# Environmental Health

*The Journal of the Australian Institute of Environmental Health*

*...linking the science and practice of Environmental Health*

**Environmental Health**
The Journal of the Australian Institute of Environmental Health

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# Call for Papers

## The Journal is seeking papers for publication.

*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

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

#### Guest Editorials

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

#### Research and Theory

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

#### Practice, Policy and Law

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

#### Reports and Reviews

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

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## EDITORIALS



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### REPORTS AND REVIEWS

In this the second issue of *Environmental Health*, the papers continue to show the diversity of issues in the environmental health field, while taking up some of the themes in the first issue and adding new ones identified in the Journal Aims.

A number of papers look at environmental health risks and how these can be better identified and overcome. Oosthuizen examines the reliability of environmental health risk assessment techniques by using biological monitoring as a means of verification of risk calculations. He concludes that such methods need to be viewed with caution. Although working in agricultural industries is associated with an increased risk of occupational hazard, the extent of the additional risk is not well understood.

Young, Strasser and Murphy in their papers (Parts 1 and 2) aim to improve our understanding of the incidence of injury within the agricultural workforce and by using Spinal Cord Injury as an example to look at additional risks that might exist. Their findings show that while a proportion of agricultural workers' additional risk of injury is accounted for by their working environment, their wider circumstances exacerbate their risk of injury, so safety interventions for reducing injury in the agricultural workforce need to go beyond the workplace in order to reduce the incidence of injury. Another paper discusses working conditions and argues that by studying the mortality trends due to exposure to excessive heat and cold and exploring the potential risk will help in the development of environmental health policy to improve the occupational environment and work place protection measures.

Outdoor music festivals that attract large crowds are regular events but the public and environmental health impacts resulting from attending can include injuries and even death. Other considerations include access to water, food and first aid services. Earl and van der Heide argue that strategic planning reduces the detrimental impacts of attending, and there is an indication that current planning approaches and management strategies are having some success. Using public telephones could also provide a potential hazard to health as Ferdinandus, Hensckhe and Palombo argue in their paper. Their results suggest that telephone surfaces may serve as potential reservoirs for the transmission of disease-causing bacteria.

Environmental health professionals have a key role to play as agents for change in promoting and implementing local policies and actions to promote sustainability. In their paper on the development of indicators of sustainability at the local level, Harris and Chu argue that "it has become increasingly evident that the most influential setting to change our relationship with the environment is at the local level".

In another paper with a focus on local level action, O'Neill outlines the procedures taken in a local landfill site in the Adelaide Metropolitan area in accordance with Environmental Protection Agency requirements. The emphasis of the report is on the control of landfill gas on the site to ensure a safe environment. Continuing the theme of the importance of action at the local level, Collins et al. discuss the formation of local collaborative groups that took responsibility for skin cancer prevention. Community action and the creation of sustainable supportive environments, demonstrated health promotion best practice. The evaluation led to the recommendation that "SUNbusters" continue and be expanded into a statewide skin cancer prevention strategy. The scientific literature is divided about conducting routine inspections of food premises and whether they are an effective way to predict and minimise food borne illness outbreaks. So argue, members of Food Services, Environmental Health Unit, Queensland Health, but go on to say that a number of studies have concluded that routine inspections are effective in improving food hygiene practices and reducing the risk of food borne illness associated with the premises inspected.

The Non-Governmental Position Paper on Critical Needs to Address Children's Environmental Health Problems was generated to bring the issue of children's environmental health to the attention of the international community. As the Report says, "Globally, inadequate fresh or clean water supplies, contaminants and pollutants in the ambient air, exposures to hazardous and unsafe products, and poor waste disposal practices, are the major causal factors in determining the impact of the environment on children's health".

Looking to the future, this issue of *Environmental Health* contains an announcement about a Special Issue to be published in December this year on *Climate Change and Health*. Special Issues are to be a feature of the Journal and it is intended to publish these as the fourth issue every year. We would like to have as many papers as possible for this issue so that the content of the papers reflects the sections in the Journal, and in particular the Science, Practice and Policy emphasis.

*Heather Gardner, Editor*

# *Environmental Health*

## Special Issue
## Climate Change and Health

### Call for Papers

Papers are sought for the **Special Issue, Climate Change and Health,** *Environmental Health*, Volume One, Number Four, to be released in December 2001. Final date for submission of papers for the special issue is Monday 1 October 2001.

Details of the journal, and Guidelines for Authors, including the aims and sections under which articles can be published are in this issue, can be seen at www.aieh.org.au, and are available from the Editor, Associate Professor Heather Gardner.

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Victoria, 3097, Australia.

Papers, reports, commentaries, and reviews on all aspects of environmental health, national and international, are always welcome.

# Environmental Health Risk Assessments: How Flawed Are They? A Methyl-Mercury Case Study

**Jacques Oosthuizen**

***School of Nursing and Public Health, Edith Cowan University, Western Australia***

*The objective was to test the reliability of environmental health risk assessment techniques by utilising biological monitoring as a means of verification of risk calculations. The study population consisted of fish consumers living in close proximity to the u'Mgeni River and the Inanda Dam, downstream from a mercury recycling plant. A control group was selected from an area upstream from the mercury plant. Fish in both the study and control areas were sampled in order to obtain the mean mercury levels to which consumers were exposed. Data related to fish consumption rates, as well as the age and body weights of individuals were obtained by interview. Standard risk assessment methodology was used to determine total daily mercury consumption per kilogram body weight per day. These data were compared to the "tolerable daily intake" (TDI) standard of the World Health Organization and the United States Environmental Protection Agency. In order to verify the risk assessment calculations, human hair samples from both the study population and from a control group were analysed as a direct measure of mercury exposure. The results of the risk estimation indicated that the study population is at risk. Human hair samples were obtained from fishermen in both the study area and control area. It was expected that the mercury concentration in hair would exceed 11 µg/g (US Environmental Protection Agency 1999), however, all results were found to be below the level of sensitivity of the laboratory test (0.5 µg/g). The results of environmental health risk assessments need to be viewed with caution as there are a number of potential sources of error inherent in the risk assessment methods, including the accuracy of data gathered from people, as well as the accuracy of both estimated and measured environmental data. It appears as if a combination of factors may have contributed to the high level of discrepancy in results. It is recommended that studies should include biological monitoring in a small "high risk" purposive sample of exposed individuals to verify risk assessment data.*

**Key Words:** *Risk Assessment, Mercury, Biological Monitoring*

In 1986, Thor Chemicals (Pty) Ltd. commissioned a large mercury incinerator in the Cato Ridge area of Kwa-Zulu Natal, between Pietermaritzburg and Durban, South Africa. The plant received and processed waste for approximately 10 years (Oosthuizen & Ehrlich 2001). Local concern about environmental pollution from the plant was aroused during the early 1990s, when it was reported that unknown quantities of effluent had overflown into the Mngcweni River from a holding pond. The plant was built close to the source of a stream that feeds into the Mngceweni River, a tributary of the u'Mgeni River, which flows into the Inanda Dam. Further, the study

area, the Valley of a Thousand Hills, in the former KwaZulu homeland is densely populated and people in this area rely upon the affected rivers and the Inanda Dam for drinking water, watering of their livestock and fishing (Oosthuizen & Ehrlich 2001).

Wherever possible, appropriate human data should be used as the basis for risk assessments. As a result of a number of tragic incidents of methyl-mercury poisoning that have occurred in the past, there is a great deal of data available on human effects associated with mercury exposure (World Health Organization [WHO] 1994).

## Methyl-Mercury Exposure Guidelines

### *World Health Organization International Programme on Chemical Safety*

WHO established that newborn infants have a 30% risk of developing abnormal neurological signs and symptoms when their mothers' hair mercury concentrations exceeded 70 µg mercury/gram of hair. Further, it was estimated that there was a 5% increased risk of neurological disorders in children born to mothers with hair concentrations between 10 and 20 µg mercury/gram of hair. The recommendations of the WHO, International Programme on Chemical Safety (WHO/IPCS) are based on clinically observable neurological changes as the indicator of effect. It was estimated that a daily methyl-mercury intake of 0.48 µg mercury per kg body weight would cause no adverse effect and would equate to a hair mercury concentration of below 11 µg/g (WHO 1991).

### *US Environmental Protection Agency limits for methyl-mercury*

The US Environmental Protection Agency employed a benchmark dose approach to determine the mercury level in hair, which is associated with no adverse effects. The benchmark dose is the intake of methyl-mercury associated with the lower bound limit of the 95% confidence interval around the dose producing a 10% prevalence of adverse effects. The adverse neurological effects used for benchmarking included delayed walking, talking, and abnormal neurological scores among children. A dose-conversion of daily intake, including an uncertainty factor of 10, produced a reference dose of 0.1 µg methyl-mercury/kg body weight/day. This dose will maintain a blood methyl-mercury concentration of approximately 44 µg/l in blood or 11 µg/g in hair (US Environmental Protection Agency 1997).

## Methods

### *Study design*

A risk assessment was conducted over a period of six months from November 1998 to April 1999. Data were collected to quantify levels of mercury pollution in various environmental media as well as in fish and to evaluate the risk the community might be exposed to by determining their fish consumption rates.

Permission to conduct the study and to take samples was obtained from the Faculty of Health Sciences of the University of Cape Town, the local traditional leader, as well as the police commissioner in the area, and from all persons who participated in the study.

### *Study area*

Two 1:50,000 topographical maps, obtained from the Land Surveyors Office, Cape Town, were used to identify and select sampling positions. Sampling in the study area was conducted from directly below the mercury recycling plant, along the Mngceweni (tributary) and the larger u'Mgeni River, with the final sampling point being the Inanda Dam, which is located approximately 20 km downstream from the plant. Control samples were collected upstream from the Mngceweni/u'Mgeni confluence to the Nagle Dam, which is located approximately 20 km upstream from the plant.

### Study population

The study population consisted of all fish consumers residing in the area. Among this population a "high risk" sub-group was identified. This group consisted of young boys who swam, played, drank and fished in the u'Mgeni River daily during the study period. A control group with similar fish consumption patterns was selected from an area upstream from the plant.

### Sampling methodology

*Cyprinus Carpio Linnaeus*, the most common species of carp in the region, is omnivorous, taking a wide range of plant and animal matter mainly by grubbing in sediment. The Sharp Tooth Catfish (*Clarias Gariepinus*) is also a common resident fish of the region and the most abundant of the catfish in South Africa. The fish preys, scavenges or grubs on virtually any available organic food, including fish, birds, frogs, small mammals, reptiles, snails, crabs, shrimps, insects, other invertebrates and plant matter, and is even capable of straining fine plankton if necessary (Skelton 1993). Samples were collected as follows.

i Human hair and river fish samples were collected during the period from 30 November 1998 to 4 December 1998. Fish samples from the two dams were collected during the period 7 December 1998 to 8 June 1999.

ii Sampling personnel wore clean cotton clothes and gumboots and un-powdered vinyl gloves during sample collection and handling. Gumboots and gloves were thoroughly washed and rinsed at each sampling point.

iii Control (reference) samples of human hair and fish were taken from the Nagle Dam and surrounds.

iv River fish samples ($n$ = 7) consisted of small freshly netted catfish and carp (mean size = 17 cm) which were purchased from local people on the riverbanks. Dam fish ($n$ = 21) consisted of larger catfish and carp (mean size = 31 cm) caught with baited hooks. These fish proved to be the most popular and abundant species caught and consumed by local people.

v All individuals included in the hair sampling protocol had lived in the study area for many years thus hair samples were representative.

