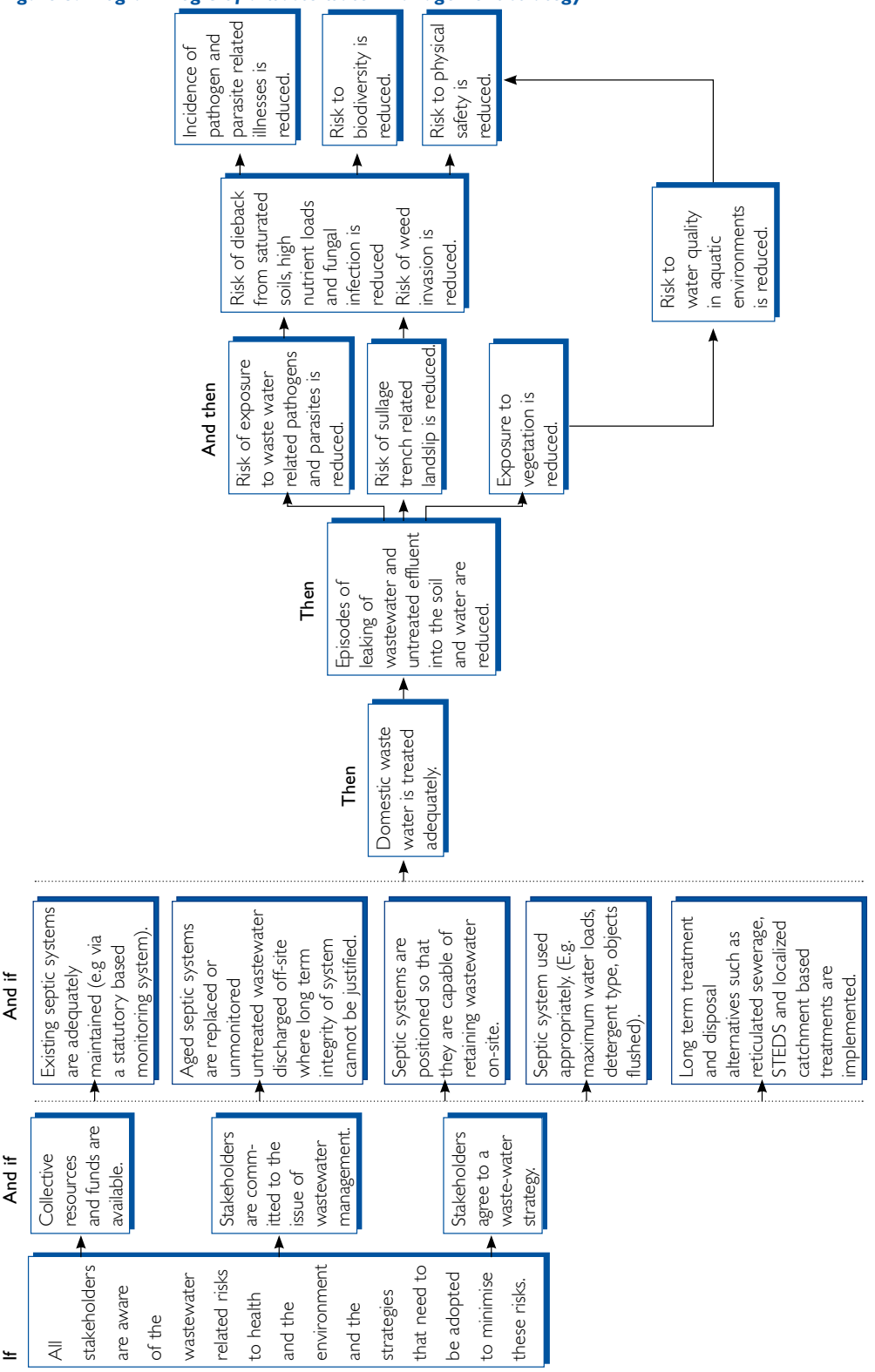
On their own, Figures 3 and 4 are only pathway diagrams. "Pathway diagrams [typically] do not include the operational detail that a logic model has...they usually start with program activities or outputs, rather than with antecedent conditions [e.g. inputs/resources]" (Cooksy, Gill & Kelly 2001 p. 120).

These pathway diagrams can be expanded to illustrate the wider elements of program logic, for example, prerequisites for implementation such as the necessary resources, skills, and support structures. The 'if' and 'then' approach utilised by Smith and described by Owen (2006), allows for the inclusion of those conditions that are necessary for the actions to be implemented according to plan and for the desired outcomes to be achieved, for example, if X conditions are met, and Y activities are undertaken, then Z outcomes are expected to occur. See Figure 5 for an example.

Program logic and DPSEEA

The program logic approach is partly implicit in the DPSEEA framework. The DPSEEA framework represents the linkages between particular environmental health issues and health, thus providing a clearer understanding of the nature of the environmental health problem. However, this approach can be further utilised to illustrate more fully the nature of the environmental health actions, and how these actions are anticipated to

Figure 5: Program Logic of a waste water management strategy



affect the environmental health problem. Clear information on the nature of the action(s) and the goals that are expected to be realised (i.e. goals that relate to any one or more of the DPSEE components) will be necessary in order to evaluate the implementation of the actions and their effectiveness in attaining the goals.

More specifically and functionally, a program logic incorporating each of the DPSEEA elements can be used to identify, to communicate and to test assumptions underpinning each of the causal linkages. It can also identify and negotiate the evaluation questions and variables, and show where in the sequence of linkages problems might lie.

Implicit in the program logic or pathway diagrams illustrated in Figures 3 and 5 of environmental health actions and/or their intended effects towards addressing an environmental health problem, is the concept of drivers and pressures leading to a state and subsequent human exposure and health effect. These linkages could be made more explicit. See Figure 6 for an example illustrating the linking actions to intended outcomes and the eventual goals associated with the DPSEEA chain for a program designed to reduce the incidence of smog related asthma.

Figure 6 outlines the key actions adopted to address particular DPSEE elements and links the 'Actions' to these using an outcome hierarchy. 'If' and 'then' statements are implicit within the outcome hierarchy. In the example above, the intermediate outcomes: 'accessing message', 'acknowledging message', 'knowledge and attitudinal change', are expected to occur before behaviour change is to be observed. Behaviour change is expected to occur before any of the DPSEE associated outcomes are achieved. That is, the community adopts different forms of transport and reduces outdoor activities on high smog alert days before any impact on the elements of DPSEE are to be observed. Though this is not always the case, behaviour change can occur before knowledge and attitudinal change, particularly where regulation and punitive action is the incentive for behaviour change.

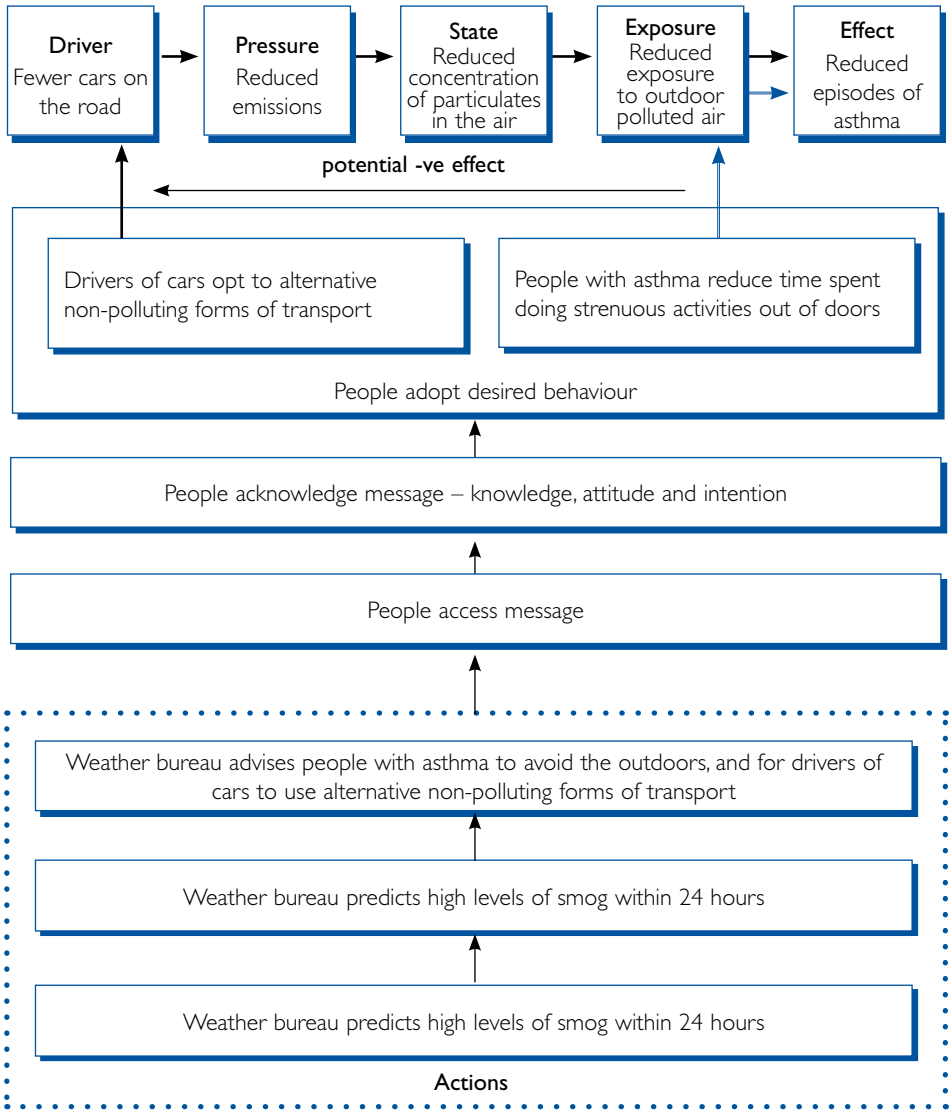
According to the example in Figure 6, the action that involves alerting the community to high smog days, and advising people to use alternative non-polluting forms of transport is expected to have an impact on the Driver and subsequently, the Pressure (e.g. cars emitting particulates), State (e.g. high air concentrations of particulates), Exposure to particulates and Effects (e.g. episodes of asthmatic attacks). Similarly, the action that involves advising people with asthma to avoid the outdoors is expected to have an impact on Exposure to air pollution and the Effects of air pollution.

This diagram (Figure 6) can be a useful tool to question and subsequently test the assumptions underpinning the program. For example, it might be possible that some people adopt the desired behaviours on the knowledge that it is to be a high smog day and nothing else. This alternative logic can be tested by evaluation and revised depending on the findings of the evaluation.

A means-ends causal pathway, such as that depicted in Figure 6, and which focuses on both the actions and the wider problem, allows planners and evaluators to articulate clearly those aspects of the environmental health problem that the action or strategy is attempting to control and any other potential influences or gaps. It also allows a probability model to be applied, and to question all elements using available evidence or the collection of new evidence supporting or refuting the linkages illustrated.

Another example of a program logic that utilises the DPSEEA framework is provided in Figure 7. This diagram illustrates an abridged program logic of a mosquito control program, one of a number developed during a short course group exercise facilitated by one of the authors, and attended by public health and environmental health practitioners. The program depicted, is a multi-strategy

Figure 6: Smog Advisory Service Logic Diagram

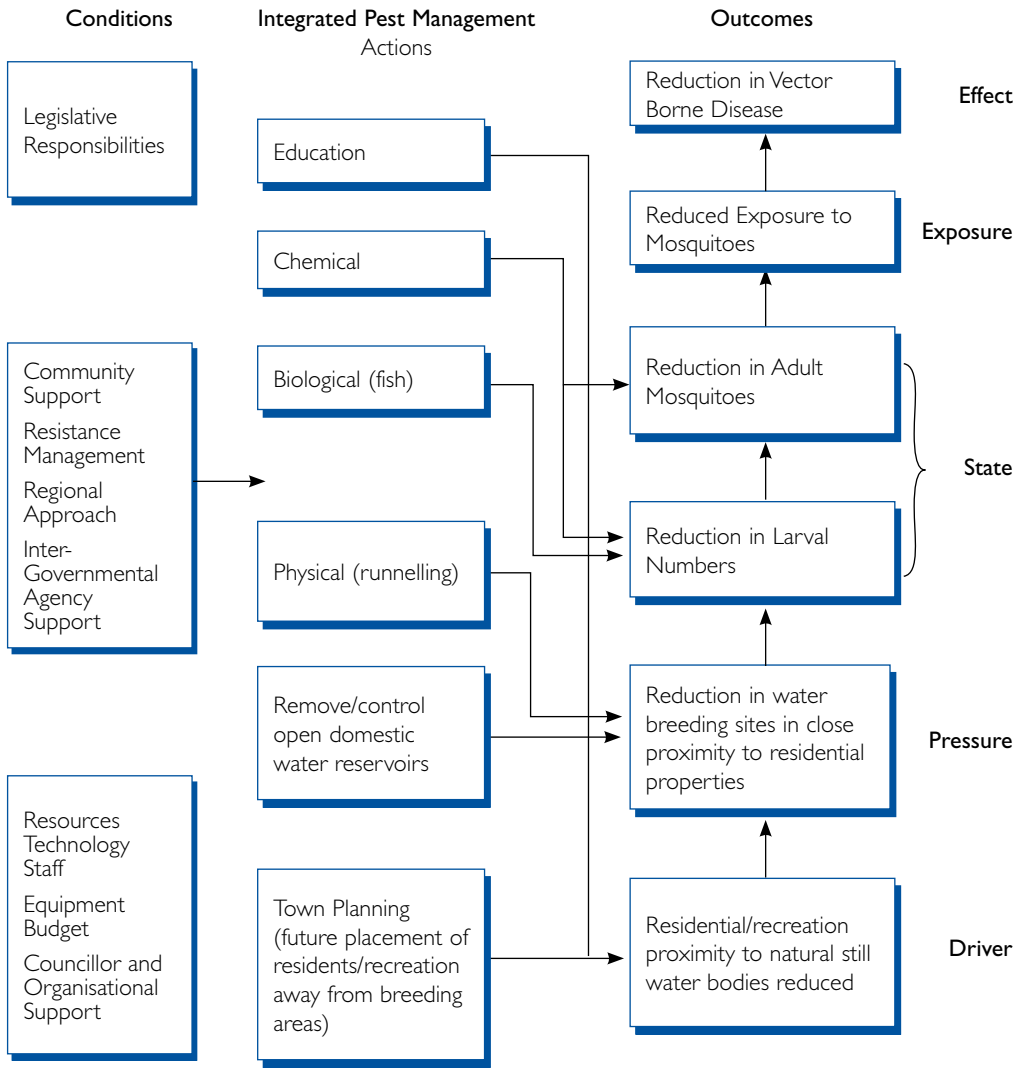


program with actions that ultimately contributed towards the goal of reduced exposure to mosquitoes and mosquito-borne illnesses and inconvenience. This diagram can be used to communicate the rationale for the strategy, to prioritise elements of the strategy and/or to identify gaps and question the evidence supporting the various linkages illustrated. Multi-disciplinary input is useful to question particular 'assumptions' underpinning the logic.