### Laboratory analysis of samples

The US Environmental Protection Agency (1999) recommend that due to cost and other considerations fish samples should be analysed for total mercury content. An assumption is made that between 90 and 100% of the mercury in fish tissue will be in the form of methyl-mercury. All samples were transported to the South African Bureau of Standards (SABS) approved analytical laboratory of Umgeni Water, immediately after collection, or were frozen at minus 150°C until they could be taken to the laboratory. Samples were analysed in accordance with approved methodology and quality control procedures as detailed in the Umgeni Water, Analytical Services Laboratory Methods Manual, Method 34, Rev Amendment no. 5 (Umgeni Water 1998, April).

### Statistical analysis of data

The SPSS statistical computer software package was used for data entry and analysis. Fish samples were classified into groups according to sample type and were compared to control samples. These data were analysed non-parametrically with the aid of the Mann-Whitney test. The level of significance of the tests did not exceed 0.05. In addition, due to small sample sizes ($n$=7) for river fish and ($n$=20) for dam fish, a Monte Carlo analysis was done to verify the significance of tests.

Body weight and daily fish consumption rates were determined by interview. The mean fish mercury levels measured in the various sampling locations were used to calculate the daily methyl-mercury intake of individuals. Individually calculated intake rates, expressed as µg mercury per kg body weight, were compared to international norms and hazard quotients were calculated.

## Results

### *Human risk assessment*

Hazard Quotients are frequently used to quantify non-cancer hazards such as exposure to methyl-mercury. The total daily intake of mercury is calculated and divided by the reference value or tolerable daily intake. When the resultant hazard quotient value is less than 1, no harm is expected, if greater than 1 the threshold has been exceeded and toxicity is likely to occur (Fan & Chang 1996).

The US Food and Drug Administration and the World Health Organization established a tolerable daily intake of 0.48 mg methyl-mercury per kg body weight per day. The US EPA, however, published a reference dose of 0.1mg methyl-mercury per kg body weight per day (US Environmental Protection Agency 1999).

Since accurate body weight data was not available, weight was determined by interview. However, it appeared as if weight was initially underestimated (Oosthuizen and Ehrlich 2001). Subsequently, more accurate body mass data for the population was obtained and the risk was re-calculated. In spite of the increased body mass estimate people are still deemed to be at risk in terms of both criteria with hazard quotients of 2.3 (WHO 1994) and 11 (US EPA 1999). See Table 1.

***Table 1: Total mercury consumption per kg body weight of the study group, compared to the WHO and US EPA standards***

| Age | Estimated Weight (kg) | Mean fish Hg level in Area (µg/kg) | Estimated daily Intake (mµg/kg) body weight | WHO Hazard Quotient | U.S.EPA Hazard Quotient |
|---|---|---|---|---|---|
| 14 | 60 | 0.33 | 1.1 | 2.3 | 11 |
| 10 | 55 | 0.36 | 1.3 | 2.7 | 13 |
| 17 | 65 | 0.36 | 1.1 | 2.3 | 11 |
| 34 | 70 | 0.33 | 0.9 | 1.9 | 9 |
| 13 | 60 | 0.36 | 1.2 | 2.5 | 12 |
| 11 | 55 | 0.3 | 1.1 | 2.3 | 11 |
| 21 | 70 | 0.45 | 1.3 | 2.7 | 13 |
| 14 | 60 | 0.4 | 1.3 | 2.7 | 13 |
| 22 | 70 | 0.15 | 0.4 | 0.8 | 4 |
| Median | Median | Median | Median | Median | Median |
| 14 | 30 | 0.36 | 2.2 | 2.3 | 11 |
| (10-34) | (20–70) | (0.15-0.45) | (0.4-3) | (0.8–2.7) | (4-13) |

*Note: a worst case scenario assumption was made that 100% of the mercury was in the form of methyl-mercury. Hazard Quotient below 1 indicates no risk.*

### *Hair samples*

Human hair mercury levels and fish consumption data in the study group ($n$ = 9) and the control group ($n$ = 5) are presented in Table 2, together with the mean fish mercury levels found in the area where subjects reside. Human hair mercury levels in both exposed and control groups were all

< 0.5 µg/g and well below the US EPA reference dose of 11 µg/g (US Environmental Protection Agency 1997).

iii There may have been seasonal variations in the fish diet that were not considered.

***Table 2: Personal data, fish consumption data and human hair mercury levels: study and control group***

| Age | Years of Residence in area | Mean fish mercury level (µg/g) | Human hair Hg (µg/g) study group ($n$ = 9) | Human hair Hg (µg/g) Control ($n$ = 5) | Min. fish meals per week |
|---|---|---|---|---|---|
| 14 | 1 | 0.33 | <0.5 | <0.5 | 7 |
| 10 | 10 | 0.36 | <0.5 | - | 7 |
| 17 | 17 | 0.36 | <0.5 | <0.5 | 7 |
| 34 | 6 | 0.33 | <0.5 | <0.5 | 7 |
| 13 | 13 | 0.36 | <0.5 | - | 7 |
| 11 | 11 | 0.3 | <0.5 | <0.5 | 7 |
| 21 | 21 | 0.45 | <0.5 | - | 7 |
| 14 | 14 | 0.4 | <0.5 | - | 7 |
| 22 | 3 | 0.15 | <0.5 | <0.5 | 7 |
| Median | Median | Median | Median | Median | |
| 14 (10 – 34) | 11 (1 – 21) | 0.36 (0.15 – 0.45) | <0.5 | | 7 |

*Note: Sensitivity level of the laboratory method was 0.5 µg/g). No members of the study or control groups had mercury amalgam fillings. The control group was matched for age and gender with five members of the study group.*

## Discussion

### *Limitations of the study*

There are a number of limitations to the study, which it is important to outline:

i Due to the geographic nature and extent of the study area as well as budgetary constraints, a limited number of samples were collected.

ii Obtaining permission to collect hair samples proved to be difficult due to superstitious beliefs regarding the use of hair or nail clippings to perform witchcraft. A limited number of samples was obtained ($n$ = 9) and controls ($n$ = 5). Care was therefore taken to ensure that people were selected that were deemed to be most at risk, owing to their fish consumption patterns and age in order to obtain a worst case scenario (purposive sample group).

iii Weight estimation of the study population may have been inaccurate.

iv The Mngcweni River is a small shallow stream, which is not used for fishing. All study area fish and hair samples were thus collected beyond the confluence of the Mngcweni and u'Mgeni rivers which is at least 2-3 km from the plant.

### *Risk assessment*

In terms of both the World Health Organization and US Environmental Protection Agency criteria, the exposed sample was deemed to be at risk with median hazard quotients of 2.3 and 11 respectively.

### *Hair samples*

It was decided that human biological samples should be included in the study

design, in order to verify the results of the risk assessment. The use of human scalp hair as an indicator of methyl-mercury exposure has been well established. The main advantage of this sampling method being the fact that it is non-invasive and allows for easy collection, storage and transport. Blood and hair mercury concentrations are related, with the hair mercury levels being 250 times greater than blood mercury levels.

Hair analysis has served as the sole basis for the estimation of methyl-mercury exposure in a number of studies (Barbosa, Silva & Dorea 1998; Holsbeek, Das & Joris 1996; Shi, Lane & Clarkson 1990; Soria et al. 1992; Suzuki et al. 1993).

All of the hair samples, obtained from a "high risk" group of frequent fish consumers in the study area, as well as from the control area had mercury concentrations below 0.5 µg/g, (see Table 2). Using the US Environmental Protection Agency (1997) reference dose of 11µg/g in human hair, the hazard quotient was calculated to be <0.045 for all persons sampled.

It is therefore evident that the results obtained from the direct measurement of hair mercury levels do not support the results of the risk assessment. The difference in results could be attributed to a number of factors and further research is required to clarify the following pertinent questions:

i Were fish consumption data accurate?

ii What impact would seasonal variation in diet have upon mercury levels in hair?

iii What impact would the normal non-fish diet of the local community have on their hair mercury levels? That is, is there one or more chelating agent that is being consumed that would help to eliminate mercury from the system?

iv Most studies of hair mercury levels have been conducted on people with long straight hair (Japanese, New Zealanders, North and South Americans). Does the short "crinkly" African hair absorb mercury to the same extent?

v What is the blood mercury level in the exposed populations?

vi Are risk assessments inherently flawed, and do they overestimate the risk due to correction factors designed to compensate for uncertainty?

## Conclusion

In this study a number of potential errors and limitations were identified as discussed above, however, there was sufficient rigour in the methodology to conclude that people were probably at risk and the sample group should have had at least 11 µg/g mercury in hair. The hair sampling exercise was intended merely to verify the results of the risk assessment, however, these results increased the level of uncertainty making the appropriate planning of interventions very difficult.

It is recommended that the results of risk assessments should be interpreted with caution and due regard for the control of potential sources of error that may affect the results. Further, risk assessment results should be verified with some form of direct human biological monitoring of a carefully selected sample group.

### *Acknowledgments*

The Faculty of Health Sciences of the University of Cape Town, South Africa supported this research. Funding for the research was obtained from the University of Cape Town, the South African Medical Research Council and the Kellogg Foundation, USA. The study was conducted with the kind permission of the community of the Valley of a Thousand Hills, Kwa-Zulu Natal, South Africa.

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# Disabling Injury in the Agricultural Workforce

## Part 1: A Review

**Amanda E. Young[1], Roger P. Strasser[1], and Gregory C. Murphy[2]**

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*Although it has long been recognised that working in the agricultural industries is associated with an exacerbated risk of injury, the extent of the additional risk is not well understood. Research aimed at defining rates of injury within the agricultural industry has been conducted for many decades, however, limitations associated with research methodologies and inconsistencies in findings mean that our understanding of injury in the agricultural workforce is limited. In this paper issues to do with earlier research attempting to investigate injury in the agricultural workforce are discussed and an alternative method of inquiry that overcomes some of these problems is proposed.*

**Key Words:** *Farm Injury, Review, Methodology, Incidence.*

The domain of environmental health is complex, covering many topic areas and requiring the contribution of many specialists. Of the topics defined as within the scope of environmental health, occupational epidemiology ranks highly, with institutions such as Harvard University's Department of Environmental Health including it as one of its main teaching and research areas. Although the understanding of occupational injury within many industries is comprehensive, this is not the case when it comes to agriculture. In response to the lack of understanding, this paper explores the current state of knowledge regarding occupational injury within the agricultural workforce.

Internationally, agriculture has long been considered one of the most hazardous industries in which to work, with authors from the United States (Field 1982; Field & Purschwitz 1987; Kraus 1985; Kelsey 1994; Powers 1950,1964), Canada (Simpson 1984), England and Wales (Anonymous 1974; Cooper 1971), Sweden (Thelin 1980), and Germany (Knabe & Wolf 1982) all commenting on the inordinate dangers associated with agricultural production. Australian agriculture is no exception (Chapman 1993; Fregar 1996; Hegney 1993). While the danger associated with agricultural production has long been recognised internationally, accurate and comprehensive information on agricultural trauma is limited and difficult to find (Gunderson et al. 1990). One of the main reasons for this is the extent to which agricultural production operates independently of regulation and control. For most other industries, workers' compensation statistics provide almost complete coverage of the injuries sustained, however, as many agricultural workers are not covered by workers' compensation (Low & Griffith 1994; Worksafe Australia 1994) such statistics do not capture all of the

injuries sustained by those occupied in the agricultural industries.