The complexity in the system

DPSEEA and program logic, alone or combined, are useful tools for describing environmental health programs, however, it is important that they embrace complexity in the system rather than simplify it. Models or frameworks such as these tend to be treated as 'closed systems', but this can be avoided by being aware of the potential for multi-directional cause-effect interactions, unintended outcomes, potential wider influences and timing and threshold

Figure 7: Program Logic of a mosquito control program



effects as described below. A recent article by Rogers (2008) provides additional guidelines for using program logic when evaluating complicated and complex aspects of interventions.

Multi-directional interactions

DPSEEA and outcome hierarchies might imply a linear uni-directional flow. However, users of such an approach should not assume that this is always the case. It is possible that impacts further along the chain impact upon previous elements, by amplifying or dampening down the initial changes or effects. In cases where this is foreseeable, bi-directional arrows could be used to illustrate these mechanisms in the logic diagrams. If evaluating the impacts of a program, it is prudent to consider the potential two-way interactive effects of the program being evaluated.

Examples might include: i. programs addressing the exposure to an existing hazard. For instance, teaching parents strategies to reduce children's exposure to lead in soil might reduce the perceived need for action by those contributing to the hazard (e.g.

industry) if they know that the risk of exposure to the hazard is minimised. ii. concerns about exposure to risks of smog, raised by smog alerts, reduce people's willingness to let their children walk to school, thereby increasing car traffic and having an amplifying effect on the problem. This is illustrated by the negative loop in Figure 6.

Rogers (2008) refers to the potential for 'recursive' causality, where the success of an intervention depends on the activation of a 'virtuous cycle' within an intervention as opposed to a unidirectional 'one pass' through the intervention.

Intended and unintended outcomes

DPSEEA and program logic diagrams, tend to include only those outcomes for which the initiative was designed to address. As well as the intended outcomes, a range of unintended outcomes or consequences might arise from the intervention. These outcomes could be positive (i.e. beneficial or adverse). Figure 7 above outlines the intended outcomes of a mosquito control program, but what negative effects are likely to occur with the use of runnelling (building shallow channels to improve linkage of marshes with tidal water) and chemical control methods?

The unintended outcome could be independent or related to those outcomes for which the intervention was designed to achieve. An intervention that decreases vehicle usage for the intended purpose of reducing air particulate emissions is also likely to have a number of added benefits, for example, reduced noise, increased physical activity, improved visibility, fewer emissions of other pollutants including CO_2, less impact on the ecological environment, and reduced fuel costs.

Negative outcomes might include crowded public transport. An intended outcome might have a negative or positive feedback loop effect on itself, thus exerting an inhibitory or promoting effect on its own progression as described further below.

Wider Influences

Potential influencing factors can play across all levels of the DPSEEA and wider program logic framework. A range of drivers and pressures, apart from those being directly addressed for instance, could lead or contribute to an exposure and subsequent

Table 1: Tabulation of wider influencing factors and unintended outcomes

Outcome	Factors that could influence the successful attainment of the outcome	Other consequences
1. Increase in the proportion of people in the high risk group who are aware of the smog alert message. 2. Increase in the proportion of people in the high risk group who reduce strenuous activity out of doors during days of smog alerts. 3. Reduced exposure to smog.	Time of day message relayed Media type Language/clarity, relevance of message Flexibility of workplace, and schools Attitudes and intentions of high risk people Frequency of smog days Ventilation of home/office	Anxiety Reduced physical activity Isolation Work/school days lost Stress If large number of smog alerts then unlikely to act on messages in the future Increase use of vehicles to avoid walking People with asthma move to areas with low smog levels

environmental health problem. These should be considered when planning strategies to address an environmental health problem. For example, lead exposure could be the result of lead paint dust generated through home renovations, lead in petrol and thus surrounding soil, and/or industry. At some point it is the role of decision makers to decide which of these drivers and pressures to address and how to address them, for example, by acting directly on the driver, pressure, state, exposure or effect. At the same time, the potential impact of any initiative on the range of other 'drivers' or 'pressures' should be noted, as these are likely to also impact on exposure and subsequent health effects, and be of interest to an evaluation of program outcomes. While designing and evaluating actions designed to address an environmental problem, it would be useful to identify the full range of 'drivers' that contribute to the problem, not just those which are being targeted.

As well as other potential 'drivers', a number of factors could influence or contribute to a particular 'driver'. For example, vehicle usage might be the 'driver' of interest but a number of factors are known to influence vehicle usage, for example, access to public transport, the state of walking paths, proximity of schools and shops, or cost of petrol among others. These factors might contribute to the level of vehicle usage, independently of any action adopted to address it.

The 'pressure' (e.g. vehicle emissions) that is influenced by a 'driver' (e.g. vehicle usage) might be further influenced by traffic congestion resulting in higher emissions, inefficient maintenance of equipment, age of vehicles or machinery, efficiency of operations, raw material selection and, fuel quality. Thus, vehicle usage alone might not explain the quantity of air particulates emitted.

Once the pollutants are released a range of factors might influence the concentration of pollutants in the air - the 'State'. For example, meteorological and topographical conditions influence the movement of pollutants and the conversion of gases to smog and ozone.

Spatial and temporal complexity, such as the rapid rates of change that occur in urban environments and the spatial variations in environmental and sociodemographic conditions need also to be considered when developing indicators to evaluate effectiveness of environmental health actions (Briggs & Field 2000).

These factors could be included in the logic diagram, or to avoid too much information, they could be tabulated. Table 1 is linked to the DPSEEA diagram in Figure 6.

'Pressures' and 'State' are generally more complex, particularly for those that are influenced by environmental and chemical interactions. Quantification of the range of factors influencing the system might be needed to be able to predict the impact of an intervention on these elements and to be able to evaluate it and to attribute effect.

To avoid 'closed system' logic diagrams, a number of questions could be asked during the logic clarification stage:

1) What effects other than those for which the actions were designed to achieve need to be included? These may relate to any element within the logic diagram e.g. the inputs, actions or outcomes of the initiative.

2) How could events later in the logic impact on events earlier in the logic? Could there be negative or positive feedback loops?

3) What factors could influence the anticipated or potential outcomes and possibly provide an alternative explanation for the outcomes observed or not observed?

4) When are effects expected to arise? Are there latency effects or thresholds that need to be reached, before a response occurs?

5) Is the response, at any point in the chain, likely to be short or long-lived? Could this impact on the magnitude and duration of the exposure or health effect?

6) What are the uncertainties for each of the linkages illustrated in the program logic? Can we be sure each link will do what is hypothesised? What evidence is available to support these linkages? What are the risks if the assumptions underpinning the logic are not correct?

A program logic can be used to assist a risk analysis by highlighting the assumptions underpinning an initiative. The risk analysis can involve questioning the evidence supporting each of the assumptions depicted, and any risk implications, if they are incorrect.

Evaluation of the Actions

The two complementary approaches, DPSEEA and program logic, allow evaluation planners to focus on and link the 'actions' designed to improve environmental health with each of the DPSEE elements of the framework.

In doing so they allow the evaluators to identify, communicate and test the assumptions underpinning the causal linkages, either in theory or practice, as described above. They can be used as a tool for the evaluator to choose the evaluation variables of interest; or recognise changes in program implementation that might affect the model depicted in the logic or "where in the chain of events the sequence breaks down". (Cooksy, Gill & Kelly 2001, p. 120). They and Weiss (1972) describe these and other benefits in relation to program logic.

Identify, communicate and test assumptions

A logic diagram that encompasses the DPSEEA framework can be used to illustrate the assumptions underpinning the causal linkages, and facilitate testing of these assumptions, either in theory or practice. It can be used to guide the examination of the appropriateness and feasibility of the actions, both with regard to their implementation and the likelihood of their translation into the desired outcomes, in the context of existing or anticipated resources and supports.

Owen (2006) outlines a number of forms of evaluation, one of which is 'clarification evaluation'. During this form of evaluation, the logic diagram can be used as a communication tool to question and adjust the logic in negotiation with key experts and stakeholders.

Choose the evaluation variables of interest

The logic diagram can be used to scope the evaluation and program monitoring activities, that is, to identify the evaluation questions and indicators for measurement. These can focus on the outcomes associated with the DPSEE associated goals, the quality or extent of implementation of the actions designed to attain the goals, and the feasibility and assumptions underpinning the actions.

Recognise problems in implementation or logic

These complementary approaches can be further utilised as tools for the evaluation of environmental health management. They can facilitate evaluations that focus on the nature and implementation of the actions leading towards environmental health, and the effectiveness of these actions in attaining the goals that might be associated with any one or more components of the DPSEEA framework.

A logic incorporating the DPSSEA elements, could assist the evaluator to

recognise changes in implementation, either negatively or positively, or where in the causal pathway the sequence fails. For instance, a breakdown occurring anywhere along the causal pathway might explain why a DPSEE associated outcome was not demonstrated. A crucial action might not have been implemented as planned. Alternatively, a preceding outcome might not have been attained, precluding any impacts further along the chain.

There might be barriers to implementation (e.g. inadequate resources, supports, skills or commitment) facilitating the need to examine the wider program logic. Alternatively, the actions implemented might be more feasible than the planned actions. Understanding these changes and the reason for them, could inform future policy development.

The feasibility of the actions at producing the desired outcomes might need to be questioned, facilitating the modification of the program logic or a complete change in strategy. New measures of success might be required if the logic is changed, or an increased knowledge of the intervention highlights more important implementation, contextual or outcome indicators. Rogers (2008) emphasised the need for flexibility in logic development and use for complex adaptive systems and emerging interventions - when specific outcomes, and the means to achieve them, emerge during implementation of an intervention. Program logic models are heuristic in nature. Any or all aspects of the logic might alter with new knowledge, gained informally through implementation or more formal research and evaluation practices. They should not be perceived to be 'fixed' models.

The Wider Contribution to Environmental Health

Australia's National Environmental Health Strategy (enHealth 1999) recognises that "environmental health is a wide ranging multidisciplinary field", highlighting the need to improve Australia's capacity to manage and respond to new and emerging environmental health issues. The integration and application of the two approaches also highlights the complexities of environmental health issues, providing the need and opportunity for the cooperation and collaboration of discipline areas, policy makers and the broader community, to address effectively and improve the approaches to environmental health problems. In doing so, it also provides the opportunity to identify areas of further research required to support evidence based practice in this field.

Conclusion

This paper shares one of the central aims of HEADLAMP - to facilitate protection against environmentally related disease and the promotion of a healthy environment (Corvalan & Kjellstrom 1996), by focusing on the actions adopted to address the defined environmental health problem and their evaluation. It pays particular attention to the 'Action' or 'A' component of the DPSEEA chain, the nature of its link with the other components of the chain and the evaluation of actions by using a simple visual systems-based approach that requires the use of logic diagrams. These diagrams provide detailed information concerning the assumptions underlying a program into a format that is clear and easy to communicate (Cooksy, Gill & Kelly 2001).

The paper not only illustrates that program logic is implicit or intrinsic within the DPSEEA framework, but also how it can be further utilised to advance the evaluation of the actions designed to address environmental health issues. Effective environmental health management requires a number of important steps that include defining the environmental health problem; addressing the problem through planned actions; and evaluating the nature

and implementation of the actions and the effectiveness of these actions at attaining the goals. The DPSEEA framework can be a useful tool for each of these activities, particularly when merged with a wider program logic model.

While the DPSEEA framework and program logic models have the tendency to be treated as 'closed or fixed systems', it is important, when using these approaches, not to assume unilinearity in the system and ignore the potential for feedback loops or two-way interactions; not to limit problem and program logic assumptions to single 'Drivers' or 'Pressures', 'States', 'Exposures' and 'Effects'; or restrict the focus to intended outcomes only. Users of such approaches need to consider the contextual and influencing factors of the problem and intervention, and revisit the logic model as new evidence arises. If used with these conditions in mind, these frameworks, together, have the potential to contribute to our understanding of problem identification, validation, and management in environmental health.

DPSEEA has provided policy makers with a tool to identify, choose, gather and link information on local and national health impacts with information on the drivers, pressures and state of the environment, but when merged with a program logic model has the potential to do more.

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The Efficacy of Two Non-Traditional Methods for Prevention and Treatment of Head Lice: A South Australian Case Study

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Here we report the results of two studies undertaken because of anecdotal evidence that non-traditional treatment methods were being employed to treat head lice. In the first, we assessed the efficacy of hairspray and gel in preventing head lice infestation and found that there was a preventative effect in using hair products applied daily. In the second study we compared the efficacy of two treatments, one a commonly recommended pediculicide and one a so-called 'natural' treatment. It was found that the extract/oil treatment was more effective than the malathion based treatment, possibly as a result of head lice becoming resistant to more traditional treatments. Additionally, our data suggest that regular checking for head lice coupled with immediate responsive treatment plays a major role in reducing the level of pediculosis in schools.

Key words: *Head Lice; Natural Treatment; Pediculicide; Efficacy; School*

Evidence indicates that head lice infestation in schools could be at 'hyperendemic' levels (Speare & Buettner 1999). Despite this, head lice control remains a low priority for health professionals, although parents and teachers believe the problem requires more consideration (Koch et al. 2001; Smith 2003). There are significant direct and indirect economic expenses as well as social, psychological and educational costs associated with head lice (Cammans et al. 1999; Chunge et al. 1991; Hansen 2004) supporting the proposition that the problem deserves greater attention. Parents, guardians, teachers and child care providers want easily understood, accurate advice about effective and reliable methods to treat head lice. Currently, there exists confusion about the efficacy and safety of some treatment products. This confusion is likely to be the result of a combination of increased chemical resistance by the head lice, individual child sensitivity, or inappropriate product application. This has resulted in, often conflicting, anecdotal evidence of success or otherwise of 'non-traditional' head lice treatments, such as using gel or hairspray to prevent head lice infestation, or the use of 'natural' treatment products in preference to traditional pediculicides.