Limitations associated with workers' compensation statistics have led researchers to use alternative methods in their attempts to define the incidence of injury in the agricultural workforce. One line of research has been to investigate deaths resulting from farm injuries. However given that i) injuries resulting in death are relatively easy to identify through the use of coroners' reports, and ii) little can be done to assist those who are deceased, studies investigating farm injuries resulting in death have not been presented or discussed in detail in this review. Instead, the interested reader is referred to the work of Clarke and Coleman (1995) for a review of the Australian research conducted into this topic. For a detailed analysis by industry sub-division, the work by Fregar, Gray, Franklin and Petrauskas (1997) is available.

Studies investigating the wider incidence of farm injuries have used a variety of methods including cross-sectional studies, analysis of hospital admission data, and extrapolation of workers' compensation statistics. However, much of this research is limited because complete coverage of injury (that is, the numerator) cannot be assured. This is especially true in the case of the more serious injuries, as these are typically not well represented in smaller-scale research (Bland 1995). Additional problems associated with interpreting and comparing past research include inconsistency in incidence measures and lack of information about the severity of injury sustained.

As is demonstrated in Table 1, the incidence of injury is reported in a multitude of ways, including per farming establishment, per workers, and per person years. Such inconsistency makes it difficult to compare rates or make an estimate of injuries per person hours, as is often used to report other industry injury rates (see Oxenburgh 1990). A further limitation has been that little information is provided about the severity or consequence of injury. This means that a clear understanding of the impact of injury is difficult to attain. While all injuries result in some level of discomfort, those injuries that result in a change to the person's abilities are most likely to cause long-term problems.

A summary of the research published between 1988 and 2000 that attempted to determine the incidence of farm injury is presented in Table 1. (At this point it is worth reiterating that it is difficult to compare directly the findings presented in Table 1 owing to the measures and procedures being highly variable. Rather, Table 1 aims to illustrate the problems faced by those attempting to quantify farm injury rates.) The studies presented in Table 1 were identified either through i) Medline (using the terms "farm" (or "agricultur*") and "injury" and "rate") or ii) other sources (e.g., secondary citations). As it was the current aim to review studies that focused on population injury rates, research excluded from presentation includes that not providing denominator information, investigating only a particular cause of injury (e.g., from farm machinery), focused on a particular type of farming, or restricting the sample to include only particular age groups. For a comprehensive review of the earlier research regarding the wider rates of farm injury, the reader is referred to the work of Elkington (1990) and for an Australian perspective, the works by Coleman, Drinkwater, Fragar and Mills (1996), Coleman, Fragar and Morton (1996), Harrison and Cripps (1994) and Day (1995) are available.

***Table 1: Research conducted into the rates of farm work-related injury (1988-2000)***

| Authors | Location | Method | Summary of Findings |
|---|---|---|---|
| Brison & Pickett (1991) | Canada | Survey of 113 farms | 9.8 injuries per 100 person years |
| Browning et al. (1998) | Kentucky, U.S.A. | Survey of 998 farmers aged 55+ | 9.3 injures per 100 farmers |
| Chater & Ferguson (1994) | QLD, Australia | Information given by 13 health service providers over 12 months | 35 injuries per 100 farm workers, 60 injuries per 100 farms |
| Coleman & Fragar (1995) | NSW, Australia | Review of emergency department presentations | 18.3 per 100 farms have injuries annually |
| Coleman, Drinkwater, Fragar & Mills (1996) | NSW, Australia | Estimate based on workers compensation data | 0.86 severe injuries per 100 farms each year |
| Crawford et al. (1988) | Columbus U.S.A. | Cross-sectional study (N=1793) | 5 injuries per 100 person years |
| Day, Ashby & Stathakis (1997) | VIC, Australia | Analysis of emergency & inpatient minimum data set | 8.3 emergency department presentations & 1.8 hospitalisations per 100 farms per year |
| Evans (1998) | Wales | Prospective survey of agricultural workers seeking medical treatment over a 12-month period | 10.5 injuries per 100 agricultural industry workers. |
| Ferguson (1994) | QLD, Australia | Retrospective survey of 1749 producers | 27.8 injuries or illnesses per 100 farms per year |
| Fuortes et al. (1990) | Iowa, U.S.A. | Analysis of hospital records | 1.52 hospitalisations per 100 farmers per year |
| Jansson & Jacobsson (1988) | Sweden | Analysis of emergency room attendance | 6.3 injuries per 100 farms per year. 2.7 injuries per 100 farms leading to temporary disability, 0.3 injuries per 100 farms leading to permanent disability |
| Layde (1989) | Marshfield, U.S.A | Review of medical records | 5.31 per 100 agricultural workers sustained a disabling injury each year |
| Low, Griffith & Alston (1996) | NSW, Australia, | Random sample of 919 farms (retrospective & prospective) | 22.3 per 100 properties reported at least one injury, 8.3 serious injuries per 100 farms per annum |
| Nordstrom et al. (1995) | Marshfield U.S.A. | Prospective study of clinic and hospital patients | 6.5 injuries & 0.5 hospitalisation per 100 farm residents |
| Pickett, Brison, Niezgoda & Chipman (1995) | Ontario, Canada. | Retrospective mail survey of 2,000 farms | 5.8 injuries per 100 persons per year. |
| Rosenblatt & Lasley (1991) | Iowa, U.S.A. | Retrospective survey of farm injuries over past 12 months | 26 injuries per 100 farm operators responding to the survey (response rate of 62%). |
| Rasmussen, Carstensen & Lauritsen (2000) | Denmark | Prospective study of 393 randomly selected farms | 8 per 100 farmers and farm labourers suffered an injury for which they sought professional treatment. |
| Stallones (1990) | Kentucky, U.S.A. | Survey conducted in 1978 of 1,992 farms | 2.1 injuries per 100 farm family members (including children) |
| Valuri & Routley (1994) | VIC, Australia | Analysis of emergency presentations | 33.9 per 100 farms have injuries annually |
| Zhou & Roseman (1994) | Alabama U.S.A. | Retrospective survey of 1000 farm operators | 7.8 per 100 farmers injured annually (some farmers injured > once). |

Of the studies listed in Table 1, the one likely to provide best coverage and be representative of the situation in Australia is the prospective study undertaken by Charter and Ferguson (1994). However, as this study used data supplied by health service providers, only injuries for which treatment was sought were detected. Thus it may be inferred that the actual rate of injury is likely to be higher than the reported estimate of 35 injuries per 100 workers.

### *Injury resulting in impairment*

International research into the rates of more severe injury has produced varied estimates. One of the main reasons for this is the variability in the "severity" classifications used. However, many of the studies also have methodological limitations associated with them. Following is a brief review of the studies focusing on severity of injury. Methodological issues to do with each individual study and each type of study design are detailed. Although studying

injuries requiring hospitalisation is one way of establishing the incidence of more serious injury, it is not considered sufficiently stringent to imply impairment. Thus studies using the criterion of hospital admission have not been included in the following review.

### *Cross-sectional studies*

Ferguson (1994) conducted an Australian study that attempted to address the issue of severity of injury. In this study surveys were sent out in two waves to 1749 "rural producers" (50.9% of the total producers in the area identified for investigation). The initial wave asked respondents to indicate if an injury had occurred on their property over the previous six months. A second survey was sent out six months later asking if an injury had occurred in the previous six months. Using this approach, the researchers hoped to obtain work-related injury statistics for a twelve-month period. While the sample size intended for this research was substantial, the low response rate (53%) makes it difficult to confidently generalise the results to the wider population.

The generalisability of Ferguson's findings is further limited by the fact that the measure of injury used was difficult to interpret. Participants were asked to report the "worst injury" sustained on their property over the previous six months. Inspection of the injuries described by Ferguson (1994) provides little detail about the consequences of the injury. In all, 69 respondents sustained an injury that could have resulted in impairment. These injuries included "crush or amputation" ($n$ = 55) and "spinal structure injury" ($n$ = 14). Other reported "worst injuries" included, internal body part ($n$ = 9), fracture ($n$ = 54), eye injury ($n$ = 22), sprain, strain or dislocation ($n$ = 228) and superficial ($n$ = 232). As it is probable that producers who incurred an injury were more likely to complete and return the questionnaire, this needs to be taken into consideration when attempting to calculate the impairment injury rate. Dividing the number of injuries resulting in impairment by the targeted sample (target $n$ = 1,749) would produce an estimate unlikely to exaggerate the incidence of injury. Doing so produces an annual estimate of 3.95 injuries resulting in impairment per 100 farms. Calculations using the number of surveys returned ($N$ = 932) as the denominator provides an estimate of 7.40 injuries resulting in impairment per 100 farms. Given the limitations associated with interpreting the meaning and thus the generalisability of Ferguson's findings, it would seem that further research is required before an understanding is gained of injury resulting in impairment within the agricultural workforce.

In their study of farmwork-related injury in New South Wales (Australia), Low, Griffith and Alston (1996) randomly sampled 919 people from the agricultural labour force including employees, self-employed and unpaid family labourers. Low, Griffith and Alston chose to define those who required more than five days off work, as suffering a "serious injury". It was their contention that this definition eliminated those injuries that were considered superficial by farmers, did not cause a great amount of disruption to the farm work schedule, and required either no or only a small amount of professional medical care. They found that the average annual rate of serious injury in Australian agriculture was 8.3 per 100 farms. Although taking six days off work does constitute an inconvenience, it is unlikely that the majority of these people suffered any long-term ill effects as a result of their injury. To capture these, a more conservative definition of serious injury would be required.

Apart from the problems associated with each individual study, there are general problems associated with using the cross-sectional design. One of its weaknesses in relation to the study of farm injury is that the cross-sectional approach is not

particularly well suited to the investigation of relatively infrequent or rare events (Bland 1995). Past cross-sectional research into farm injury has demonstrated that even with quite large samples the more serious injuries are not well captured (see for example, Ferguson 1994 and Low, Griffith & Alston 1996).

### *Census type research*

Some researchers have attempted to overcome the problem of identifying the more serious injuries by expanding the denominator to include an entire geographical area. Cogbill and Busch (1985, p. 206), in their study of all injuries resulting from agricultural trauma admitted to the participating hospital (located in Wisconsin) over a six-year period, found that 10% resulted in "severe long-term disability". However, because they did not provide denominator information, that is the population of agricultural workers that the participating hospital served, it is not possible to determine the rate of disabling injury.

A population study of 2454 Swedish farms used regional emergency room records over one year to identify the number of farm work-related accidents that had occurred (Jannson 1987; Jannsson & Jacobsson 1988). In all, 167 injuries were reported. Of these, 65 resulted in "temporary disabilities" and seven resulted in "permanent disabilities". Dividing these by the population base indicates that on 2.9% of farms an injury occurred that resulted in at least a "temporary disability". Although this study is superior in terms of catchment, there is still the problem of determining the per person injury rate as information regarding the number of people working on the farms was not provided.

In a review of the epidemiology of farm injury, Layde (1989) estimated that in the United States, the disabling injury rate was 53.1 per 1000 agricultural workers per year. Although no mention was made as to whether the disability was permanent or not, the author indicated that disabling injuries were defined as "all injuries that require professional medical attention or result in more than one-half day time lost from usual activities" (p. 5). While this definition does exclude injuries that impact only minimally on the worker's life, it is unlikely that all injuries would have resulted in the acquisition of a significant impairment.

The use of hospital emergency room admission information has the potential to provide comprehensive coverage of injuries for which a hospital admission was required, but this method can also be flawed, especially if admissions only to provincial hospitals are analysed. In such cases, emergency room admission information is likely to exclude some of the more serious injuries that are taken directly from the site of the accident to a specialist medical centre (typically located in a metropolitan centre). It is necessary that researchers attempting to define the incidence of injury look further than local hospital records and include an analysis of specialist trauma centre admissions.

### *Estimates based on other industry injury rates*

Using Australian workers' compensation data, Coleman et al. (1996a) attempted to estimate the number of permanently disabling and severe work-related injuries that occur in Australian farming each year. Coleman et al. divided the average annual number of permanently disabling and severe injuries requiring six or more months off work (370.33) by the number of farms in NSW (42,817), and concluded that the injury rate was 0.86 severe injuries per 100 farms per year. By applying this percentage to the number of farms in Australia, Coleman et al. estimated that 1293 new permanently disabling and severe injuries occur nationally each year. Based on Ferguson's finding that workers' compensation statistics underestimate the total farm injury rate by a factor of six, Coleman, et al. (p. 17) concluded that, "5,172 new severe and disabling injuries

occur per annum". (Coleman et al. chose to multiply their estimate by the "conservative" factor of four.) While the estimate arrived at by Coleman et al. (1996a) is logical, it is problematic on at least four accounts.

First, because they divided the number of accidents by farming establishments, and not the number of people employed in the agricultural industries, the estimate reflects the number of farming establishments on which an injury occurred. Considering that more than one employee may work on each farming establishment, and that the compensation statistics used reflected the incidence of injuries to employees and not at work sites, a better estimate could be arrived at through dividing the incidence of injury by the number of agricultural industry workers. Second, while it can be suggested that a person who has had six months off work has acquired a permanent disability, this is not certain to be true. Third, while it was Feguson's finding that compensation statistics captured only about 15% of all injuries, this is unlikely to be true for the more serious injuries. Finally, the injury profile for self-employed persons is likely to be different from that of employees. The self-employed have been found to be 2.9 times more at risk of sustaining an injury (Brison & Pickett 1991). As a higher proportion of those occupied in the agricultural industries are self-employed, the applicability of other industry statistics may be questioned. So while estimates based on other industries may provide insight, close attention needs to be paid to the way the estimate is derived.

### *An alternative method of estimating disabling injury in the agricultural workforce*

In view of the limitations associated with past research it may be argued that a census of all agricultural workers is required to assess accurately the magnitude of the problem of farm injury. However, considering the resources needed to conduct such a venture in a way that would produce valid and reliable results, it is unlikely that such an exercise will be undertaken. An alternative to a complete census is to take a census of those with a particular type of injury. Not only does this provide information about the incidence of that injury type, if the injury type's proportion of all injury is known, this information can then be used to make inferences about the wider incidence of injury. Although it is true that there are advantages associated with this methodology, if the injury of choice is treated at a wide variety of health facilities, capturing all cases can be challenging. Further, it can be difficult to make comparisons if people receive treatment from a range of providers. One injury type that is relatively rare, but of considerable consequence, is spinal cord injury (SCI).

### *Spinal cord injury: The clinical significance*

Of all injuries sustained, few are more devastating than SCI (Rosenberg, Gerhart & Whiteneck 1993). As in other countries, SCI is a significant problem in Australia. While SCI is relatively rare, it is important due to the severity of outcome in individual, social and economic terms (O'Connor & Cripps 1997). Suffering a SCI is a devastating event often resulting in the need for major life changes. By its nature a SCI requires considerable adjustments to be made so that individuals can effectively manage the personal, social and vocational consequences of their injury (Halstead & Grabois 1985). Careers can be significantly affected, particularly if the person injured was previously working in an occupation that is physically demanding. Working in agricultural occupations usually requires high degrees both of gross and fine motor skill, mobility, and physical power (Coleman et al. 1996). Thus the agricultural worker with SCI is placed in a very challenging position when attempting to return to the labour market.

Another issue of significance associated with SCI is that it can result in a variety of impairments that are similar to those found

to be common in residually injured farm workers. In their study of agricultural injury, Zhou and Roseman (1995) found that 63% of the people with residual injuries had problems typically associated with SCI. These included difficulties in the use of the limb, persistent pain, decreased range of movement, restricted physical activity and persistent numbness. A further 19% of injuries resulted in amputations, which in terms of functionality, are not largely different from the consequences of many spinal cord injuries. Thus, it may be suggested that what is learnt from the investigation of SCI in farmers would be applicable to the wider group of farmers with impairments.

### *Spinal cord injury: The methodological advantages*

In Australia, all people who sustain a traumatic SCI are treated in one of six specialist spinal units (Burke, Burley & Ungar 1985). Consequently, the entire population of people with a SCI can be accessed with relative ease. A problem encountered by researchers attempting to compare agricultural workers with other workers is that both groups may not respond to a particular injury in the same way. The injury and illness profiles are likely to be different. For those who are self-employed, their response to injury is moderated by their vested interest (Ferguson 1983). To add to the problem, farmers will often persevere under the most adverse of circumstances (Renwick 1986), continuing to work wherever possible despite injury or illness (Webster, Bath & Lush 1985). However, in the case of SCI, the victim has very little choice as to whether or not they seek medical treatment. Because all patients are admitted to hospital, detailed records are kept and impairment is objectively defined.

## Conclusion

The task of defining the incidence of injury in the agricultural workforce has proven challenging. Although there has been considerable research into this topic, limitations associated with many of these investigations mean that our understanding of farm injury is still incomplete. For the reasons outlined above, SCI was chosen as the focus of research aimed at assessing the additional risk of injury associated with being employed in the Australian agricultural workforce. For details of the results of this investigation, please see Part 2 of this paper in this issue.

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# Disabling Injury in the Agricultural Workforce

## Part 2: Rates

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*This paper reports on research conducted with the aim of i) defining the incidence of spinal cord injury (SCI) within the agricultural population, and ii) estimating the additional risk of suffering a SCI associated with working in the agricultural industries. Through the analysis of all new traumatic spinal cord injuries between 1990 and 1996 in South-Eastern Australia, it was found that those working in the agricultural industry were at more than six times greater risk of suffering a SCI than were the remainder of the population. In comparison with those employed in industries other than agriculture, it was found that agricultural workers were at approximately five times greater risk of SCI. Agricultural workers were found to be at close to twice the risk of suffering a work-related SCI in comparison with those employed in other industries. Findings reveal that while a proportion of agricultural workers' additional risk of injury can be accounted for by their working environment, agricultural workers' wider circumstances are placing them at an exacerbated risk of injury. Based on this finding, it is inferred that safety interventions targeted towards reducing injury in the agricultural workforce need to go beyond the workplace in order to reduce the incidence of injury in this population.*

**Key Words:** *Spinal-cord-injury, Epidemiology, Agriculture, Incidence.*

As detailed in Part 1 of this paper, our understanding of injury within the agricultural workforce is limited. Based on the premise that many of the methodological limitations associated with earlier research could be overcome by focusing on a particular type of injury for which almost complete coverage could be assured, the current investigation into the rates of spinal cord injury in the agricultural workforce was undertaken[1].

While not widely studied, there has been some research that has identified agricultural workers as over-represented in the spinal cord injured population. In their study of all of spinal cord injury (SCI) admissions seen in Colorado between January 1986 and June 1991, Rosenberg, Gerhart and Whiteneck (1993) found that 9.5% of those who suffered a work-related accident had "occupations" that they described as farming, fishing and forestry. Considering that at the time, agricultural workers made up only approximately 2% of the workforce in the United States (Layde 1989), it is apparent that more agricultural workers presented with work-related spinal cord injuries than would be expected based on population employment data.

Australian research has included an analysis of the pre-injury occupational titles as provided by 150 people who suffered a SCI. Of these, 13.2% described their pre-injury occupational title in a way that indicated they had worked in the agricultural industries (Young & Murphy

1998). With agricultural workers comprising only about 5% of the Australian workforce, findings from this research support the contention that there is also an over-representation of agricultural workers in the Australian spinal cord injured population.

This research aimed to define the rates of SCI in those employed in the agricultural industries. Based on the higher rates of injury in the agricultural industry, it was hypothesised that:

- The incidence of SCI would be higher in those who are employed in agricultural industries.
- More of the agricultural industry workers' injuries would be work-related in comparison with the injuries of those employed in other industries.

## Method

The sample was identified using a consecutive sampling technique based on new admissions to the participating Spinal Unit between January 1, 1990 and December 31, 1996. The number of new admissions over the study period was 643. In order to facilitate comparisons, the Centres for Disease Control's clinical definition of SCI was employed. This defines spinal cord injury as the occurrence of an acute, traumatic lesion of neural elements in the spinal canal, resulting in temporary or permanent neurological deficit (Thurman et al. 1995). Using this definition, 414 of the 643 new admissions could be classified as traumatic. Of these, 21 people were from overseas and had either been sent to Australia for rehabilitation ($n$ = 10) or were overseas residents injured in Australia while either on work, study or vacation ($n$ = 11). As it was considered that this group was not representative of the Australian population they were excluded from further reporting. The final number of people fulfilling all inclusion criteria was 393.

### *Measures*

The information targeted for collection (and reported in this paper) included:

- Basic demographic information
- Date of injury, admission & discharge
- Injury type
- External cause of injury
- Compensation status
- Whether the injury was work-related
- Labour force status
- Occupation and industry classifications

Occupational situation was based on the Australian Bureau of Statistics labour force classifications. Further sub-divisions were made for those not in the labour force (e.g., students, homemakers). In line with definitions of the Australian Bureau of Statistics, participants categorised as "employed" included people who worked for one hour or more for pay, profit, commission or payment in kind in a job, business, or farming enterprise. This definition defines contributing family members as employed if they work more than one hour a week. Occupation was coded according to the Australian Standard Classification of Occupations (ASCO), second edition (McLennan 1997). Industrial classification was coded using the Australian and New Zealand Standard Industry Classification System. Compensation entitlement was categorised as compensable, not compensable or unclear. If the patient was compensable they were sub-classified as being covered by workers' compensation, transport accident compensation or other.

External cause of injury was classified based on the International Classification of Disease (ICD-9-CM). An assessment as to whether or not the injury was occupationally related was made based on the patient's case notes. While there have been calls for a standardised definition of work-related injury (see Heads of Workers' Compensation Authorities 1996), there are currently several operationalisations in use. The definition used in this study was any injury occurring while the employed person (as defined above) was in the course of employment where that employment was a contributing factor. In line with ICD-10-AM guidelines, other Australian SCI research (see, for example, O'Connor & Cripps 1997) and compensation criteria in several Australian states, transport accidents that occurred while commuting to or from work were classified as work-related.