Over the past two years we have undertaken research to assess the accuracy of a number of these anecdotal accounts. Here, we report the results of two studies undertaken over consecutive years. In the first study, we assessed the efficacy of hairspray and gel in preventing head lice infestation (hereafter called the 'prevention study', and in the second we compared the efficacy of two treatments, one a commonly recommended pediculicide and one a so called 'natural' treatment (hereafter called the 'extract/oil study').

Methods

Prevention study

This study assessed the efficacy of using hairspray or hair gel as a method to prevent head lice infestation. Local retailers donated the gels and hairsprays and, therefore, a number of commercial brands were used.

Three primary schools in the southern suburbs of Adelaide were selected to participate in the trial. A total of 114

children, aged approximately 8-10 years, agreed to participate. As children were more likely to participate if they could use a product of their own preference they were given the choice to use hairspray, gel or no product. The majority of girls (91.6%) (total using hairspray n = 38) chose to use hairspray, while most boys (94.9%) chose to use gel (total using gel n = 38). Thirty-eight children were the reference treatments, and were asked to refrain from using any hairstyling products in their hair. There was an even distribution of girls and boys (56 girls and 58 boys).

Product use and application instructions were given to the students and a demonstration of the application procedures performed on two student volunteers. The application dose was a three second spray for the hairspray, and an amount of gel the size of a 50 cent piece. Students were provided with sufficient hair styling product and were given a 'fridge' diary as an application reminder and to track each child's use. Teachers were asked to distribute the information kits and collect consent forms.

Children were examined weekly on seven occasions, with a dry combing method using a fine-toothed comb. Children were called one at a time into a private area away from other class members. Active infestation was defined as the presence of live head lice, as the presence of viable eggs is difficult to determine. This ensures that infestation numbers are not overestimated, as live lice must be seen for a positive diagnosis to occur. Health care professionals and non-specialists frequently over-diagnose as a result of failing to distinguish active from extinct infestations (Speare & Buettner 1999). Any incidence of live head lice or eggs was recorded. Guardians of children with live head lice were contacted by the school and advised that their child would need to be collected and treated before returning to school. Students with active lice in two or more consecutive weeks were excluded from the study.

A chi-squared test was used to determine statistically significant differences between the products, and between the treatments and the control group (the children not using hair products), with the value reported giving an indication of the extent of the relationship between each of the two variables.

Extract/oil treatment study

This study assessed the efficacy of a 'natural' head lice treatment product (hereafter referred to as the extract/oil product) being manufactured and directly distributed by a small landholder in the Adelaide hills. The ingredients in this product are presented in Box 1. The effectiveness of the extract/oil product was compared with the main treatment product supplied by the South Australian Government to schools: K.P. 24 Medicated Lotion, a 0.5% malathion treatment in an alcohol base (hereafter called malathion product). The extract/oil product was donated by the manufacturer, and the malathion product was provided by the City of Onkaparinga, purchased through a company that supplies products to schools in South Australia.

Four primary schools in the southern suburbs of Adelaide were selected to participate in the trial. At the study initiation, all children were examined for head lice, again using the dry combing method. If any lice were found, regardless of size, number, or lice lifecycle stage, the child was asked to participate in the trial and the level of head lice infestation classified according to the categories described by Speare (2000) (Table 1). A guardian of each child was asked to apply the treatment of their choice that evening, as outlined in the instructions given to them. Offering guardians a choice of treatment product was for safety reasons, and to encourage participation in the research. Each product was supplied in 50 mL polyethylene containers, not the original manufacturer's container. The product name was, therefore, removed, although the ingredients of both

Table 1. Categories for degree of head lice infestation (before treatment) (source: Speare 2000)

Category	Degree of head lice infestation (before treatment):
1	Low level of lice and some/no nits
2	Moderate number of head lice with active nits
3	Large number of head lice and nits. Head lice visible in every stage of life cycle

products were labelled on the containers so the guardian could make an informed choice. This was important because some children had suffered reactions previously to particular products. Although the treatments were divided into non-labelled containers, many guardians were inquisitive about the treatment. Comments about the malathion product included "I've tried that before and it didn't work"; "I'd prefer to use a natural product", and "my child is allergic to that treatment". The extract/oil treatment product was slightly more popular than the malathion product, making the treatment numbers unequal. Participants were given two 50 mL supplies of their treatment product and asked to apply the product for a minimum of 3 hours or until the hair had dried. The instructions were based on the administration conditions provided by the manufacturers - which allowed for a wide range of application times. In order to reduce variation within treatments, an application time was chosen that fell within the application times recommended by both products. Products were applied the day of the initial examination, and again after 7 days. This approach was altered slightly in the case of there being only eggs found, but not active head lice. In these cases, the child was given the treatment to take home, and asked to apply it after one week.

Following the initial treatment, each child was checked three days later to determine the effect of the treatment. Treatment effect was classified according to the level of activity of the lice (an indication of head lice resistance to product) described by Speare (2000) (Table 2). Each child was also checked 3 days after the final treatment (applied 7 days after the initial treatment) and again the level of activity of lice (Table 2) was recorded. The final treatment stage was aimed at killing the lice that would have hatched from the eggs, which were protected from the treatment product during the initial application by a cocoon-like shield.

Table 2. Categories for level of head lice resistance to product (after treatment) (source: Speare 2000)

Category	Level of head lice resistance to product (after treatment)
1	Child is healed from head lice infestation. Head lice show no signs of life. No movement of appendages. Reproduction is stopped. (Not resistant: totally susceptible population)
2	Head lice still alive but not moving at normal pace. Can be caught easily and appendages not moving (Semi resistant: susceptible population)
3	Still moving a normal pace. Product shows no signs of success. All appendages moving freely and reproduction occurring (Resistant)

Chi-squared tests were employed to determine statistically significant differences between the two treatment groups in terms of the level of head lice infestation at the start of the study, and to determine significant differences between the treatments in the level of head lice resistance following the initial and final applications of the products. As above, the value reported gives an indication of the extent of the relationship between each of the two variables.

Results

Prevention study

Of the 121 students aged approximately 8-10 years who were invited to participate, 114 (94%) agreed to take part in the study assessing the efficacy of using hairspray or hair gel as a method to prevent head lice

infestation. Data from the three schools were combined. Overall, 34.2% of children screened had active pediculosis at least once during the seven-week study period. Forty one percent of those positive infestations were girls (23/56) and 27% were boys (16/58). Girls had a higher rate of multiple infestations (22.4%) having active head lice on more than one occasion during the study period compared with 15.5% of boys (these data exclude those children who had active head lice on consecutive weeks).

The hairspray and gel treatments were statistically significantly different from the control (Table 3) when tested alone and with the gel and hairspray treatments combined (possible because they are not significantly different) (Table 3). This indicates that there is a preventative effect of using hairstyling products in reducing head lice infestation.

Overall, the number of cases decreased over the research period (R^2 = 0.69) (Figure 1), suggesting that regular checking and responsive treatment results in an overall decrease in the number of cases of pediculosis.

Table 3. Comparisons of hair gel and hairspray as preventative treatments using Fisher's exact test

Treatment	*p* value
Gel compared with no product	0.0021*
Hairspray compared with no product	0.0007*
Gel compared with hairspray	0.7523
Gel and hairspray data combined compared with no product	0.0000*

**indicates a statistically significant difference*

Extract/oil treatment product study

Forty-eight children were found in the initial screening to have active pediculosis and were, therefore, invited to take part in the study comparing the efficacy of a 'natural' head lice treatment with a malathion-based product. Of these, 46 (96%) agreed to take part. A total of 21 children were given the malathion product to apply and 25 children the extract/oil product.

The proportion of children exhibiting Category 1 (the lowest level of infestation) head lice prior to treatment was equally distributed between those children asked to use the extract/oil product and those using the malathion product (Table 4). There was a higher proportion of children using malathion with Category 2 head lice, and a

Figure 1: Proportion of children with active head lice over the seven-week checking period

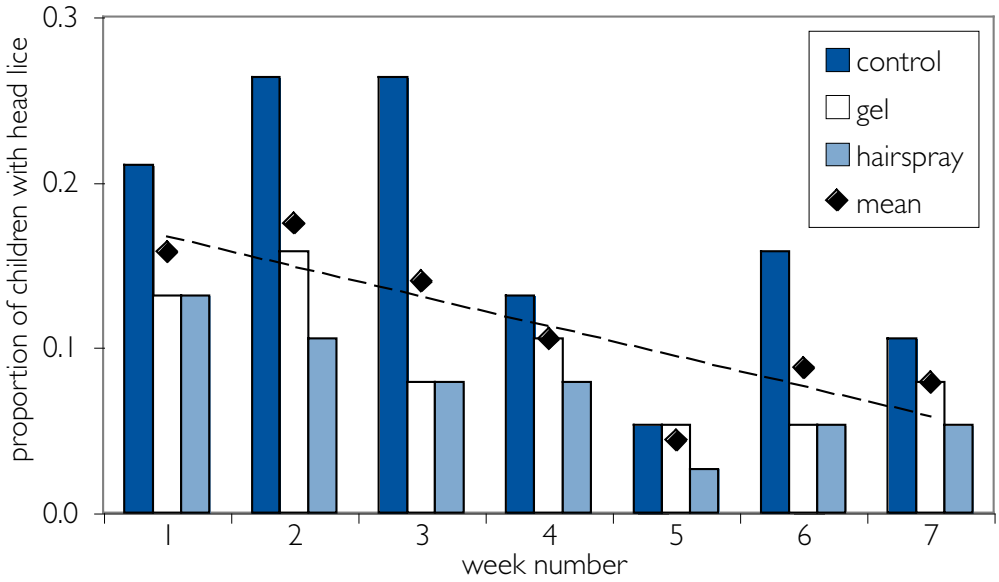


Table 4. Initial degree of head lice infestation and head lice response to the two treatments (proportion of children with head lice exhibiting characteristics described in Tables 1 and 2)

	Before treatment (categories from Table 1)		After initial treatment (categories from Table 2)		After final treatment (categories from Table 2)	
	malathion	extract/oil	malathion	extract/oil	malathion	extract/oil
Category 1	0.14	0.16	**0.29***	**0.64***	**0.71***	**0.96***
Category 2	0.62	0.48	0.71	0.36	0.29	0.04
Category 3	0.24	0.36	0	0	0	0

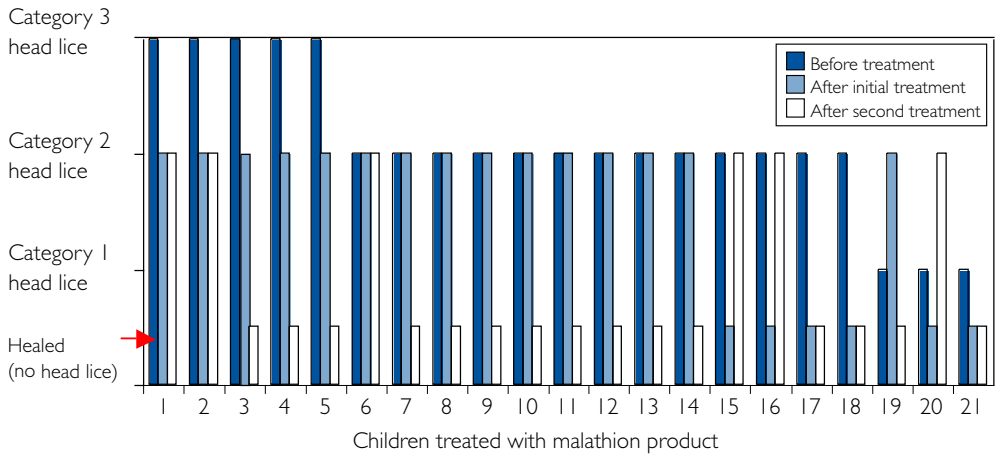
**Numbers in bold indicate proportion of children healed from head lice infestation*

higher proportion using extract/oil treatment with Category 3 head lice (the highest level of infestation). This variation in treatment numbers was a result of allowing guardians to choose the treatment for their children, meaning the distribution was not completely random, although comparison of the numbers of children in each category of infestation prior to treatment application indicated that there was not a statistically significant difference between the two treatment product groups (chi-squared = 0.6109).

Following both initial and final treatment, children using the extract/oil treatment product had a statistically higher success rate than those using the malathion product. More children using the extract/oil product had no active head lice by the end of the second treatment than those children applying the malathion product (71% and 96% respectively) (Table 4 and Figure 2). This trend was also evident earlier: after the first treatment 29% of malathion users and 64% of extract/oil users had no head lice. Additionally, the susceptibility to the treatment was higher in the head lice exposed to the extract/oil treatment (71% of the children whose head lice were exposed to malathion still had Category 2 head lice after the initial treatment and 29% after the final treatment).

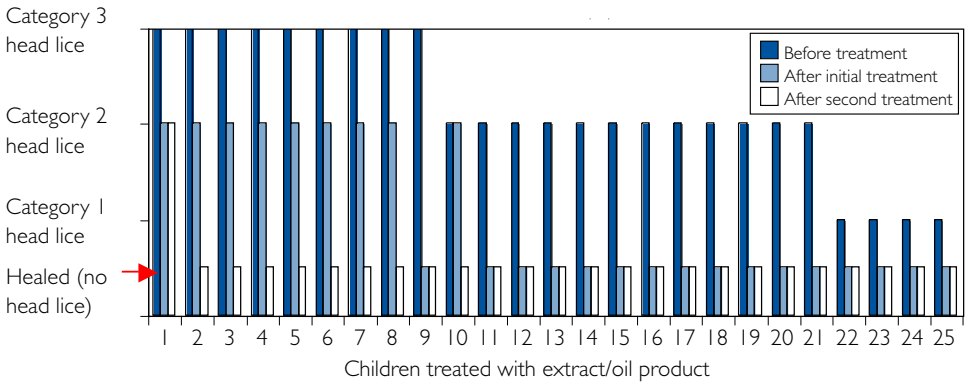
The malathion treatment also resulted in a greater number of ineffective treatments. 'Ineffective' is defined here as there being no decrease in the category of the head lice between treatments. Child 6 had no change in the level of head lice over the entire treatment period, and children 15, 16 and 20 exhibited an increase in the level of head lice infestation over the 7 days (Figure 2). Children 1 and

Figure 2: Initial degree of head lice infestation (darkest bar) and head lice response to treatment with malathion (pale and un-filled bar)



Note: The number given to each child has been reallocated since data collection both to assist data interpretation and to ensure each child's anonymity is protected

Figure 3: Initial degree of head lice infestation (darkest bar) and head lice response to treatment with extract/oil (pale and un-filled bar)



Note: The number given to each child has been reallocated since data collection both to assist data interpretation and to ensure each child's anonymity is protected

2 (malathion treated) and child 1 (extract/oil treated) had a decrease in the level of infestation after the initial treatment but no subsequent decrease following the second treatment (Figures 2 and 3).