Consistent with the American Spinal Injury Association definitions, level of injury was assessed at the lowest level of the spinal cord with normal sensory and motor function on both sides of the body (American Spinal Injury Association 1992). People whose injuries affected any of the cervical segments were classified as having tetraplegia. Those with lesions in the thoracic, lumbar or sacral regions were classified as being paraplegic. The extent of the neurological injury was also assessed as either complete or incomplete. Based on the neurological assessment, patients were categorised as sustaining a complete tetraplegia, incomplete tetraplegia, complete paraplegia or incomplete paraplegia.

### *Participants*

Of the 393 new admissions to the participating Spinal Unit, 142 people, or 36.1%, of the study population were not employed at the time of their injury. Of the 251 people employed at the time of their injury, 53 could be classified as employed in the Agriculture, Forestry and Fishing division of the Australian and New Zealand Standard Industrial Classification (ANZSIC) system. Other highly represented industrial classifications included: construction ($n$ = 45), manufacturing ($n$ = 32), retail ($n$ = 29), and transport and storage ($n$ = 23). (For further details regarding the pre-injury employment details of the study population, see Table 1.) The agricultural workers' mean age at injury was 43.5 years. In comparison, other industry workers were on average just over 10 years younger ($m$ = 33.4 years). Of agricultural workers, 9.4% were females, as were 13.1% of the other industry workers.

## Results

People employed in the agricultural industries made up 21% of those employed at the time of injury and 14% of all admissions. Of those defined as employed in the agricultural industries: 43 worked in the agricultural subdivision, seven worked in services to agriculture, and three worked in forestry.

The distribution of the various injury types was quite consistent across the three groups (see Table 2). However, there was a tendency for agricultural workers to suffer complete tetraplegia and incomplete paraplegia at a higher rate than the other groups. When the two working populations were compared, chi-squared analysis revealed that there was no statistically significant difference in the types of injuries sustained either in regard to paraplegia versus tetraplegia or incomplete versus complete lesion ($\chi 2$ (1) = 0.484 & 1.228 respectively). There were no statistically significant differences when the four-level categorisation method (i.e., complete tetraplegia, incomplete tetraplegia, complete paraplegia and incomplete paraplegia) was used ($\chi 2$ (3) = 1.530, $p > .05$).

***Table 1: Pre-injury employment situation and industry (as applicable) for those who suffered a traumatic SCI resulting in persistent neurological damage (1990-1996)***

| Pre-Injury Employment Situation | Cases ($n$ = 393) | Percent of all Cases | Percent of Occupational Situation Grouping |
|---|---|---|---|
| Employed | 251 | 63.9 | |
| Agriculture, forestry & fishing | 53 | 13.5 | 21.2 |
| Mining | 3 | .8 | 1.2 |
| Manufacturing | 32 | 8.1 | 12.8 |
| Electricity, gas & water | 2 | .5 | .8 |
| Construction | 45 | 11.5 | 18.0 |
| Wholesale | 9 | 2.3 | 3.6 |
| Retail | 29 | 7.4 | 11.6 |
| Accommodation, cafes & restaurants | 9 | 2.3 | 3.6 |
| Transport & storage | 23 | 5.9 | 9.2 |
| Communications | 4 | 1.0 | 1.6 |
| Finance & insurance | 5 | 1.3 | 2.0 |
| Property and business | 11 | 2.8 | 4.4 |
| Government administration & defence | 4 | 1.0 | 1.6 |
| Education | 4 | 1.0 | 1.6 |
| Health & community services | 5 | 1.3 | 2.0 |
| Cultural and recreational services | 8 | 2.0 | 3.2 |
| Personal and other services | 4 | 1.0 | 1.6 |
| Missing | 1 | .3 | 0.0 |
| Not in paid employment | 142 | 36.1 | |
| Housewife | 6 | 1.5 | 4.2 |
| Retired | 34 | 8.9 | 23.9 |
| Student | 42 | 10.7 | 29.6 |
| Pension (not age retired) | 2 | .5 | 1.4 |
| Unemployed | 58 | 14.8 | 40.8 |

***Table 2: Injuries sustained by those who suffered a traumatic SCI resulting in persistent neurological damage (1990-1996)***

| Injury Type | Agricultural Workers *f* (%) | Other Industry Workers* *f* (%) | Not Employed *f* (%) | All *f* (%) |
|---|---|---|---|---|
| Overall | | | | |
| Complete Tetraplegia | 10 (10.9) | 30 (15.3) | 26 (18.6) | 66 (17.0) |
| Incomplete Tetraplegia | 15 (28.3) | 73 (37.2) | 53 (37.9) | 141 (36.2) |
| Complete Paraplegia | 12 (22.6) | 39 (19.9) | 29 (20.7) | 80 (20.6) |
| Incomplete Paraplegia | 16 (30.2) | 54 (27.6) | 32 (22.9) | 102 (26.2) |
| Work-related injuries | | | | |
| Complete Tetraplegia | 6 (18.8) | 6 (8.6) | | 12 (11.8) |
| Incomplete Tetraplegia | 7 (21.9) | 24 (34.3) | | 31 (30.4) |
| Complete Paraplegia | 7 (21.9) | 18 (25.7) | | 25 (24.5) |
| Incomplete Paraplegia | 12 (37.5) | 22 (31.4) | | 34 (33.5) |

** Missing data applied, percentages calculated using valid n.*

With data supplied by the Australian Bureau of Statistics publication, Australian Demographic Statistics, the average annual incidence of traumatic SCI resulting in persistent neurological damage was estimated to be 10.9 per million people. Table 3 displays the number, population and incidence for each year studied. The average annual incidence of SCI for those employed in the agricultural industry over the study period was 61.5 per million (see Table 3 for further details) using denominator information based on the Victorian and Tasmanian population demographic information (denominator information was not available for the entire catchment area).

Tasmanians working in the agricultural industry were at 6.28 times greater risk of suffering a SCI than were the remainder of the population (95% CI 2.81 - 14.13). When the analysis was restricted to only those Victorians and Tasmanians who were employed pre-injury, it was found that those who worked in the agricultural industries were at 4.88 times greater risk of SCI than were those employed in other industries (95% CI 2.10 - 11.44).

The major external cause of injury was transport accidents. Comparison of the cause of accident (see Table 4) reveals that the agricultural workers were more likely to have sustained an injury that would be categorised as "other accident", particularly being struck by an object falling or otherwise. Examples of these other accidents included having a tree fall on them ($n$ = 4), hit by a round hay bale ($n$ = 3), contact with an animal ($n$ = 2), accidental gunshot, being crushed by a truck container, and being run over by a tractor.

***Table 3: Incidence of injury by place of residence, industry and year injury occurred***

| Population | Incidence | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | Mean |
| Victoria | | | | | | | | |
| Cases* | 45.0 | 55.0 | 46.0 | 49.0 | 43.0 | 41.0 | 54.0 | 47.6 |
| Population ('000) | 4378.6 | 4401.6 | 4438.9 | 4465.2 | 4479.1 | 4501.2 | 4539.1 | 4457.7 |
| Incidence per million | 10.3 | 12.5 | 10.7 | 11.0 | 10.9 | 9.1 | 11.9 | 10.9 |
| Victoria & Tasmania combined | | | | | | | | |
| Cases* | 56.0 | 57.0 | 50.0 | 53.0 | 51.0 | 44.0 | 59.0 | 52.9 |
| Population ('000) | 4840.8 | 4866.2 | 4907.4 | 4936.0 | 4951.5 | 4974.6 | 5013.4 | 4927.3 |
| Incidence per million | 11.6 | 11.7 | 10.2 | 10.7 | 10.3 | 8.8 | 11.8 | 10.7 |
| Total catchment area | | | | | | | | |
| Cases* | 60.0 | 62.0 | 53.0 | 56.0 | 54.0 | 45.0 | 63.0 | 56.1 |
| Population† ('000) | 5040.8 | 5066.2 | 5107.4 | 5136.0 | 5151.5 | 5174.6 | 5201.4 | 5125.4 |
| Incidence per million | 11.9 | 12.2 | 10.4 | 10.9 | 10.5 | 8.7 | 12.1 | 10.9 |
| Victorian & Tasmanian agricultural industry workers | | | | | | | | |
| Cases* | 10.0 | 5.0 | 2.0 | 7.0 | 8.0 | 6.0 | 9.0 | 6.7 |
| Population ('000) | 114.4 | 112.6 | 113.8 | 104.4 | 102.0 | 105.9 | 113.6 | 109.5 |
| Incidence per million | 87.4 | 44.4 | 17.6 | 67.0 | 78.4 | 56.7 | 79.2 | 61.5 |
| Victorians & Tasmanians employed in industries other than agriculture | | | | | | | | |
| Cases* | 28.0 | 31.0 | 20.0 | 28.0 | 22.0 | 23.0 | 32.0 | 26.3 |
| Population ('000) | 2154.3 | 2045.3 | 2015.6 | 1996.9 | 2049.3 | 2138.2 | 2172.0 | 2081.7 |
| Incidence per million | 13.0 | 15.2 | 9.9 | 14.0 | 10.7 | 10.8 | 14.7 | 12.6 |
| Victorians & Tasmanians not working in agriculture (including those not employed) | | | | | | | | |
| Cases* | 48.0 | 52.0 | 48.0 | 47.0 | 46.0 | 38.0 | 50.0 | 47.0 |
| Population ('000) | 4726.4 | 4753.6 | 4793.6 | 4831.6 | 4849.5 | 4868.7 | 4899.8 | 4817.6 |
| Incidence per million | 10.2 | 10.9 | 10.1 | 9.7 | 9.5 | 7.8 | 10.2 | 9.8 |

* *Of admission of traumatic SCI resulting in persistent neurological damage.*

† *Estimated population served by the SU (i.e. Victorian and Tasmanian populations plus an additional 200,000 residing in Southern New South Wales).*

*Populations' statistics from Australian Bureau of Statistics catalogues 3101.0, 6204.0 & 6202.2*

The average annual incidence of SCI Victorians and Tasmanians not employed in the agricultural industries (including those not employed) was 9.8 per million. Calculation indicated that Victorians and

Agricultural workers were less likely to suffer a fall than were members of the other groups. Swimming/diving accidents made up 25% of the falls sustained by other industry workers. Only one of the agricultural industry workers suffered their SCI in this way.

sustained by agricultural workers were work-related ($\chi 2$ (1) = 9.6 $p$ < .01) with an additional 23.8% of the injuries sustained by agricultural workers being work-related (95% CI = 8.96 - 38.6). Agricultural industry workers were found to be at 1.65

***Table 4: External cause of injury***

| Cause of Injury | Agricultural workers *f* (%) | Other Workers *f* (%) | Not Employed *f* (%) | Total *f* (%) |
|---|---|---|---|---|
| Overall | | | | |
| Transport Accidents | 29 (54.7) | 113 (57.1) | 65 (45.8) | 207 (52.7) |
| Falls | 11 (20.8) | 67 (33.8) | 61 (43.0) | 139 (35.4) |
| Other Accident | 12 (22.6) | 10 (5.1) | 3 (2.1) | 25 (6.4) |
| Assault | 1 (1.9) | 3 (1.5) | 6 (4.2) | 10 (2.5) |
| Event of undetermined intent | 0 (0.0) | 2 (1.5) | 3 2.1) | 5 (1.3) |
| Sequelae of morbidity | 0 (0.0) | 1 (0.5) | 1 (0.7) | 2 (0.5) |
| Work-related injuries | | | | |
| Transport Accidents | 13 (40.6) | 38 (54.3) | | 51 (50.0) |
| Falls | 8 (21.9) | 22 (31.4) | | 30 (39.4) |
| Other accidents | 10 (31.3) | 9 (12.9) | | 19 (18.6) |
| Assault | 1 (3.1) | 1 (1.4) | | 2 (2.0) |

### *Work-related injuries*

In total, 102 (26.4%) of the injuries sustained were work-related. Of these, 71 (70%) occurred while duties directly related to the person's work were being carried out. The remainder occurred while commuting to or from work. The proportion of work-related injuries as experienced by those working in the agricultural industry and other industries is presented in Table 5. The work-related injuries sustained by the two groups were similar in type (see Table 2) with chi-squared analysis revealing no statistically significant differences between the groups: tetraplegia versus paraplegia, $\chi 2$ (1) = 0.45, $p$ > .05; incomplete versus complete, $\chi 2$ (1) = .580, $p$ > .05; complete tetraplegia versus incomplete tetraplegia versus complete paraplegia versus incomplete paraplegia, $\chi 2$ (3) = 3.422 $p$ > .05.

To investigate whether the proportion of injuries sustained by the two groups of workers differed in relation to the number that were work-related, a chi-squared analysis was performed. Results indicated that significantly more of the injuries

times greater risk of suffering a work-related SCI in comparison with other industry workers (95% CI = 1.52 - 1.79).

When one inspects the cause of the work-related accidents (see Table 4), a similar trend is evident to that observed when the causes of all injuries were compared. Again, "other accidents" comprise a greater proportion of the accidents sustained by agricultural workers (31.3% verses 12.9%). Transport accidents make up a greater proportion of the cause of accidents suffered by other industry workers (40.6% versus 54.3%). Inspection of the transport accidents sustained by the agricultural workers indicates that nine (69%) occurred while industry-specific duties were being undertaken. Of these, one occurred while a tractor was being driven on the road, two involved the transportation of stock, two resulted from a fall from an animal, and four others occurred while the injured was using an off-road motorbike. Of the transport accidents sustained by other industry workers, 10 (26%) were directly

related to occupational duties (these involved transport drivers, police and a pilot). The remainder sustained their injuries through a motor vehicle accident on the way to or from a place where work was to be conducted.

to suffer a SCI than were those who worked in the agricultural industries.

In order to determine if agricultural workers' additional risk of SCI could all be attributed to the dangers associated with their work environment, injuries that were

***Table 5: Work-related injury by occupational grouping***

| Work-related Injury | Agricultural Workers *f* (%) | Other Workers *f* (%) | All Workers *f* (%) | Entire Population* *f* (%) |
|---|---|---|---|---|
| No | 21 (39.6) | 121 (63.4) | 142 (58.2) | 284 (73.6) |
| Yes | 32 (60.4) | 70 (36.6) | 102 (41.8) | 102 (26.4) |
| Valid Total | 53 | 191 | 244 | 386 |

** Missing data applied, percentages calculated using valid* n.

As would be expected, more of the agricultural industry workers were defined as residing outside of a capital city metropolitan area at the time of their injury in comparison with those occupied in other industries (95.5% versus 43.2%). In order to determine if agricultural workers' additional risk of injury could be attributed to living in a rural location (the incidence of SCI is known to be higher amongst rural residents), the relative risk associated with living in a non-capital city metropolitan area while not working in the agricultural industries was calculated. The average incidence of SCI for those not residing in their state's capital city and not employed in the agricultural workforce was 10.6 per million. In comparison, for those residing in the capital city and not working in the agricultural industries, the average incidence was 8.5 per million. Relative risk calculations indicate that non-capital city residents not involved in the agricultural industries were at only 1.25 times greater risk of suffering a SCI than were city dwellers not occupied in the agricultural industry (95% CI 0.67–2.31). So while slightly more likely to suffer a SCI, country residents working in industries other than agriculture were found to be much less likely

work-related were excluded from the denominator and incidence rates were recalculated. The incidence of non-work related SCI was found to be 7.75 per million Victorians & Tasmanians employed in industries other than agriculture. In comparison, the non-work related incidence rate for Victorians employed in the agricultural industries was 24.79 per million. Calculations of relative risk indicate that agricultural workers were at 3.20 times the risk of suffering a SCI that was not work-related (95% CI 0.89 – 11.57).

## Discussion

Study findings support the hypotheses that the incidence of SCI is higher in those employed in the agricultural industries, and that more of their injuries are work-related. Considering that the Spinal Unit whose patients provided data for this investigation serves the entire and defined population, one could expect that those presenting to the spinal unit should have similar characteristics to those of this population. However, this was found not to be the case. According to the Australian Bureau of Statistics, over the study period approximately 5.2% of those working in the SU's catchment area were employed in the

Agriculture, Forestry and Fishing Industry. However, admissions information indicates that 21% of those working at the time of injury were employed in this industry. Clearly there is a vast over-representation of agricultural industry workers in admissions to the Spinal Unit.

As detailed in Table 3, the incidence of persistent SCI was stable at approximately 11 per million over the study period. This is consistent with past and current research into the incidence of SCI in South-Eastern Australia (Cripps & O'Connor 1998; O'Connor & Cripps 1997; O'Connor & Cripps 1999). The average annual incidence for Victorian agricultural workers was found to be 62.3 per million and 61.5 when figures from the Tasmanian and Victorian populations were combined. In both cases, calculations of relative risk indicate that those working in the agricultural industries were at greater than six times the risk of SCI than were the remainder of the population. Figures relating to the working population indicate that agricultural industry workers were at approximately five times greater risk of suffering a SCI than those working in other industries. Given that the lower bound of the confidence interval was not less than one, it can be concluded that that the increased risk of SCI associated with being an agricultural industry worker is statistically significant (Dicker 1996). However, given that the confidence intervals encompass quite a wide range, it is difficult to make a precise estimate as to the extent of agricultural workers' additional risk of injury.

Although the overall percentage of work-related injury (i.e. 26.4%) is higher than that reported by some past researchers (see for example Norrell 1973, and Rosenberg, Gerhart & Whiteneck 1993), it is suggested that this is due to the current study defining injuries sustained on the way to or way home from work as work-related. If one compares the findings of this research with the findings of O'Connor and Cripps (1997) who used the same definition (and who found that 25% of injuries were work-related), the proportion of injuries defined as work-related is consistent. Results from the current study indicated that not only are agricultural workers at close to twice the risk of suffering a work-related SCI as are other industry workers, they are also more likely to sustain an injury which was caused by a hazard intrinsically related to their work environment. These findings highlight the need for the agricultural workplace to be the target of injury prevention programs.

While results indicate that the sample size was sufficiently large for the conclusion to be drawn that the observed additional risk of injury was reliable, it should be noted that this is not the case in regard to the various causes of injury. As the number of agricultural workers suffering their work-related injuries as a result of the various causes was only relatively small, the current data do not allow for firm conclusions to be drawn about specific activities that are likely to result in SCI. However, consistent with past research into the causes of serious farm injury (see, Cogbill & Bush 1985 and Zhou & Roseman 1995, for examples, and Elkington 1990 for a review of the earlier literature), accidents involving farm machinery and livestock have been identified as common causes of work-related SCI in the agricultural workforce.

One factor that could account for some of the additional risk could be the fact that those who work in the agricultural industries work more hours per week than do those who work in other industries (McLennan 1996). Thus it can be suggested that if calculations of injury rates were made per person hours worked, as is often used to report other industry injury rates (see Oxenburgh 1990) then the disparity in injury rates might be less. While it is true that some of the additional risk of work-related SCI associated with employment in the agricultural industries can be attributed to additional hours worked, inspection of average weekly hours worked by agricultural

industry workers reveals that the additional hours worked do not account for all of the additional risk of injury. Statistics from the Australian Bureau of Statistics indicate that over the study period, Australians employed in the agricultural industries worked approximately 49 hours per week. In comparison, those employed in other industries worked approximately 39 hours per week. Thus as those occupied in the agricultural industries did not work 1.65 times (rather only 1.25 times) the hours of those employed in other industries, it can be concluded that there are other factors related to the workplace that also place the agricultural worker at a heightened risk of injury.

While some of the additional risk of injury associated with being an agricultural worker could be attributed to occupational duties, there was also additional risk that could not be accounted for by workplace exposure. Indeed the estimated additional risk of non-work related SCI was found to be in the order of 3.20 when comparisons were made with the remainder of the working population. While it is acknowledged that this finding is not definitive as the lower bound of the 95% confidence interval was less than 1 (i.e., 0.89), it is suggested that this finding interpreted in context with the other results suggests that agricultural workers are at greater risk of SCI beyond that associated with their work environments. As the relative risk of SCI was found to be only marginally greater for those living in a rural setting and not occupied in the agricultural industries in comparison with those similarly occupied living in the capital city metropolitan area (i.e., RR = 1.25, CI 0.67 – 2.31), it is suggested that the identified additional risk of injury for agricultural workers cannot all be attributed to their tendency to reside in rural areas. Thus it is suggested that beyond working in a dangerous environment, agricultural workers are undertaking additional activities that result in them more frequently suffering SCI.

So, not only do findings from this study concur with past research that has suggested that farmers tend to put a higher emphasis on production than on safety (Emmett 1988; Hiscock-Corney 1989; Kendall et al. 1990; Sanford 1990), the current findings also suggest that this tendency to consider safety issues as secondary may be a generalised phenomenon that results in agricultural workers undertaking a wider range of dangerous behaviours. Thus, it may be inferred that safety interventions targeted at this group need to go beyond the workplace in order to reduce the risk of injury in this population.

### *Inference to the broader incidence of work-related injury in the agricultural workforce*

As was detailed in Part 1 of this paper, the incidence of work-related injury in the agricultural industries is difficult to ascertain. Through comparing the incidence of work-related SCI in the Victorian agricultural population with the numbers of people who sustained a work-related SCI while working in other industries, an estimate of the additional risk associated with working in an agricultural setting was calculated. In addition, information regarding the wider incidence of work-related injury in the non-agricultural population can be used to estimate the broader incidence of work-related injury in the agricultural population.

According to the Victorian workers' compensation system reports (Victorian WorkCover Authority, 1998), there were 364,816 work-related injuries over the seven-year study period. People employed in the agricultural industries sustained 7448 of these. Subtracting these left 357,368 work-related injuries being sustained by people employed in industries other than agriculture. Results from the current investigation revealed that of 162 spinal cord injuries sustained by Victorian workers employed in industries other than

agriculture, 58 were known to be work-related. However, only 40 of these work-related injuries were covered by workers' compensation. The remainder were either commuting accidents that occurred after November 1992 when in Victoria these accidents were no longer covered by workers' compensation ($n$ = 9) or were suffered by people not covered by workers' compensation ($n$ = 9). By dividing the number of compensable work-related spinal cord injuries that occurred in Victoria over the study period by the number of injuries sustained by people employed in the non-agricultural industries (40/357,368) we see that SCI makes up 0.011 percent of the work-related injuries sustained. If we assume that those employed in the agricultural industries are no more or less likely to sustain differing severity of injury[2], then this information can be used to estimate the broader incidence of work-related injury in the agricultural population.