Discussion

Prevention study

The prevalence of active pediculosis found at the initiation of the prevention study (12.1%) was within the range reported by Counahan et al. (2004) (0-28%) and lower than that reported by Speare and Buettner (1999) (21%). The higher proportion of girls with active pediculosis compared with boys has also been previously reported (Counahan et al. 2004; Droogan 1999). This suggests our results are comparable with those that might be found with other primary school aged children.

The children using hair products had a lower incidence of head lice compared with those not using any product, indicating that hairspray or gel might provide some form of protection against infestation. It has been suggested that the sticky coating that the hair product provides might make it more difficult for the louse to crawl along the hair shaft (Moore 2004). It is also possible that the hair product is sloughed off over the day, removing the lice at the same time, or that it is more difficult to access the scalp for feeding. This is speculative as the mechanism for protection is unknown.

As a precautionary measure prior to undertaking this study a review of the literature was undertaken to assess the safety of children regularly using hairstyling products. There is no evidence suggesting either acute or chronic toxicity beyond the warning that for hairspray intentional misuse by concentrated liquid and/or inhaling could lead to asphyxiation and death (National Institutes for Health/National Library of Medicine Specialized Information Services [online]). However, it should be noted that it was not the intention of this research to establish the safety of these products.

At the weekly inspections children commented that a parent had checked their hair the night before, probably because the child was participating in this study. The notable decrease of head lice infestation over the seven week period indicates that regularly checking and immediate treatment results in lower numbers of children with head lice. Actively promoting regular checks, combined with immediate treatment if head lice are found, is probably the best method to reduce the incidence of head lice.

Extract/oil study

Overall, the extract/oil treatment product had a higher treatment success rate and fewer cases of head lice resistance compared with the malathion based product. There is evidence that head lice are becoming resistant to common pediculicides (Eichenfield et al. 1998). Downs et al. (1999) reported a 64% failure rate for malathion based products, a higher failure rate than that found in this study (28%). Interestingly, Hunter and Barker (2003) report high variation in susceptibility of head lice collected from school children from different schools, with two schools providing head lice that were not susceptible to malathion compared with 94-100% mortality of head lice collected from children from other schools.

Hunter and Barker (2003) suggest that maximising control of head lice requires detailed information on the susceptibility of head lice strains from different schools to different pediculicides. Alternatively, Downs et al. (2007) suggest that the problem of resistance emphasises a need for newer pediculicides. Certainly, parents and school have a lack of confidence in the effectiveness of pediculicides, which might account for the use of alternative methods (such as tea tree oil) (Downs et al. 2000). The effectiveness of the extract/oil product found in this study supports the hypothesis that head lice are becoming resistant to traditional pediculicides. However, this treatment method might simply be more effective because it is a chemical for which head lice currently have little tolerance, but that susceptibility will decrease as exposure increases.

It should also be noted that the extract/oil product tested in this research is not entered on the Australian Register of Therapeutic Goods database. For this reason, it may not be sold 'over the counter' as a therapeutic agent in pharmacies, however, the public is able to purchase this product from the factory. It is also available through some health food stores and hairdressing salons. Its safety has not been established, although the main ingredients (Box 1) are contained in a number of other commercially available therapeutic products, including head lice treatments.

Box 1: Ingredients in the Extract/oil treatment product

Water, Organic Crushed Mineral Extract, Grapeseed Oil, Vegetable Glycerine, Ethanol, Lecithin, Sesame Oil, Cold Pressed Neem Oil, Organic Tea Tree Essential Oil, Organic Echinacea Extract, Spike Lavender Essential Oil, Organic Garlic Extract, Organic Lemon Balm Extract, Organic Roman Wormwood Extract, Rosemary & Star Anise Essential Oils, Citronella Essential Oil, Pine Oil Extract, Wild Thyme Essential Oil, Himalayan Cedarwood Essential Oils, Xanthin Gum, Guar Gum.

Conclusion

We found pediculosis was prevented in more children when they used hair spray or gel applied daily. We also found that an extract/oil treatment (a 'natural' treatment) was more effective than a malathion based treatment in treating head lice, probably as a result of head lice becoming resistant to more traditional treatments. Additionally, our data suggest that regular checking for head lice coupled with immediate responsive treatment plays a major role in reducing the level of pediculosis in schools.

Note

This study was undertaken with approval from the Flinders University Social and Behavioural Research Ethics Committee SRBE 3526 and 3241.

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Crowds at Outdoor Music Festivals: An Examination of Crowd Psychology and its Implications for the Environmental Health Practitioner

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Outdoor music festivals (OMFs) attracting large crowds are commonplace in Australia. These crowds are different from others because they are emotionally charged, highly motivated and somewhat unpredictable. Problems in these crowds do occur. To prevent or limit the effect of these problems it is necessary to plan the event well and ensure that planned actions are implemented by undertaking comprehensive monitoring programs. Environmental Health Practitioners (EHPs) contribute to these programs through monitoring public health outcomes at OMFs and crowd safety is the responsibility of other professionals. EHPs working at OMFs are in an environment where the crowd impacts on every aspect of the event and would benefit from an understanding of the workings of crowds. This article provides an introduction to crowd psychology and discusses key factors such as demographic characteristics, crowd movement, artists, performances, and alcohol consumption that all potentially affect collective behaviour within crowds. This paper continues the discussion commenced in Earl, Parker and Capra (2005) in an earlier issue of this journal where the role of EHPs in event planning was presented.

Key words: *Outdoor Music Festivals; Crowds; Crowd Behaviour; Sociological Theories*

Outdoor music festivals (OMFs) attracting large crowds are commonplace in Australia. These crowds are different from those at many other events as they tend to be emotionally charged (Tatrai 2001), highly motivated (Raineri & Earl 2005) and somewhat unpredictable (Davis & Associates 2004). Behavioural problems within these crowds can typically result when there are disruptions in the flow of pedestrian traffic caused by obstructions like queues forming in their path (WA Department of Health 2005), because of a perceived threat such as a crowd crush (Emergency Management Australia [EMA] 1999), or during a competitive rush for a prime position or prized item (Fruin 2002; Tatrai 2001). In order to minimise these problems it is important to get the layout of the event right.

Getting the layout right for an OMF means designing the site to allow easy crowd movement by providing good pedestrian routes and entry/exit points; having gathering points and viewing areas suitable for the size of the event; supplying sufficient facilities such as toilets, food outlets, bars and welfare facilities dispersed appropriately within the site; and servicing the event with an adequate number of skilled and experienced event staff including security personnel (Au et al. 1993). Getting the mix of these features right is difficult and is best achieved by thorough, effective and comprehensive planning prior to the event (EMA 1999; Tatrai 2001). Equally as important is ensuring that planned actions are implemented.

An EHP from the Mendip District Council that licenses the Glastonbury Festival in the United Kingdom (UK), said that it was critical "to establish and maintain a presence through professional and comprehensive monitoring of the event" (Earl, Parker

& Capra 2005, p. 60). This monitoring usually involves multidisciplinary teams that include Environmental Health Practitioners (EHPs). EHPs within these teams generally focus on food safety, sanitation, potable water supplies, noise and waste management all of which are compatible with EHP's knowledge and skill sets. This monitoring work is undertaken in an environment where crowd behaviour influences every aspect of an event. Consequently, there is merit in EHPs gaining a fundamental understanding of how these crowds work and the various factors that can influence their behaviour.

The purpose of this article is to continue the discussion commenced in Earl, Parker and Capra (2005) where the role of EHPs in event planning was presented. The article provides EHPs with a basic understanding of crowds and other factors influencing crowd behaviour. The information is supported by contemporary literature.

An Understanding of Crowds at OMFs

Macionis (2004, p. 605) described a crowd as "a temporary gathering of people who share a common focus of attention and who influence one another". As stated above, these particular crowds are known to be highly emotional. Paulus (1980), an environmental psychologist, explained that the level of emotion is related to the density of people within that crowd. In that, as crowd density increases, the intensity of an individual's moods and behaviours increases (Freedman 1975). This level of emotional intensity has been used to describe different types of crowds that might be encountered, which are:

- casual crowds - people who happen to be in the same place at the same time with only brief interaction if any, such as shoppers in a mall;

- conventional crowds - people who have come together for a scheduled event and share a common focus, such as graduation ceremonies;

- expressive crowds - people who are releasing their pent up emotions with others who share similar emotions such as a football grand final; and

- acting crowds - people so intensely focused on a specific purpose or object and on the verge of violent or destructive behaviour, such as those associated with mobs, riots or panic driven crowds (Blumer cited in Kendall, Murray & Linden 2000).

Casual, conventional and expressive crowds can be observed regularly at OMFs and on very rare occasions, acting crowds can also be seen. A famous example of extreme crowd behaviour occurred during the 1999 Woodstock festival in America where 500 festival goers rioted, lighting fires, looting vendor tents, smashing ATM machines, and toppling toilets and speaker towers (Vider 2004). The change in crowd behaviour that results in problems such as riots or stampedes is a sequential process.

Put simply, the behaviour change process commences with a failure of some aspect of the social system affecting the crowd, such as running out of alcohol. Individuals, sensing there is a problem, analyse inputs and observe reactions within the crowd; a common belief begins to form and spreads throughout the crowd; the crowd becomes more organised; and finally is mobilised into action (EMA 1999). It is these collective crowd behaviours that are of particular interest.

Social scientists have had moderate success in explaining collective behaviours, especially participation in extreme behaviours like rioting or looting. Vider (2004) said that understanding the relationship between the individual and the crowd was important. There are a number of sociological theories which have been developed to provide insight into this relationship - the Contagion,

Convergence and Emergent-Norm (EMT) theories and the Social Identity Model (SIM) of Crowd Behaviour.

Sociological Theories Associated with Crowd Behaviours

The *contagion* theory, posed by LeBon (1960), has been frequently referenced in event safety literature (e.g. Davis & Associates 2004). Le Bon (1960) believed that being in a crowd has a hypnotic effect and that, with the anonymity of belonging to a large group, individual personalities vanish. A collective or group mind then emerges along with irrational, emotionally charged behaviour (LeBon 1960; Vider 2004). This theory only focuses on the collective aspect of the crowd and discounts the actions of individuals within the crowd (Vider 2004).

Critically, more recent authors have comprehensively rejected Le Bon's group mind idea along with the notion of individuals being anonymous, irrational and emotional (Levy 1989; McPhail 1989; Reicher 1987). McPhail (1989) said that individuals in crowds typically assemble with friends, acquaintances or family members, which discounts the anonymity perspective. Schweingruber and Wohlstein (2005) added that there is no evidence to support individuals within crowds suffering any cognitive deficits. Finally, Couch (1968) argued that emotions are part of all social interactions including those associated with being in a crowd. Emotions and rational behaviours are not mutually exclusive and being emotional does not necessarily lead to irrational behaviours (Massey 2002; Schweingruber & Wohlstein 2005).

At the opposite end of the spectrum, the *convergence* theory maintains that crowd behaviour develops due to individuals with a shared predisposition or like-minded individuals converging at the same place (Fogiel & Goldstein-Fuchs 2000; Levy 1989). This theory stemmed from early work by Sigmund Freud and Floyd Allport and the later works of Neal Miller and John Dillard (Levy 1989). In applying this theory, crowd behaviour is considered to be rational or premeditated with individuals just expressing existing beliefs and values (Macionis 2004). This theory was not popular and was heavily criticised for "not having a structured framework or explaining critical aspects of crowd dynamics such as behavioral shifts, multiple predispositions or role acquisitions" (Levy 1989, p. 70).

There is also the *emergent-norm* theory or EMT posed by Turner and Killian (1987). The EMT combines aspects of the two previous theories, arguing that it is the combination of like-minded individuals, anonymity, and shared emotion that leads to collective behaviours. In applying this theory people come together with specific expectations, beliefs and values that are changed due to interactions within the crowd with new behaviours emerging as a result (Macionis 2004).

The problem with the EMT is that there is no evidence to support the emergence of new forms of behaviour just from being in a crowd (Couch 1968; Schweingruber & Wohlstein 2005). Waddington and King (2005) explain, as the different groups within a crowd bring their own sets of values, beliefs and expectations with them it is unlikely that new behaviours would be adopted. On a technical note, McPhail (1991) added that the EMT lacked the specificity needed to allow it to be tested properly thus making it somewhat impractical.

The final theory to be discussed in this paper is the *social identity model* or SIM posed by Reicher (1982 cited in Drury and Winters 2004). Drury (2007) explains this theory maintains that people act as one in a crowd because they share a common social identity. Social identity is described as the part of the self-concept that results from membership in social groups (Stangor 2004). This common identity specifies the appropriate normative behaviours. The SIM recognises "that

different identities have different [normative behaviours] - some peaceful, some conflictual" (Drury 2007, p. 3). Drury and Reicher (1999, p. 383) explain:

> *Control over behaviour is not lost but rather governed by the [expectations, beliefs] and values that define [a particular] social identity. Crowd members still act in terms of self-interest, but they are different interests being based on a different and collective self.*

In applying this theory individuals categorise themselves into particular social groups such as Goths, Punks or Metal Heads. These individuals then gain an understanding of, and adopt, that group's expectations, beliefs and values which become the basis of future behaviour. Individuals usually have a variety of these social identities and each has the potential to impact on group processes (Drury & Winter 2004; Vider 2004).

The SIM has been credited with recognising the transformation of identity, not a loss of one, and the retention of an individual's decision-making abilities (Vider 2004). However, Vider (2004) commented that this theory neither explained the emergence, then spread, of the collective behaviour nor individuals becoming bystanders rather than participants.