In the current study, 24 of the 40 injuries suffered by Victorian agricultural workers were work-related. Of these, one would not have been covered by workers' compensation, as it was an accident that occurred in 1995 on the way home from work; after November 1992 such accidents were no longer covered by the Victorian workers' compensation system. Thus the number of injuries that would have been covered by workers' compensation was 23. If the number of work-related injuries occurring in the agricultural industries is x, and the number of work-related spinal cord injuries is 23, then using the equation 23 / x = 40 / 357,368, x can be estimated to equal 205,487.

Applying the average annual injury number of 29,355 (205,487/7) back to the average number of Victorians who were employed in the agricultural industries over the study period (93,900), we can estimate that 31.3% of agricultural workers sustained an injury for which they could have lodged a workers' compensation claim, had they been covered by this system. This is in stark contrast to other industry workers, of whom only 2.7% made workers' compensation claims (average annual injury number 51,052.6 divided by the average non-agricultural workforce of 1,897,100). While the difference in the number of work-related injuries is vast, the derived estimate of injury in the agricultural industry it is consistent with other Australian estimates (see Charter & Ferguson, 1994 as presented in Table 1 of Part 1 of this paper). Thus the current results, together with Charter and Ferguson's findings, may be used to suggest that the annual rate of injury within the agricultural workforce approximates between 30 and 35 per 100 workers.

Compensation statistics can also be used to estimate the number of more substantial injuries occurring within the agricultural industries. Between 1990 and 1996, Victorian workers' compensation statistics (see Victorian WorkCover Authority, 1998) indicate that approximately 39,000 people were awarded a lump sum after suffering a traumatic injury that left them "maimed" in some way (i.e., with some type of permanent impairment). Spinal cord injuries accounted for 0.10% of these. If spinal cord injuries make up only 0.10% of the maiming work-related injuries sustained by agricultural workers, then it can be estimated that 23,000 maiming injuries occurred in the Victorian agricultural industries over the study period. This translates to 3,286 injuries a year or 3.5% of the Victorian agricultural workforce. By applying this figure to the estimated Australian agricultural workforce (approximately 430,000), it can be argued that approximately 15,050 Australian agricultural industry workers suffer a "maiming" injury each year.

Past research investigating more severe injuries is difficult to compare with the current findings due to definitional issues and the fact that in the majority of cases reports are made in terms of farms rather

than workers (see discussion of these as presented in Part 1 of this paper). As such the current estimate can not be used in conjunction with past findings to derive an approximation of maiming injury within the agricultural workforce. However, the current findings provided a basis that may be used as evidence to suggest that the annual rate of maiming injury within the agricultural workforce is approximately 3.5 per 100 workers.

Although it is advised that care is taken when in interpreting these findings owing to the small numbers on which estimates were derived, and the fact that there is considerable under-reporting of work-related injuries in employees who are covered by workers' compensation, the preceding exercise has demonstrated that the risk of injury associated with working in the agricultural industries is far in excess of that associated with working in other industries. As well as providing insight into agricultural workers' additional risk of injury, study findings also raise questions concerning the post-injury experience of this population. Agricultural industry workers can be faced with a combination of difficulties, including distance, environmental extremes and lack of understanding of options open to them. This can mean that once discharged from hospital they receive fewer rehabilitation services than do other industry workers. With fewer services it may also be argued that they are likely to suffer inferior outcomes. Clearly no firm conclusions can be drawn at this stage. However, what the current investigation does highlight is the need for further research into the consequence of impairment in the agricultural workforce.

## Conclusion

Results from this study indicated that those working in the agricultural industries were more likely to suffer a SCI than were the remainder of the population, and those employed in industries other than agriculture. Not only were they more likely to suffer a work-related SCI, but they were also more likely to be undertaking duties that were directly work-related when their injury occurred. While the current findings reinforce the need for initiatives to be taken to curtail the incidence of injury in those who work in the agricultural industries, results also highlight the importance of caring for the population of agricultural workers who sustain a serious injury and are left with a severe impairment.

### *Endnotes*

1. Some parts of this paper have been published in the *Journal of Agricultural Safety and Health* (a publication by the American Society of Agricultural Engineers).
2. At this point it is difficult to determine if agricultural workers are at a greater risk of suffering a severe injury over a minor injury, however, personal experience with agricultural industry workers leads the current researchers to believe that agricultural workers are at greater risk of suffering the entire spectrum of injuries.

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# The Development of Indicators of Sustainability at the Local Level: Methodology and Key Issues

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*In the past decade the importance of local policies, strategies and action to promote sustainability has become more apparent. It has also become increasingly evident that the most influential setting to change our relationship with the environment is at the local level where the responsibility and efforts to pursue global sustainability becomes actionable by communities. To this end, environmental health professionals have a potential role to play as key agents for change. However, to facilitate local actions, there must be appropriate means to inform local decision makers and residents about the connections between development, the environment and health. Based on a collaborative research project with a local government, this paper presents the development of indicators of sustainability as one mechanism that environmental health professionals could utilise to facilitate change. The paper first defines indicators and discusses their potential uses. It then presents a methodology for indicator development at the local level and examines key issues associated with the process of developing indicators of sustainability. It concludes by pointing out the need to couple indicators with locally appropriate action programs to maximise their contribution to facilitating change in the pursuit of a viable and livable future.*

**Key Words:** *Sustainability Indicators, Local Level, Environmental Health*

In recent decades it has become increasingly evident that the patterns and direction of global development exceed viable limits and that economic trends are not sustainable. This realisation has seen the emergence of such concepts as sustainable development and sustainability to guide the practices and fundamental changes that are required for humankind to progress toward a more socially and ecologically viable existence. Since their inception in the 1970s these concepts have been interpreted to have many different meanings (Sunderlin 1995). For some they have meant little more than another strategy for sustaining development (Esteva 1992). For others, a more commonly accepted and cited definition is that provided in the 1987 report of the World Commission on Environment and Development (WCED), in which sustainable development was defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1990, p. 87).

Despite this and other definitions, sustainability remains a difficult concept to elucidate and this might be because it does not represent a tangible or easily quantifiable goal (Gowdy 1994). Basiago proposed that it should be understood as a philosophy and methodology that "sets up a schema for asking important questions, but does not provide, a priori, an answer" (1995, p. 118). This interpretation supports the understanding that there is no pre-determined path or end-state that define, or result in, sustainability. Whichever options are chosen, certain central features should guide them: futurity, inter-generational and

intra-generational equity, global environmentalism, the precautionary principle, and the maintenance of biodiversity (Basiago 1995; Tisdell 1990; WCED 1990). These concepts and principles embody the connections between development, the environment and health, and collectively represent a powerful vision that has considerable appeal for the majority of people (Sunderlin 1995).

The concepts of sustainable development and sustainability embody significant changes in the priorities and values that presently govern "the global village" (Pirages 1994). Indeed, the global preoccupation with the pursuit of economic growth is increasingly recognised as the basis of unsustainability (Mehmet 1995; Tisdell 1988). Hence, the concepts of sustainable development and sustainability are not about "business as usual", but necessitate accepting responsibility for our actions and the associated consequences (Bossel 1998). Accordingly, proponents of these concepts advocate for a fundamental shift in priorities from the prevailing economic growth-centred, consumer-driven philosophy to one which marries aspirations for economic growth with the imperatives dictated by long term environmental and social considerations (Barbier 1987; Bossel 1998; WCED 1990). Yet for this shift in priorities to take place and the process of sustainability to be more than academic rhetoric, there needs to be supporting mechanisms and strategies that make these concepts and connections actionable at the global, national and local levels.

As the new millenium commences, the importance of local policies, strategies and action to promote sustainability is becoming more apparent. Indeed, it has been asserted that the most influential mechanisms for changing our relationship with the environment will be at the local level, as many of the issues relating to sustainability have their origins in local activities (Boothroyd et al. 1994; United Nations 1992). It is at the local level that sustainability can be operationalised within a concrete setting, and the responsibility of struggling for global sustainability becomes actionable by the majority of people. Further, it provides a context within which such fundamental strategies as community participation and intersectoral cooperation can be activated to mobilise and engage the community, local government, industry, and interest groups as agents of sustainability (Brugmann 1994a; Yanarella & Levine 1992). However, to promote local actions towards sustainability, there is a need for mechanisms and change agents, such as environmental health professionals, that enhance the understanding of community and local decision makers about the local connections between development, the environment and health.

This paper presents the development of indicators of sustainability (IOS) as one mechanism to build the connections between development, the environment and health at the local level. It first provides an overview of indicators, their potential uses, and presents a methodology for their development at the local level. The methodology is based upon a synthesis of several indicator development models developed by other communities, the substantial body of literature relating to group decision making, government-community partnership building, and the experiences of the authors in developing indicators with an Australian local government authority. This is followed by a discussion of key issues commonly encountered during the process of developing indicators at the local level. It concludes by stressing the need to couple the development of indicators with locally appropriate programs of action to maximise local understanding and participation for change to secure a viable and livable future.

## An Overview of the Uses of Indicators

We all use indicators every day and common examples include the temperature of food, the time of day as indicated by hands on a

clock, and school report cards. These simple examples make the subject of interest visible and thereby enhance decision making. Broadly speaking, an indicator is something that communicates information about a particular issue or problem of significance (Jung 1997). They are a "window into the complexities of modern life" (Tyler Norris Associates, Redefining Progress & Sustainable Seattle 1997). Hence, indicators are surrogate measures of phenomena of interest, such as wellbeing and sustainability, that cannot be measured directly (Carley 1981). This is important as it means indicators, and sets of indicators, however comprehensive and complex they might be, are an empirical approximation of reality not reality itself and, therefore, only have meaning or significance when related back to the subject of interest (Hammond et al. 1995). While the relationship between indicators and reality might seem glaringly obvious, many of the widely accepted and promulgated measures of societal wellbeing used by governments do not seem to fulfil this basic requirement.

The usage of indicators to guide government policy and action and inform communities is not new. The most obvious example has been the prominent usage over the past 50 years of economic indicators such as the Gross Domestic Product (GDP) or Gross National Product (GNP) (Miles 1985). A steadily climbing GDP, or GNP, remains the ultimate goal of national (and increasingly state and local) government policies and has been widely used by governments as an indicator of human and societal wellbeing (Cobb, Halstead & Rowe 1995; McMichael 1994). Historically, this usage has been supported by the correlation, in industrialised nations, between rising per capita GDP levels and greater life expectancy and lower infant mortality rates (Daly & Cobb 1989). However, this somewhat simplistic usage of GDP as the primary indicator of a complex system has become less valid in the past few decades as its relationship with human wellbeing has become increasingly less apparent (Pirages 1994; Schatan 1990).

The GDP is a highly aggregated indicator that is essentially a gross measure of market activity. As such, it only includes financial transactions, ignores the distribution of wealth, and fails to distinguish between desirable and undesirable activities, societal costs and benefits, or sustainable and unsustainable practices (Cobb, Halstead & Rowe 1995). Accordingly, such matters as environmental despoliation, illness and crime ultimately result in additions to the GDP. Korten proposed that growth in GDP actually measures "the rate at which the economically powerful are expropriating the resources of the economically weak in order to convert them into products that all too quickly become the garbage of the rich" (1997, p. 2). Thus, it could be suggested that the GDP, as an indicator, is the embodiment of the conception of development as economic growth, which has been the cornerstone of the industrial way of life (Henderson 1994). The historical overuse of economic indicators serves to highlight the need to develop more appropriate measures of societal wellbeing.