In summary, it is evident that these theories only "address particular elements of crowd behaviour" (Levy 1989, p. 72). The *contagion* theory considers collective behaviour the result of individuals being anonymous, irrational and emotional within a crowd. The *convergence* theory explains this behaviour as like-minded individuals at the same location responding to stimuli in a simular way. The EMT says that social interactions alone are responsible for collective behaviours while the SIM attributes a shared social identity within a crowd as the cause.

Clearly, an explanation of the relationships between individuals and the crowd remains incomplete (Hogg & Abrams 1988; Levy 1989). The SIM, however, has been hailed as one of the most developed, comprehensive modern theories available, making it particularly salient. On a more practical level, there are specific characteristics of an audience and environmental factors that are known to be associated with collective behaviours.

Critical Factors Affecting Crowd Behaviour

Crowds behave and respond according to a variety of critical factors that have been summarised into audience composition, crowd related activities, the artists and performances, and physical aspects within the site (Davis & Associates 2003; UK Health & Safety Executive [HSE] 1999).

Audience composition

Turner (1995, cited in Vider 2004) observed that crowds have dynamic internal processes with social identities, group formation and shared features constantly interacting and reacting with each other. These internal processes are catalysed by a range of notable variables. Examples of these catalysing variables are being in close proximity, such as in the mosh pit; visible similarities, such as haircuts, tattoos, piercings and certain types of clothing; shared interests in the music or artist; cooperative interactions such as helping others who have fallen; or positive interdependences like supporting others to crowd surf (Turner 1995, cited in Vider 2004). It is combinations of these processes and variables that help to build a shared social identity within a crowd. A strong shared social identity increases cohesion within the crowd (Vider 2004).

Cohesion is defined as the measure of significance, importance or attachment that individuals have towards the crowd (Stangor 2004). High levels of cohesion within a crowd increase the likelihood of spontaneous socialisation (Reicher 1987 cited in Vider 2004). In the presence of the right stimuli, a critical mass within the crowd can be rapidly achieved and a change in crowd behaviour is quick to follow (Vider 2004). An example

of spontaneous socialisation is the collective reaction in a crowd to the news that a favourite artist is refusing to perform or has walked off stage early. Individuals attending OMFs have an influence on crowd behaviours (Tatrai 2004).

People attending OMFs have their own knowledge, experience and expectations and these influence their decision making prior to and during the event (Tatrai 2004). Before an event, individuals make decisions about the consumption of illicit drugs and alcohol or their behavioural intentions, when at the event their decisions might involve activities such as crowd surfing or moshing. While at the event, any changes in an individual's mental state, such as getting very drunk, or emotional condition, particularly increases in stress levels or the ability to act, can have a flow on effect to behaviour within crowds (Davies & Associates 2004). Some individuals are more noteworthy than others because they exert some influence over the rest of the crowd.

These more noteworthy individuals are collectively referred to as crowd leaders. Vider (2004) categorised these individuals into two subcategories - true leaders and exemplars. On one hand, true leaders stand out from the rest of the crowd with attributes that make them more persuasive, visible, audible, or better connected into the crowd (Vider 2004). Exemplars on the other hand, are individuals whose unique behaviours are interpreted as normative and become adopted by others (Vider 2004). For example, one person throws a bottle at the stage or starts to crowd surf and others join in. Reicher (1987 cited in Vider 2004) argued that behaviour within a crowd is generally not determined by the true leaders but by the exemplars. It is beneficial to be aware of the demographic characteristics of crowds that can impact on collective behaviours (HSE 1999).

Upton (2004) identified younger people, particularly young males as being prone to bad behaviour, such as slam dancing or moshing, with the consumption of large amounts of alcohol or the presence of a strong social identity adding to the problem. A publication from the Danish Ministry of Culture (2000) reported that young people felt a strong sense of community when attending OMFs and that this was one of the key aspects that attracted them. Commons, Baldwin and Dunsire (1999) expressed particular concern about this sense of community as it gave individuals the confidence to experiment with new or risky behaviours, such as illicit drug taking or taking part in unsafe sex. Tatrai (2001) posed the case that events attracting a broad demographic with a balance of ages and gender would have a positive effect on crowd behaviours.

Crowd related activities

The crowd related activities that are of interest include moshing, slam dancing, crowd surfing, 'swirling', and more recently 'circle pits'. Swirling is when the patrons are moving in a circular motion drawing in more and more people to the swirl (WA Department of Health 2005). A circle pit is where a human circle is formed and pairs of individuals take turns to enter the cleared central area and slam and bash each other. This activity is also known as 'fight dancing'.

The primary focus for most crowd related activities is the 'pit' or 'primary pit'. This is the area at the front of the stage in direct view of the performers. Upton (2004) a crowd management specialist from the UK, reported that this part of a crowd, usually only about 5% of the total capacity, generate up to 75% of the energy released during an event. Upton (2004) added that providing good controls for this area takes considerable resources, however, it does allow the rest of the crowd to relax and enjoy themselves.

It should be noted that many references describing the primary pit area use another term - mosh pit. Mosh pits are a little different and can occur anywhere within a crowd often

involving much larger numbers of people. Ambrose (2001, p. 3) explained that "there are certain acts...where the mosh pit extends to the entire auditorium or field where they are playing". Consequently 'mosh pit' should be considered any place where moshing occurs within a crowd.

The availability and consumption of alcohol by festival goers at OMFs can have an influence on crowd behaviour. Wertheimer (1993) highlighted this when discussing the findings of a large survey of event professionals in the United States. Seventy percent of the respondents in that study reported alcohol consumption as the major risk factor that had to be managed at their events (Wertheimer 1993). Allsop, Pascal and Chikritzhs (2005) warned that it is difficult to predict the effects of alcohol consumption on any group. Drunken males were identified as potentially problematic, especially in relation to aggressive types of behaviour such as fight dancing (Allsop, Pascal & Chikritzhs 2005). It should be noted that the relationship between alcohol consumption and aggressive behaviour is complex and influenced by a range of social cues including (i) aggressive music or an antagonistic performer (Parker & Auerhahn 1998); (ii) the expectations, characteristics, values and attitudes that individuals have (Allsop, Pascal & Chikritzhs 2005); and (iii) any changes to an individual's perceptions, motor skills, emotions or cognitions (Allsop, Pascal & Chikritzhs 2005).

Finally, there is increasing evidence that the use of illicit drugs, such as cocaine and methamphetamine, are also having an impact on crowd behaviours at OMFs and other events (see e.g. Earl et al. 2004; Vider 2004).

Artists and performances

The dynamics within a crowd can be particularly influenced by the character and actions of the artists and the type of music being performed (Hill 2002). Fruin (2002) reported that artists cancelling shows at late notice, late starts, walking off stage early, diving into the audience, throwing souvenirs and encouraging inappropriate or hazardous group reactions, all have negative effects on crowd behaviours.

In terms of performances, a study undertaken by Earl et al. (2004) found the type of music being performed, especially heavy metal, punk rock and rap performances, was a significant influence on crowd behaviour. In particular, it was the tempo, rhythm and recognition of songs that triggered behaviour change within the crowd.

Physical aspects within the site

There is usually considerable crowd movement within an OMF (Raineri 2004). Consequently, physical restrictions within the site might contribute to disruptions of normal pedestrian traffic flows. These disruptions might be the result of an obstruction left in a pedestrian route, closed gates or doors, patrons stopping to view street art or other attractions, or queues forming for an attraction or ride (WA Department of Health 2005). There might also be problems associated with the seating or viewing arrangements. These problems could be associated with seat availability, aisle widths, marshalling areas, relative locations of food, alcohol or merchandise outlets and toilets, or the distribution and timing of performances. The number of stages at an OMF might also create problems for patrons because of their relative locations, accessibility, visibility or audibility and the types of barrier systems used (EMA 1999; HSE 1999; Raineri & Earl 2005; Tatrai 2004; WA Department of Health 2005).

Observers often compare crowd movement to a fluid-like flow. Fruin (cited in Davis & Associates 2003) warned that crowd densities need to be as high as seven persons per square metre and higher to appear as a fluid mass. For example, during the Hillsborough football stadium disaster where a number of deaths occurred, crowd densities were considered

to have reached 11 persons per square metre where the bodies were found. Consequently, limiting crowd densities becomes critical (Fruin cited in EMA 1999; Raineri 2004).

Fruin found "critical crowd densities are approached when the floor space per person is reduced to about 0.5m^2" (Fruin cited in EMA 1999, p. 91). This figure has been recommended by some guidance publications such as the HSE event guide for the calculation of crowd densities at events. HSE explains, the maximum number of people who can safely be accommodated in an open field can be calculated by dividing the total area available to the audience (in m^2) by 0.5 (HSE 1999). The WA Department of Health argues that acceptable crowd densities can also be derived from calculations as low as 0.3m^2 per person (2005). However, Tatrai (2004) advised there was limited legislative or good practice guidance to support higher density calculations than those recommended by Fruin.

Kemp, Hill and Upton (2004) argued strongly that using Fruin's method to calculate crowd densities fails to consider how space is interpreted with festival goers choosing to sit, lie or move around the site as apposed to just standing in one place. Disregarding the warning from Kemp, Hill and Upton (2004) could result in emergency response difficulties for medical and security staff deep within crowds.

Implications

There are many public health issues that can result from poor crowd management. Individuals could slip, trip or fall in a crowded area that could result in them being trampled or worse. The rapid uncontrolled movement of large numbers of people similar to a stampede, or alternatively crowd surges that are slow rather than quick also cause problems. Additionally, people might be crushed against objects, such as a fence or wall that breaks, resulting in a crowd collapse, and person against person crushing caused by gross overcrowding, or the opposing movements of people within a confined area, can all result in public health issues (Davis & Associates 2003).

In order to manage the effects of crowds and reduce crowd related incidents, Tatrai (2004), an Australian event security and risk management expert, advised that crowd management needs to be effective, well planned and expertly implemented. Tatrai termed this 'safety by design' (Tatrai 2004). To achieve this (i) the site should allow good access and crowd movement, have effective segregation where needed and be an adequate size; (ii) have emergency management plans; (iii) have a variety of methods to communicate with the audience; (iv) utilise alcohol management strategies; and (v) have appropriate security services suitable for the type of event and expected audience (Tatrai 2004).

Many crowd safety issues arise in the main viewing areas of OMFs due to the large numbers of festival goers in attendance with the audience generally standing rather than being seated. There is specific concern directed at controlling the small percentage of the crowd in front of the stage. This control is critical as this is an area of extreme crowd pressures (Upton 2004). As a general rule of thumb, Upton (2004) recommends that the main viewing areas are divided into zones that are colour coded or numbered and separated using a safety barrier system. Each zone would have separate entrances, exits, emergency evacuation systems and be self-contained in terms of concessions and welfare services (Upton 2004).

Critically, each zone needs to be assessed individually as key features will differ for each. Upton (2004) said that the following should be considered for each zone:

- there needs to be a realistic approach to the establishment of crowd capacities and densities for each zone;

- sight lines for the audience will vary for each zone. The focus for the first zone will be the artists and the stage, while it is likely to be video screens for the other zone;
- the condition of the ground will need to be considered with regard to the degree of incline, drainage, condition of the grass, locations of hard standing features and the impact all these features might have on the crowd;
- the expected crowd behaviour, such as crowd surfing and moshing, the intensity of the performance and artists' known actions, all need to have been considered within the planning processes;
- rescue teams might need to reach, triage and extract casualties and remove them safely from any part of the crowd. As a result, there needs to be adequate medical and security staff on hand that reflects the intended audience numbers for each zone. There also should be strategies in place to assist these staff to do their work if the need arises;
- trained and experienced crowd managers need to be appointed to coordinate crowd safety activities for each zone;
- tickets should clearly indicate which zone they are for.

The use of the multi barrier system known as the "D" barrier system as highlighted in the WA Department of Health (2005) event guide is a good example of a method to implement Upton's recommendations. This system involves the installation of a straight safety barrier across the front of the stage surrounded by a curved barrier that includes the 'front of house' mixing structure to form the 'D' shape. The WA Department of Health (2005) insists that the capacity of the area within the 'D' should be strictly limited to 0.4m^2 per person and must be closely supervised. This approach has been utilised for a number of large events in Australia.

Conclusion

OMFs present unique challenges in terms of the safety and management of large crowds. EHPs have a role in the monitoring of OMFs and as crowds impact on every aspect of these events there is merit in gaining a fundamental understanding of crowds to assist them with this work. This article provides an overview of the nature of crowds and discusses the key factors influencing collective behaviour. Key factors covered include leadership within the crowd, demographic characteristics, crowd movement, artists, performances, and alcohol consumption. These all have the potential to affect collective behaviour within a crowd.

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Environmental Health Emergency Response to a Natural Storm Disaster in NSW, Australia

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In June 2007, severe storms and flash flooding resulted in a natural disaster in the Hunter Valley region of NSW, Australia. We describe the magnitude of the disaster, the resultant public health threats and the environmental health response. The disaster highlights the unique contribution that the environmental health profession can make at the forefront of the response and recovery phases of a natural disaster.

Key Words: *Storm; Flood; Environmental Health; Disaster; Public Health; Emergency*

On Friday, 8 June 2007, the cities of Lake Macquarie and Newcastle, and the Hunter Valley Region north of Sydney, extending from the coast to the Dividing Range in New South Wales (NSW), Australia, experienced severe storms that continued for 24 hours. A natural disaster was declared, which affected seven local government areas including Maitland, Port Stephens, Newcastle, Cessnock, Lake Macquarie, Singleton, Muswellbrook and Dungog. The Bureau of Meteorology measured gale force winds of 124 km/hour at Nobby's Beach, while the 24-hour rainfall of 293.6mm was recorded at Mangrove Mountain (Bureau of Meteorology 2007). The weather caused extensive damage, power outage and flooding to houses, businesses, schools, nursing homes, hospitals, and local infrastructure including roads, power, water supplies and sewerage systems. The storm also resulted in the grounding of a 76,741 tonne bulk coal carrier, the Pasha Bulker, containing over 700 tonnes of fuel oil, 38 tonnes of diesel and 40 tonnes of lube oil.

There were nine fatalities, major flash flooding and over 200,000 homes and businesses were without power, some for more than a week, resulting in loss of heating and also food spoilage due to interruption of electricity to refrigeration. Inundation of houses and buildings by contaminated floodwater generated massive domestic waste accumulation. With widespread flooding affecting many homes, eight evacuation centres were established for displaced residents. Of major environmental health importance were the 1200 food premises affected by inundation or power outage, as well as 2663 septic tanks, 3 public swimming pools and 7 hairdressers which were flooded. In addition, 207 private/commercial drinking water supplies were inundated and 60 major sewage pump stations servicing the region lost power and overflowed into the floodwaters. Recovery centres were established in Newcastle, Cessnock, and Singleton to provide coordinated and interagency information and assistance, including public health and environmental health advice and, in one location, household cleaning kits.

A Public Health Emergency Operations Centre (PHEOC) was established by Hunter New England Population Health Unit (HNEPHU) under the provisions of the NSW Health Plan, a Supporting Plan to the NSW State Disaster Plan Displan (NSW Health April 2005) to respond to acute public health and environmental health issues and to prevent a potential large scale and widespread disease outbreak. The PHEOC was directed by the Public Health Controller,

utilising an Incident Control Structure (ICS), with reporting responsibility to the Health Services Functional Area Coordinator (HSFAC). In addition to commanding all public health resources, the Public Health Controller controlled the overall direction of Population Health personnel activities; appointed position holders under the ICS structure (Operations, Planning, Logistics & Finance); provided expert public health advice; coordinated incident management and strategies; approved Situation Reports and other information for release; communicated and provided information to the HSFAC and media; and provided information and support to the heads of operations, planning, logistics and finance.

The PHEOC responsibilities included:

- leading the recovery phase including public, mental and community health service provision;
- twice-daily liaison with all water utilities in the affected area to assess water quality and quantity provided to all communities, as well as the sewerage system situation;
- coordinating a local government public and environmental health response across seven local government authorities, including daily teleconferencing;
- ongoing community health risk assessment;
- initiating a surveillance system for health presentations directly related to the storm effects, increasing environmental health field and vaccine surveillance, as well as surveillance of sales of gastroenteritis pharmaceuticals;
- maintaining communication to relevant agencies by daily situation reports;
- providing extensive advice to the community through regular media releases and interviews on television, radio and in the print media;
- developing and distributing information to the public.

A 1800 health telephone hotline was established and widely publicised to provide 24-hour advice and respond to community concerns. Trained health professionals were equipped to triage calls, to provide basic environmental health and other general storm related advice, to direct callers to more detailed advice on appropriate websites, to provide agency call numbers, or to refer callers to relevant health experts, including the HNEPHU Environmental Health team. It was also used to gauge concerns and, together with public health risk assessment, provided the impetus for the PHEOC to develop several fact sheets to provide public health advice. These were ratified by NSW Health and the NSW Food Authority, and uploaded onto the NSW Office for Emergency Services website, www.emergency.nsw.gov.au. They were also provided to the media and support agencies, and distributed at recovery centres. Fact sheets included topics such as microbiological risks of contaminated flood water, general safe flood cleanup, cleaning and disinfecting domestic food utensils and equipment, contaminated water and vegetable/herb gardens, cleaning domestic swimming pools and cleaning underground rainwater tanks.

Coordinating the Public Health Response in Partnership with Local Government Public Health Coordinators

On Saturday, 9 June 2007, it became evident that although two local government areas, Newcastle and Lake Macquarie, had borne the brunt of the initial wind and storm damage, seven local government areas would be affected by flooding particularly in the

proximity to the Hunter River and its tributaries. The PHEOC contacted the Local Government Public Health Coordinators to assess levels of infrastructure damage and preparedness to respond to rising floodwaters in their areas, raise awareness of potential public and environmental health issues, establish the resources available across the region and assess the evolving public health risks.

From 10 June 2007, a formal communication system was established between the Local Government Public Health Coordinators and the PHEOC through a scheduled daily teleconference during the response and recovery phases for five days and thereafter daily email liaison for an additional four days. This provided a forum for structured two-way sharing of information in relation to environmental health issues, including food premises, private commercial water supplies, swimming pools, mosquito breeding, on-site wastewater treatment systems, information requirements, complaints and assistance from other agencies. Progress on assessment and risk mitigation was reported, including the numbers and types of premises visited and provided with advice, and those formally inspected. This assisted in determining personnel resource needs, fact sheet content and provided intelligence for planning.

A major challenge for local government was the significant quantity of damaged items and rubbish discarded and accumulated on the roadside for council garbage collection, as well as access to waste depots. Councils prioritised collection in local areas on the basis of structured sanitation surveys to determine the amount and types of putrescible items discarded onto the streets from private residences, food premises and other commercial businesses. These assessments included rapid inspection for the presence of any pests or vermin, and offensive odours. Initial priority for assessment was given to those streets in which food premises were known to be located as well as residential streets assessed to be the worst affected by the floods. Councils implemented additional garbage collection services and provided large skip bins in commercial areas for use by food premises and other businesses. Councils also offered free entry to the waste depot for disposal of flood affected household items.

Environmental Health Officers (EHOs) from HNEPHU were able to assist their local government counterparts directly in a number of ways. In one community that was initially neglected a community meeting was facilitated by the local council to address community concerns. HNEPHU EHOs were able to provide independent expert advice on cleaning and sanitation at this gathering, supporting council messages and actions, which defused a potentially volatile situation. In another local government area specific assistance was requested by the council in relation to conducting site visits and risk assessments at a number of primary schools with onsite waste water disposal systems that had been affected by the floods. Site visits were undertaken within a week of the flooding, when water had subsided, and included assessment for ponding of water in the disposal area, offsite migration of wastewater, odours, broken lids and other structural damage that could pose a public health risk. Mitigation advice was offered, and was received and effectively implemented.

Water and Sewage

The loss of electrical power through the greater Newcastle and Lake Macquarie region had an immediate impact on provision of water and sewage services due to reliance on electric pumps. The immediate concern was an inadequate quantity of safe water with some suburban locations initially having no water. There were 60 sewerage pump failures across the region resulting in the back up and overflow of sewer mains and subsequent

contamination of floodwaters.

During the three-week period following the initial storm event there were a minimum of twice daily telephone communications between the major water utility and HNEPHU. Briefings focused on water quality, water quantity, ongoing protection of the supply, sewage overflows, treatment plant discharges and complaints. Over several days, the electricity utility worked to restore power. Where reticulated electrical power could not be immediately reconnected, the major water utility worked with the electricity utility to provide connections to temporary portable electrical generators to run pumps to reinstate water supply and sewage services. This included sourcing generators from Queensland and Victoria.

The Chichester Dam water catchment received significant rainfall causing increased turbidity beyond the level that the treatment plant could manage. This could have resulted in inadequately disinfected water being introduced into the reticulation system. Fortunately, during a short reprieve in the storm, access by water utility operators to Chichester Dam was possible to enable the supply to be diverted.

Most urban water supply systems had sufficient water to meet demand with only a few elevated areas, serviced by relatively small reservoirs, remaining without water for a period of three to four days. Redirecting water reticulation by adjusting valves until all electrical power was reinstated, filled several small reservoirs. Although sewage overflows continued for several days and considerable emphasis in communication with the communities involved was placed on limiting exposure to the sewage, all overflows were within license requirements.

The flooding also affected two smaller water utilities in the Hunter Valley. Both maintained safe drinking water supplies, initially, by introducing water restrictions to conserve existing reservoir storages. After storage was depleted for one utility, water from the Hunter River was drawn, resulting in high water turbidity. The utility instigated a voluntary precautionary 'boil water advice' until turbidity levels were low enough for the water to be adequately treated to meet the water quality requirements in the Australian Drinking Water Guidelines 2004 (ADWG). There was increased microbiological water sampling for a four-week period with no subsequent water quality failures.

Evacuation Centre Risk Assessments

Eight evacuation centres were established across the region and inspections were conducted in three centres (capacity of 280 people) that were operational for greater than 24 hours. A Field Environmental Health Risk Assessment Checklist, previously developed by HNEPHU for conducting assessments at Rural Fire Service camps during bushfires was used to make recommendations to the Combat Agency where public health and potential disease transmission risks were identified. This Checklist was designed utilising the NSW Health Public Health Emergency Management Handbook (NSW Government 2003), Australian Emergency Manuals Series (Emergency Management Australia 1999), The Sphere Handbook - Humanitarian Charter and Minimum Standards in Disaster Response (The Sphere Project 2004) and the Handbook for Emergencies (United Nations High Commission for Refugees 2000). The Checklist incorporates the following focus areas:

- water, sanitation and hygiene - water supply quality and quantity, toilet, hand washing and shower facilities, hand washing facilities for catering staff, waste water, solid waste, and medical waste storage and removal;

- food - food providers, staff training and health, food handling practices, food storage, temperature control, types of foods including high risk foods,

cooking facilities and equipment, waste storage and removal, and dining facilities;

- shelter - sleeping facilities, overcrowding issues, temperature and noise control; and

- health services - first aid, ambulance, hospital facilities.

Common issues identified were inadequate hand washing facilities, overfilled waste bins and the presence of unflued gas heaters in one evacuation centre. Safe food storage and preventing cross-contamination of food was discussed with the Salvation Army on-site, who under the NSW State Disaster Plan, provide food services at evacuation centres. Similarly, the St Vincent de Paul Society, which provides linen in accordance with the NSW State Disaster Plan, were advised to provide receptacles for used towels, or, alternatively, to provide adequate drying facilities so that towels could dry properly without contact with soiled materials.

School Assessments

Requests were received from the NSW Department of Education and Training (DET) to conduct inspections at two of the worst affected school campuses. HNEPHU EHOs provided advice on appropriate disinfection methods and chemical dilutions to disinfect adequately classrooms, tables, chairs and equipment. Advice was also given on wall materials that needed replacing, preventing tracking of contaminated waste water back into disinfected rooms, safely removing large debris, cleaning play equipment, discarding food in the canteen, and sanitising sporting ovals.

And then There Was the Coal Ship...

The effect of the severe storm was not confined to a land based emergency response. The Pasha Bulker, a 76,741 tonne Panamax bulk coal carrier ran aground on Nobby's Beach, Newcastle. Early on the morning of Friday 8 June 2007, Newcastle Ports Corporation radioed the 56 ships moored off the coast of Newcastle instructing them to move out to sea and thus escape the approaching severe storms. The Pasha Bulker failed to heed this warning and as the storm hit, the Pasha Bulker could not clear the coast and became beached at 9.15 am. While the carrier was still waiting to load 58,000 tonne of coal, it did contain 700 tonnes of fuel oil, 38 tonnes of diesel and 40 tonnes of lube oil. A full scale evacuation of crew was performed heroically from the distressed vessel by a rescue helicopter in extreme weather conditions. This was followed by the relocation of fuel, diesel and lube oil to higher sections of the ship to limit the potential of a spill into the ocean and onto Newcastle and Stockton beaches.

The major public health issue was the potential of human exposure to volatile fuels through dermal and respiratory exposure, and even possibly ingestion. An EHO was deployed on-site to provide public and environmental health advice as required.

Over the next couple of weeks the area became a 'tourist' attraction with more than 10,000 people visiting to view the grounded ship. Food vendors set up vans and stalls to take advantage of the crowds, thus presenting a further environmental health risk. The key health message to the public was to avoid all contact with any oil spill, particularly for wildlife conservationists who were preparing to rescue birds and marine life should a spill occur.

The Pasha Bulker was refloated on 2 July, towed out to sea and following inspection it returned to the port of Newcastle for repairs. During the refloat, two separate oil spills were detected from the damaged propeller and rudder, however, these were minor with no public or environmental risk.

Recovery Centre Risk Assessments

Three Emergency Recovery Centres, established following the storm/flood by the Department of Community Services (DoCS) in Singleton, Cessnock and Newcastle, were also assessed for public and environmental health risks prior to being opened to the public. The buildings selected had been unoccupied for an extended period of time. The assessments resulted in extensive advice on: the provision of hygiene and cleaning, removal of waste, food preparation and storage (for food parcels for the public), public and occupational safety (trip, electrical and structural hazards), an adequate supply of clean water, sufficient hand washing and toilet facilities, heating and cooling equipment, and public access.

HNEPHU EHOs also served as members of the interagency team available at the recovery centres during the immediate period after opening. This provided the opportunity to offer public health and environmental health assistance as well as information in the form of fact sheets and face-to-face consultations for community members affected by the disaster. However, as a result of more pressing community needs it was considered more beneficial that public and environmental health assistance be made available through fact sheets with emergency contact numbers distributed by agencies with an ongoing presence at the recovery centres.

Additional Impact on Environmental Health Services

Over 200 requests for service and/or complaints were received and responded to by HNEPHU EHOs alone, in addition to requests and complaints received and responded to by local government agencies. During the recovery phase the nature of requests initially related to household cleanup, the disinfection of possessions, and the risk to health of contaminated floodwater. However, in the second and subsequent weeks the nature of requests related mostly to public health advice in relation to insurance claims as well as to assisting real estate agents, tenants and landlords.

Conclusion

The severe storms that affected the Hunter Valley over the June 2007 long weekend and resultant public health threats in the ensuing weeks, demanded that Environmental Health Officers play a pivotal role in risk assessment, communication and mitigation. Natural disasters highlight the unique contribution that the environmental health profession can make at the forefront of the response and recovery phases to a natural disaster.

The nature of the threats stretched available capacity, and the debrief with Local Government Public Health Coordinators after the storm highlighted the difficulty environmental health staff in local government would have had in responding to a longer term disaster or secondary event, like a large outbreak of food or waterborne disease.

It was a great relief that the response to the environmental health threats coordinated by the PHEOC in partnership with other agencies prevented environmentally determined health presentations in the aftermath of the floods, as documented by enhanced surveillance through real-time automated emergency department surveillance and active surveillance through general practice and community pharmacies.

It is clear that state and local governments must continue to invest in ensuring an adequately skilled and available environmental health workforce that is equipped to respond to disasters and emergency events.

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Are New Zealand School and Municipal Swimming Pools Clean and Safe?

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In 2000 in New Zealand, school and municipal swimming pools were classed as public swimming pools and were expected to maintain pool water quality as recommended in the new Standard NZS 5826:2000 Pool Water Quality. This research study was an attempt to gauge the level of compliance of these pools to some important parameters stipulated in the Standard. In addition, fungi testing, though not currently included in the Standard, was undertaken in this study to determine what levels of fungi were present because of their potential adverse health impact. Ten school pools (8 outdoors, 2 indoors) and 16 municipal pools (7 outdoors, 9 indoors) were investigated. There was generally a higher rate of failure for school pools when compared to municipal pools for the chemical parameters of pH, alkalinity, free available chlorine (FAC) and combined available chlorine (CAC). In school pools, 31% of samples failed the cyanuric acid test. Of all the pools tested microbiologically, one school pool failed and it was for Pseudomonas aeruginosa. *All pools passed the* Staphylococcus aureus *and faecal coliforms tests. There was a very significant difference in fungi levels (0-2, 3-5 or >5 cfu/100mL) between indoor or outdoor pools. Outdoor pools had a significantly higher level of fungi than indoor pools* ($p = 0.0060$). *There was no significant difference in fungi levels between municipal or school pools* ($p = 0.18$). *Although no growth of pathogenic fungi was found in this study, they might pose a potential health risk if they are present in swimming pools. The correlation between fungal numbers and any of: pH, alkalinity, FAC or CAC was, on the whole, fairly poor. Compared with a previous study in 2001, in this study the school pool results showed (a) much the same compliance for: pH, alkalinity and FAC, (b) much worse for CAC, (c) worse for cyanuric acid, (d) much better for* Staphylococcus aureus, *(e) the same for* Pseudomonas aeruginosa.

Key words: *Swimming Pool; Fungi; Microorganisms; Pool Water Quality*

In 2000, New Zealand adopted a new Standard for public swimming pools, which categorises school pools as public pools the same as municipal pools. The new Standard is NZS 5826:2000 (Standards New Zealand 2000). Guidelines for swimming pools have also been published by the World Health Organization (2006).

No comprehensive study of comparative pool quality has been documented for school and municipal pools since the introduction of the new Standard in 2000. A school pool study was undertaken in 2001 (Lau & Caughley 2002). In 1977, some limited work was published regarding public swimming pools in New Zealand (Auckland Healthcare 1997; Ball 1997). Therefore, this provided an excellent opportunity to research the pool water quality based on randomly selected school and municipal pools in the Greater Wellington region covering Wellington City, Porirua, Lower Hutt and Upper Hutt.

In this study, levels of the test parameters pH, alkalinity, cyanuric acid, free available chlorine (FAC) and combined available chlorine (CAC), faecal coliforms, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* were measured and compared to the criteria in NZS 5826:2000 Pool Water Quality. The results of the tests were evaluated to ensure adequate swimmer comfort and microbiological safety. In addition, fungi testing was undertaken even though such testing is not currently included in the Standard. The fungi testing was included in the study to determine what levels of fungi were present because of their potential adverse health impact.

Studies in relation to fungi in the swimming pool environment have investigated the role of genuses *Trichophyton* and *Epidermophyton* in contact transmission (Aho & Hirn 1981; Kamihama et al. 1997) and procedures to reduce the spread of fungi (Al-Doory & Ramsey 1987).

Materials & Methods

A total of 10 school pools was randomly selected and each was sampled on two different occasions and 7 days apart (n = 20). A total of 16 municipal pools were tested once with 3 pools been tested twice (n = 19). Of the 10 school pools, 8 were outdoors and 2 indoors. Of the 16 municipal pools, 7 were outdoors while 9 were indoors.

For school pool samples, the on-site tests for FAC and CAC were performed using the portable HACH DR100 colorimeter, while the cyanuric acid test was undertaken using the portable BioGuard dipstick method. Cyanuric acid was not measured for municipal pools.

Chemical tests for pH and alkalinity (total) were based on APHA 21st edition, Method 4500H and Method 2320B respectively (Greenberg, Eaton & Clesri 2005).

Microbiological tests were for faecal coliforms (APHA Method 9222D), *Staphylococcus aureus* (APHA Method 9213B) and *Pseudomonas aeruginosa* (APHA Method 9213E). Fungi (mould and yeast) test was based on filtering 100mL of sample and using dichloran rose Bengal chloramphenicol (DRBC) medium.

Results

For the chemical tests: pH, alkalinity, FAC, CAC, there is generally a higher rate of failure for school pools when compared to municipal pools (Table 1). In school pools (where 8 out of 10 were outdoor pools), 31% of samples failed the cyanuric acid test. For the 9 pool samples (from 7 pools) that failed the FAC test, the values recorded ranged from 0.1-1.8 mg/L (see Tables 1 & 2).

Table 1: Chemical and microbiological results of school and municipal swimming pools tested in 2006[1]

Test	Acceptable level	School (n = 20)	Municipal (n = 19)
pH	7.2 - 8.0	4 (20%) fail All too low	2 (11%) fail Both too high
Alkalinity (mg/L)	60 - 200	6 (30%) fail All too low	All pass
Free Available Chlorine (mg/L)	2 - 10	7 (35%) fail All too low	2 (11%) fail Both too low
Combined Available Chlorine (mg/L)	0 - 1.5	8 (40%) fail All too high	3 (16%) fail All too high
Cyanuric acid (mg/L)	25 - 150	5 (31%) fail[2] All too low	Not done
Staphylococcus aureus (cfu/100mL)	< 100	All pass	All pass
Pseudomonas aeruginosa (cfu/100mL)	< 10	1 just fails[3]	All pass
Faecal coliforms (cfu/100mL)	< 1	All pass	All pass

Notes *1. 10 schools were each tested twice, for each test above (n = 20 of each test). 16 municipal pools were tested once (3 pools twice), for each test (n = 19 of each test).*

2. Only 8 schools were tested twice for cyanuric acid (n = 16).

3. 10 cfu/100mL isolated; FAC of 0.1 mg/L

Table 2: Pool samples that failed the FAC test

Pool School (S)/ Municipal (M)	Pool ID	FAC (mg/L)	Indoor (I)/ Outdoor (O)
S	S9	0.7	O
S	S10	0.2	O
S	S17	1.7	I
S	S12	1.6	O
S	S9	1.1	O
S	S4	0.1	O
S	S12	1.7	O
M	EMn	1.0	O
M	ELr	0.9	O

Microbiological tests showed that one school pool tested positive for *Pseudomonas aeruginosa* (Table 1). This positive sample was the second sample collected from school S4 in which the FAC value was low at 0.1 mg/L when compared to the first sample at 3.0 mg/L. All pools passed the *Staphylococcus aureus* and faecal coliforms tests. Generally, the results for the two samples collected from each school were much the same.

Table 3: Fungi results of municipal swimming pools tested in 2006

pH	Alkalinity	FAC	CAC	Indoor (I)/ Outdoor (O)	No. Moulds +No. Yeasts =No. Fungi (cfu/100mL)
7.6	77	3.7	1.2	I	0 + 0 = 0
7.7	104	5.8	**1.9**[2]	I	0 + 0 = 0
7.9	87	2.7	0.5	I	0 + 0 = 0
8.6	155	2.8	**1.7**	I	0 + 0 = 0
7.6	71	3.0	1.2	I	1 + 0 = 1
7.7	85	3.5	0.9	I	1 + 0 = 1
7.9	82	4.5	0.2	O	1 + 0 = 1
7.8	130	3.3	0.7	I	1 + 0 = 1
7.8	122	3.1	0.7	I	1 + 0 = 1
7.9	98	3.0	0.2	O	1 + 0 = 1
7.8	87	3.3	0.6	I	2 + 0 = 2
7.8	118	2.3	1.2	I	1 + 1 = 2
8.0	117	2.4	**1.8**	I	**0 + 3 = 3**
8.0	117	2.2	1.3	I	**2 + 1 = 3**
8.0	98	4.4	0.2	O	**3 + 0 = 3**
8.0	82	3.3	0.2	O	**4 + 0 = 4**
8.1	101	4.0	0.1	O	**2 + 3 = 5**
7.7	82	**0.9**	0.2	O	**3 + 5 = 8**
7.8	85	1.0	0.2	O	**5 + 9 = 14**
r^1 = -0.05	**r^1 = -0.24**	**r^1 = -0.60**	**r^1 = -0.44**		

Notes *1. r = correlation coefficient between fungi and either pH, alkalinity, FAC or CAC.*

2. Blue shaded numbers indicate values outside Standard values, or, in the case of fungi, values > 2 cfu/100ml.

Table 4: Fungi results of school swimming pools tested in 2006

pH	Alkalinity	FAC	CAC	Indoor (I)/ Outdoor (O)	No. Moulds +No. Yeasts =No. Fungi (cfu/100mL)
7.2	**57**	6.0	**3.6**[2]	O	0 + 0 = 0
7.3	**55**	8.0	**8.0**	O	0 + 0 = 0
7.6	122	2.2	**4.2**	I	0 + 0 = 0
7.5	88	4.0	0.8	I	0 + 0 = 0
7.2	80	3.0	0.6	O	1 + 0 = 1
7.7	61	5.6	**2.4**	O	1 + 0 = 1
7.6	70	3.0	1.0	O	1 + 0 = 1
6.8	64	3.0	**1.8**	O	1 + 0 = 1
7.3	**47**	**0.7**	0.2	O	1 + 0 = 1
7.6	101	3.0	0.4	I	1 + 1 = 2
7.6	76	**1.7**	**3.1**	I	**4 + 0 = 4**
7.4	76	**1.7**	0.1	O	**1 + 4 = 5**
7.3	**48**	**1.1**	0.4	O	**0 + 5 = 5**
7.0	**49**	**0.2**	0.4	O	**6 + 0 = 6**
7.5	123	2.0	0.8	O	**6 + 3 = 9**
7.5	117	3.0	0.4	O	**5 + 4 = 9**
7.4	116	4.4	**2.4**	O	**6 + 5 = 11**
7.1	85	**1.6**	0.1	O	**15 + 1 = 16**
6.9	**56**	3.4	**2.6**	O	**16 + 6 = 22**
7.3	87	**0.1**	0.2	O	**25 + 6 = 31**
r^1 = -0.30	**r^1 = 0.15**	**r^1 = -0.38**	**r^1 = -0.27**		

Notes *1. r = correlation coefficient between fungi and either pH, alkalinity, FAC or CAC.*

2. Blue shaded numbers indicate values outside Standard values, or, in the case of fungi, values > 2 cfu/100ml.

Compared with a previous study (Lau & Caughley 2002), in this study the school results were (a) much the same for pH, alkalinity and FAC, (b) much worse for CAC, (c) worse for cyanuric acid, (d) much better for *Staphylococcus aureus* and (e) the same for *Pseudomonas aeruginosa*.

There was a very significant difference between fungi levels (0-2, 3-5 or >5 cfu/100mL) and whether the pool was indoor or outdoor (Tables 3 & 4). Outdoor pools had a significantly higher level of fungi than indoor pools (p = 0.0060). There was no significant difference between fungi levels and whether the pool was municipal or school (p = 0.18).

The correlation between fungal numbers and any of: pH, alkalinity, FAC or CAC was, on the whole, fairly poor. However, fungal numbers tended to be higher when the FAC levels were lower than the minimum Standard value of 2 mg/L.

Fungi identified in this study were moulds *Achaetomium*, *Arthrinium*, *Cladosporium*, *Epicoccum*, *Malbranchea*, *Penicillium*, *Phoma*, *Trichoderma*, and yeasts *Rhodotorula* and *Cryptococcus laurentii*.

Discussion

This research study of 10 school and 16 municipal pools in the Greater Wellington region provided the opportunity to evaluate important aspects in pool water quality. Very useful feedback to participating schools in particular assisted them to meet the new Standard NZS 5826:2000 Pool Water Quality.

In the area of chemical testing in which pH, alkalinity, FAC and CAC were determined, there was generally a higher rate of failure for school pools when compared to municipal pools. This higher rate of failure in the former group might be attributed to the fact that municipal pools have more financial and personnel resources to maintain better compliance of the Standard. In the 8 outdoor school pools studied, 31% of samples failed the cyanuric acid test. The failure in the cyanuric acid test indicated that a satisfactory FAC level might not have been adequately maintained for longer periods since the UV light from sunlight would rapidly destroy the available chlorine.

Failure in pH compliance in this study would have resulted in rapid dissipation of disinfectant, eye discomfort, corrosion of metals, and plaster and concrete etching for low pH (Table 1). In cases of high pH non-compliance this would have contributed to chlorine inefficiency, scale formation and eye discomfort.

Failure in alkalinity compliance noted in this study for school pools (Table 1) would have resulted in pH bounce and corrosion tendency for low alkalinity.

For the 9 pool samples from 7 pools that failed the FAC test (Tables 1 & 2), 7 samples had values which ranged from 0.7-1.8 mg/L, values which would have passed any of the guidelines for the UK (1-5-2.0 mg/L), the US (1-3 mg/L) or Italy (0.6-1.2 mg/L) (World Health Organization [WHO] 2006). The fact that these 7 pool samples passed the microbiological guidelines even though they failed the FAC test might suggest that the cut-off guideline value of 2 mg/L in New Zealand might be on the high side.

A satisfactory finding in this study was that only one school pool failed the *Pseudomonas aeruginosa* test and this was due to the low FAC level of 0.1 mg/L. While the microbiological compliance to the indicator organisms mentioned in the Standard NZS 5826:2000 is satisfactorily high, a potentially worrying aspect is the finding related to fungi growth in some pools. Not surprisingly, outdoor pools had a significantly higher level of fungi than indoor pools ($p = 0.0060$). The external environment in which these pools are located would be a significant source of fungi. The finding that viable fungi were isolated from a number of the pools studied means that there is the potential for viable pathogenic fungi. This potential health risk cannot be overestimated and more research is needed to determine the prevalence of fungal-related illnesses from swimming pools. *Trichophyton* and *Epidermophyton* species, which cause athlete's foot, were not found in the pool samples. Currently, fungi testing for swimming pools is not a requirement in the Standard NZS 5826:2000. Perhaps, with more research, particularly in outdoor pools, this might prove to be necessary.

The isolation of fungi from the pool samples would indicate that for some of the pools tested, filtration is inadequate and this might mean that the larger pathogenic protozoa like *Cryptosporidium* and *Giardia* could also be found.

Endnote

This study was presented in part to the Annual Scientific Meeting of the Australian Society for Microbiology in Adelaide, 9-13 July 2007.

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The National Drought Crisis: Implications for the Health of Australians

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The aim in presenting this viewpoint is to review briefly the repercussions on human health of a significant environmental event in Australia's history. This is a facet of the drought crisis which has received relatively little attention in the media. It is essential that those working in the field of medicine, public health and environmental health are aware of these implications and the degree to which they have already impacted or potentially can impact on the fabric of our society. This review also alludes to challenges we as a nation face in the near future with regard to our preparedness level to deal with the large-scale adverse health impacts of the drought.

Key words: *Drought; Public Health; Environmental Health*

Over the last six years Australia has been ravaged by a crippling drought, the country's worst on record (Grice 2007). While the financial repercussions of failed crop harvests, and stock losses have been acknowledged, there has been little discussion regarding the impact of this drought on the health and wellbeing of Australians.

This review focuses on how these fluctuations in temperature and rainfall patterns impact on aero-allergen production, and on water-borne and vector-borne disease. Also of increasing concern are the psychological impacts of the drought crisis on the health of individuals and the social fabric of rural communities.

The human species, owing to its social organisation and cultural practices is better buffered against environmental stressors than many other plant and animal species (McMichael & Woodruff 2002). Over time, regional populations can adapt to extremes of climate, such as drought, owing to these defence mechanisms. Unfortunately, prolonged periods of extreme conditions, can exert stresses on populations that overwhelms their survival capabilities.

The adverse repercussions of Australia's prolonged drought are multifactorial. There has been an increase in morbidity from acute exacerbations of existing chronic disease as well as due to the emergence of previously non-existent disease (McMichael, Woodruff & Hales 2006).

Since the health of the environment impacts on human health, an appreciation of the inter-relationship between the environment and human activities is paramount. There is wide agreement among environmentalists internationally that human-induced climate change is a contributor to the unprecedented adverse environmental events that we are experiencing (Frich et al. 2002; Intergovernmental Panel on Climate Change [IPCC] 2007; Worldwide Fund for Nature [WWF] 2006). A consideration of health in relation to ecological sustainability needs to be addressed if we are to make a responsible commitment to maximise the health and wellbeing of the Australian people.

The Health Effects of Drought

The health effects of the drought is a topic for an increasing amount of research. Such impacts include the effects on air quality, the altered patterns of transmission of infectious disease, mental health concerns, and the health impacts of population displacement.

Exacerbations of chronic disease

The arid Australian land already encourages much aero-allergen production; drought only further intensifies this, often causing a 'dust-bowl' like phenomenon. There is a clear relationship between increases in allergen-producing organisms such as mould, house dust mites and increases in temperature and reduced rainfall (Beggs & Curson 1997). This can have harmful effects on those suffering from airway disease, including asthma, emphysema and chronic respiratory disease such as cystic fibrosis. Over the previous two years as the drought has intensified, the percentage of individuals presenting to regional hospital emergency departments with acute airway problems and allergen associated diseases, requiring hospital admission, has doubled (Personal Communication, Department of Accident & Emergency, Goulburn Valley Base Hospital, September 2006). While many of these illnesses are effectively reversible with appropriate medical care, for many rural families the hours of lost work-productivity, unforeseen financial strain and time away from their livelihoods is not so easily reversible.

The Emergence of Infectious Disease

Many infectious agents are sensitive to climatic changes. Researchers have predicted an increase in water and vector-borne infectious diseases due to current climatic changes (Weiss & McMichael 2004).

As the ongoing drought threatens the availability of water sources, the quality of our drinking water quality could also become threatened. As a consequence of the drought many rivers experience lower flow rates and fewer floods which are natural mechanisms for cleaning river systems (National Water Commission 2006). Consequently, point source contamination from sewerage discharge, land clearing or salination secondary to desertification are not easily removed and the result is water which is of questionable quality.

Several recent studies suggest that inter-annual variations in climatic and environmental conditions in Australia will impact on outbreaks of Ross River virus and Barmah Forest virus (Tong, Hu & McMichael 2004). It is postulated that as the climate warms and rainfall decreases these disease vectors will spread further south and result in increasing outbreaks of disease not previously experienced in those parts of the continent. There might be a similar increase in the potential distribution of dengue fever, particularly because the mosquito vector for dengue can follow a similar migration pattern but also because mosquitoes are able to breed quite successfully in urban environments (WHO 2000).

The Effect on Mental Health

Drought over a sustained period can have a profound effect on the mental health of individuals and communities who are attempting to cope in extremely stressful economic, environmental and social conditions. It has been reported that one Australian farmer commits suicide every four days (Burgess 2006). This figure has recently been contested by Beyond Blue, the National Depression Initiative which claims that we do not know what the exact rate of suicide or depression due to the drought is, but we do know that the rate of rural suicide is much higher than in the city and that this figure is likely to increase (Kennett 2007). There is also the increasing spectrum of other mental health issues such as helplessness, difficulties coping, loneliness and social isolation which if left unchecked can spiral into depression. A number of factors make it difficult for people in drought affected rural communities to seek help about their depression including the stigma surrounding mental illness, privacy issues within small rural communities, and the scarcity of professional services. Mental health effects are even purported to affect

children in rural areas who see their families struggling to make ends meet. A recent report highlighted a significant increase in school absenteeism as a result of farming families in too much debt to be able to afford education for their children or due to loss of education resources such as teachers, or transport services becoming relocated (Alston & Kent 2004). It has been commented that these frequent periods away from a network of friends, teachers and growth of normal social behaviours may negatively impact on teenage development with the risk of leading to early depression (Kilkkinen et al. 2007).

The Health Impacts of Population Displacement

Farmers unable to generate adequate livelihoods in rural communities have contributed to the rise in migration rates of rural families to the cities. The number of farms in Australia has declined by 25% over the past 20 years as farmers leave the land (Byrnes 2007). Severe drought is leading to a rapid decline in farm numbers triggered by a combination of falling incomes due to unsustainable land and the lure of the city life for younger generations (Burgess 2006). Not only does this affect the status of a nation with a proud history of agriculture, but it also poses challenges for urbanisation.

Overcrowding in urban areas with the associated risks of spread of infectious disease is a potential problem. Further, the growth of our urban populations places additional pressures on the water supply in these areas, which are already struggling to contain water usage with the use of staged water restrictions.

Current Interventions

Current interventions have focused on financial incentives to motivate rural families to remain on their properties. Since 2001 the total federal financial assistance provided has been in the order of two billion dollars with an additional $100-200 million state-funded financial packages released within the last 12 months (National Rural Health Alliance 2007). These financial incentives include $3000 grants per farm business to assist with infrastructure improvements. It also encompasses the National Drought Coordinator Program where worst hit areas have had a 'full-time Drought Coordinator' appointed to manage the federal drought support activities at the local level (Department of Primary Industry [DPI]a 2007).

Another initiative is the Planning for Change Program which offers financial support to industries and local communities to identify the adverse physical impacts of the drought and put into practice workable solutions to remedy them (Department of Primary Industry [DPI]b 2007).

There have also been several national community-oriented incentives aimed at sustaining community wellbeing. The establishment of a volunteer network that provides practical help to local non-government organisations (NGOs) involved in drought relief is one example. Other community services include the Drought Personal Support Line, counseling services, mental health promotion short-courses and mental health 'first aid' training (Department of Human Services [DHS] 2006).

Conclusion

There is convincing evidence to support the role of climate change in ultimately leading to extreme events like that of Australia's prolonged drought. Collaborative research highlights the adverse implications on health of Australians as a result of drought. While current national interventions aim to remedy certain facets of this problem, including improving farming infrastructure, retention of families in rural communities, and community mental health, there are aspects which still need addressing. One such aspect is our

preparedness as a nation to deal with potential epidemics of emerging infectious diseases arising from these environmental changes. Further, although not discussed above, we need to be aware of the need to protect our water resources through clean agricultural practices, and to put in place infrastructure to reduce greenhouse gas emissions.

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2008 Environmental Performance Index

Daniel C. Esty, Marc A. Levy, Christine H. Kim, Alex de Sherbinin, Tanja Srebotnjak & Valentina Mara

Yale Centre for Environmental Law & Policy, New Haven, 2008, 93 pages.

http://epi.yale.edu

There are a number of environmental performance measures or indicators available, but arguably the most comprehensive is the recently released *2008 Environmental Performance Index* (EPI). The EPI recognises the need for environmental and health decision making to be driven by high quality data, but identifies that there are still large data gaps and a lack of time series data that hamper efforts to track many environmental issues, to spot emerging problems, to assess policy options, and to gauge effectiveness. The EPI is an attempt to try and address some of these gaps and to provide a sound analysis on which improved decision making can be made.

Many of the existing environmental performance measures do not adequately account for environmental health, whereas the EPI focuses equally on environmental health and ecosystem vitality as the two overarching objectives. For both of these objectives, a series of well established policy categories are identified for which a series of 25 indicators have been established. In the case of the environmental health objective, the policy categories are the environmental burden of disease, human health effects of water, and human health effects of air pollution. The indicators for these categories are then the environmental burden of disease, adequate sanitation, drinking water quality, indoor air pollution, urban particulates, and local ozone levels.

The EPI employs a proximity-to-target methodology which tracks a country's performance against established targets and a final rating (out of 100) is calculated by measuring the distance between the target and the current national achievement. Of interest is the weighting that each of the policy categories has been given, with the environmental burden of disease weighted at 25% of the total EPI. This means that the environmental burden of disease plays a significant role in the final outcome of an EPI rating for a country, with the WHO's latest report on the environmental burden of disease reviewed in a previous issue of *Environmental Health* (refer to 2006, vol. 6, no. 4, pp. 62-3).

The role of the environmental burden of disease in the final EPI ratings is highlighted in that there were many more high performing countries for the environmental health objective than for ecosystem vitality. Sixty-six countries have scores of 90 or higher in environmental health compared with only two countries scoring over 90 in ecosystem vitality. Performance in the environmental health category was highly correlated with wealth, indicating that many of the low-rated countries have not made the requisite investment in baseline environmental amenities. However, many of the developed countries such as Australia and the United States who performed highly in environmental health, received a much lower overall ranking due to their poor performance against the ecosystem vitality objective.

Of the 149 countries for which an EPI rating could be established, Switzerland, Sweden and Norway received the top three

rankings respectively, with New Zealand ranked at 7, the United Kingdom at 14, the US at 39, and Australia at 46. Within the Asia-Pacific region, New Zealand, Japan, Malaysia and Taiwan were ranked in the first four places respectively, with Australia in fifth place. In regard to Australia's performance against its target indicators, we performed extremely well in the environmental health indicators, scoring 99.3 out of 100, but we scored poorly across the ecosystem vitality indicators, with an overall score of 60.4/100 and scoring the poorest on the climate change and water quality/stress indicators.

The following policy conclusions emerged from the EPI:

- Environmental and health decision making can be made more data driven and rigorous.

- Wealth correlates highly with EPI scores, however, at every level of development, there are countries that perform much better than their income-group peers. This suggests that good governance contributes to better environmental and health outcomes.

- The top-ranked countries have invested in water and air pollution control and other elements of environmental infrastructure and have adopted policy measures to mitigate the impacts caused by economic development. In contrast, low ranked countries generally have not invested in environmental and public health infrastructure and have weak policy regimes.

- Even though the EPI uses the best available data, the overall data quality and availability is alarmingly poor.

Based on the outcomes of the EPI analysis and the gaps identified, policy makers are urged to: (i) invest in environmental and health data monitoring, indicators and reporting; (ii) set clear policy targets on a full range of important environmental and health issues; and (iii) underpin environmental protection efforts with performance measures at the global, regional, national, state, local, and corporate scales.

Overall, the *2008 Environmental Performance Index* provides environmental health practitioners with a rich data set and a highly developed methodology that can be used to enhance decision-making at all levels of government.

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Sustaining Life on Earth: Environmental and Human Health through Global Governance

Colin L. Soskolne Ed.

Lexington Books, 2008, 459 p., ISBN-10-0-7391-1730-0

Sustaining Life on Earth is a text that 'pulls no punches' when it comes to presenting a compelling case for individuals, governments and industry to take seriously the need for an urgent change in the 'business as usual' approach that we have currently adopted concerning sustainability. In fact, the preface to the text argues that our current approach 'is no longer an option if we wish to steer a course that stops fouling our collective nest (i.e. Earth), and one that places us on a course that is more likely to result in a future, a future secure in health and happiness; health and happiness not only for ourselves, but also for the generations of children to come' (p. xvii).

Throughout the book the following themes are evident: (i) that concern about ecological degradation can not be adequately addressed by one academic discipline working in isolation, but requires a variety of experts who are willing to think outside of the traditional confines of their discipline; ii) that the burdens and dangers imposed by ecosystem change are not limited to one country or region, but require international cooperation; (iii) that economic and social welfare are inextricably connected to the 'health' of local, regional and international ecosystems; (iv) the need to examine and understand existing global governance systems, particularly relating to 'justice' as trade continues to supersede the right to life and health across the globe and to re-examine the meaning of democracy; and (v) that individually and collectively we adopt the values and principles contained in the Earth Charter that was produced by the International Union for the Conservation of Nature.

The text contains 27 contributed chapters and emphasises the inter-disciplinary and trans-disciplinary nature of sustainability by bringing together a large range of eminent academics and practitioners from many disciplines and from many countries. The chapters are arranged into five parts and each part has a summary written in non-specialist language. In addition, the introduction and conclusion are also purposely written in non-specialist language so as to engage interest from a wide range of disciplines.

Part 1 links governance to ecology, economy and human wellbeing. Part 2 then links globalisation and human rights with the broader recognition of the human condition and the way we make individual and collective policy decisions. Part 3 goes on to clarify how governance determines the viability of life-sustaining ecosystems and how fundamental these are to human health and wellbeing. In Part 4, the role of covenants is examined, with particular reference to the Earth Charter as being the covenant that will guide us towards sustainability. Part 5 then brings together the preceding parts by discussing the theories and approaches identified in the earlier chapters through examining specific topics. These topics include: governance amid ideological influences in a globalising world; the rights to food and water; social forces, or drivers, at play in environmental and human catastrophes; and how culture and media influence children. The final chapter then brings these preceding analyses together to provide policy recommendations and a coherent case for the changes that are needed to sustain life on Earth.

The essential message of this book is that 'it reminds us of the real interdependence between the health of ecosystems and the health of the human species, as well as our greater moral obligation to this planet and the generations to come. That combination of self-interest and moral necessity must now become integral to our social objectives, our value systems, and the way we administer this invaluable inheritance that is Earth' (p. xv). Given such a powerful and important message, we as environmental health practitioners should be 'front line' advocates within in our communities and to our elected officials, with this text providing significant 'ammunition' in this critical 'battle'

.

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Examine all figures carefully to ensure that the data are presented with the greatest possible clarity to help the reader to understand the text. Similarly, determine if a figure would communicate the information more effectively than narrative. Photographs, which disclose their identity, must be accompanied by signed permission.

Each table and figure must be produced on a separate page, double spaced, numbered consecutively, and given a title. 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.