The modern social indicators movement emerged in the 1960s in response to the need to develop and use more appropriate indicators of societal wellbeing. This movement was based on the recognition that economic indicators "did not provide the broad-based information needed for monitoring social change, evaluating social programs, building policy development, and, in general, assessing quality of life or levels of well-being" (Andrews 1989, p. 25). It has produced a diverse range of social and health indicators and indices often oriented around the theme of quality of life (Ziglio 1991). In addition, the immense number of initiatives related to social indicators has provided considerable theoretical and practical direction with respect to such

matters as the desirable characteristics of indicators and the steps involved in their development. The emergence and widespread acknowledgement of the importance of sustainability has resulted in the recognition that we need a healthy community to obtain maximum quality of life, and "for that quality of life to last, it needs to be sustainable" (Ontario Healthy Communities Coalition 1996, p. 20). Thus, social indicators have often been incorporated within the broader demand for indicators relating to global, national and local sustainability.

## Potential Uses of Indicators

Indicators may be developed and used to serve a number of different, but complementary functions. The primary function of indicators is to summarise and simplify information about a complex system and thereby make it more accessible and understandable (Hammond et al. 1995). Yet within this overriding function there are three distinct uses that indicators are commonly perceived as fulfilling: i. establishing a baseline of data, ii. making comparisons, and iii. as part of a planning process to assess needs.

i. Establishing a baseline of data

First, and often considered foremost, indicators offer a means of establishing a baseline of data, setting targets or standards, and measuring progress toward these targets (Hawe, Degeling & Hall 1990). Thus, they can have a key role in the planning and evaluation of programs and policies relating to the process of sustainability. Indeed, IOS are increasingly being recognised as necessary tools "to chart and track the course toward a sustainable future" (Organization for Economic Co-operation and Development [OECD] 1991, p. 8).

ii. Making comparisons

Indicators present the opportunity to conduct comparisons between communities or geographic areas (Kline 1996; Waddell 1995). These uses relate to the process of benchmarking which is discussed below. Used in these ways, indicators provide a means, both for governments and the community, to understand whether the programs, strategies and actions being implemented are generating the desired effects.

iii. Assessing needs

Indicators represent a source of information that can be utilised as part of the planning process to aid in the assessment of needs (see example in Appendix A) and subsequently to advocate for change or action (Healthy City Toronto 1994). Thus, IOS can be applied to "influence progress in implementing action strategies which may result in a more sustainable situation" (Brugmann 1994b, p. 12). In this way, the development and publication of IOS may serve as a means of involving and educating, and thereby motivating government, interest groups, industry and the community about the issues relating to sustainability (Boyden 1979 cited in Parker 1995). In this regard, IOS developed at the local level can have a unifying effect on local community interests and consequently strengthen commitment to the process of creating a healthy and sustainable community (Baum & Brown 1989, p. 141).

In the context of this paper, perhaps the most significant, but least recognised function of IOS, is that it provides a practical method for elucidating and

quantifying the meaning of sustainability and, at the local level, the features and meaning of a sustainable community. This is important as the concept of sustainability does not represent a tangible or easily quantifiable goal or provide, a priori, an answer, but should instead be understood as a philosophy that establishes the basis for asking important questions (Basiago 1995; Gowdy 1994). In other words, there is no pre-determined path or end-state that defines or results in sustainability or a sustainable community (WCED, 1990). Further, a community's needs and concerns are contextually specific and this means that each community must determine its own path to a more viable relationship with the environment (Hayes & Wilms 1990). It is in this context that the process of developing IOS offers communities an opportunity both to define what sustainability means to them, and develops measures of their vision.

## A Methodology for Developing Indicators of Sustainability at the Local Level

The development of IOS is a complex and time-consuming endeavour for which there is no single best approach. However, it is possible to outline a methodology that serves to define broadly the likely stages of an indicator development project. The methods and process of the development of indicators are vitally important as they determine the resulting indicators and their potential use(s). It should be noted that while the methodology appears to be a linear process in presentation, the actual implementation of a project of this nature could involve many loops as the project evolves and those involved struggle with the multidimensional task of developing a useful and lasting product (Andrews 1989).

Prior to presenting the methodology it is necessary to point out the importance of broad community participation in the process of indicator development. Community participation has been recognised as a fundamental requirement for a more sustainable planet as it provides a means to motivate individuals and communities and organise action (WHO 1992). With regard to the development and implementation of indicators at the local level, a broad participatory process is as important as the results (Parker 1995) for a number of reasons. First, the community has an intimate understanding of the issues and concerns facing its members and this knowledge is critical to the development of appropriate and applicable indicators. Second, a participatory approach has the potential to enhance the acceptability, usefulness and longevity of the indicators developed (Bamberger 1991). It also offers a viable means of encouraging community ownership of the project and the indicators; thereby securing long-term community support (Bracht & Tsouros 1990). In addition, this approach reflects the requirement for researchers, environmental health professionals and community development workers to "work in partnership with, rather than on" local communities and thereby more actively seek to meet their needs (Baum 1998; Cunningham 1993).

We recognise that public participation is not foreign to environmental health professionals, as it is an integral part of much of their work, such as regulatory impact statements, needs assessments and drafting regulations and guidelines. However, for IOS to be meaningful and influential, the developmental process needs to generate a sense of ownership by communities. To this end, it is not adequate merely to administer the widely adopted community consultation process: making information available and inviting public submissions and so on. Thus, for IOS development, we advocate for the highest level and extent of community participation and equating that with community control of the process to createa genuine partnership (Chu 1994). This would enhance acceptance and understanding of the indicators and promote

community action oriented around, and ownership of, both the IOS and the process of pursuing sustainability.

Drawing from a range of literature, the outputs of several overseas community IOS development projects and the experience of our collaborative project with a city council, we have developed the following methodology for the development of IOS. It is acknowledged that the underlying structure of the methodology presented is not greatly different from that of other models relating to group decision making processes and the development of partnerships between government and the community. Thus, the methodology presented might, at least in part, be considered an application of these widely accepted models to the process of developing IOS.

There are three distinct yet interrelated phases and a total of 13 stages in the process (see Figure 1). Phase one involves the establishment of the project and includes the initiation and formation of formal structures for its management and implementation. Phase two, the action phase of the project, entails generating interest and broad participation in the project to ensure the issues of most consequence to the community are identified and suitable measures developed. Phase three incorporates the collection of data, preparing and reporting the indicators, and the establishment and maintenance of a formal mechanism that would be responsible for the ongoing process of data collection and review of the indicators.

The stages involved in the development of indicators of sustainability are:

- Initiate project, determine its likely parameters and identify stakeholders;

- Establish a steering committee to oversee and direct the process of indicator development. This group would have overall responsibility for the project, which may include such matters as determining its broad direction, allocation of resources, reviewing progress and ratifying the indicators selected. Accordingly, the composition of the committee is critical as it embodies the legitimacy and credibility of the project as a whole (WHO 1997, p. 28).

- Establish a working group to undertake or coordinate the variety of tasks required. The working group would be responsible for designing and implementing or coordinating the process of indicator development. It should be at the heart of the project and be composed of a cross section of the identified stakeholders. Collectively, these two groups represent formal mechanisms through which different interest groups may participate in the process of shaping and implementing the project and thereby gain ownership of the indicators developed;

- Develop an overarching vision for the project and refine the project's scope and parameters. Establishing a broad theme or vision in the early stages of an indicator development program is important as it offers broad direction for the whole project;

- Determine the primary purpose of the indicator set and identify its clients, users and audiences. This is a critical step in the process of developing and selecting indicators as it provides direction and meaning for this process;

- Hold a series of workshops or public meetings to explore and determine the issues of most importance to the community and thereby generate the features of sustainability with the community;

- Decide what are to be the most important characteristics of the indicators and thereby generate selection criteria to be applied to provisional indicators. Characteristics should include such matters as scientific soundness of the measure (validity and reliability), relevant to both the community and its potential to effect change in the issue, sensitivity to change, user-friendly and accessible data (type and presentation of data), and availability of data;

- Review comparable indicator programs to gain an understanding of what has been achieved in similar settings and to build a library of potential indicators;

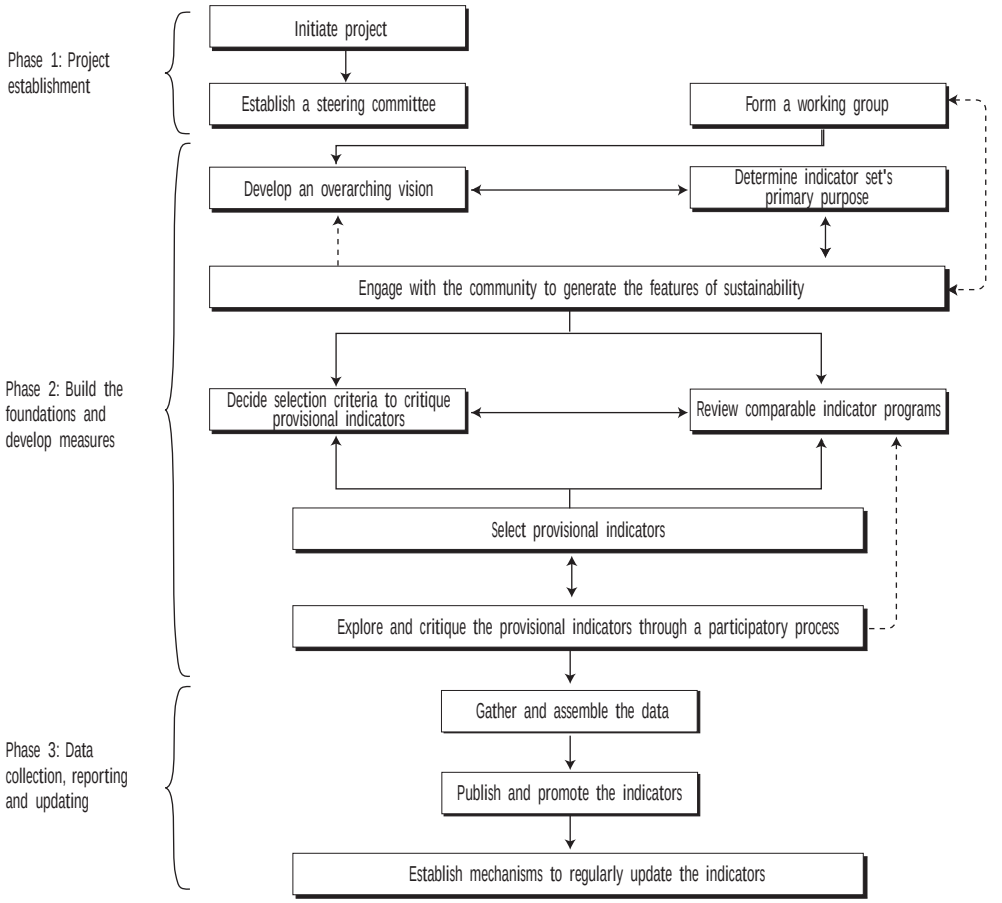
- Draft a set of provisional indicators;

- Explore and critique the provisional indicators through a participatory process such as a series of workshops or public meetings and by applying the selection criteria;

- Gather and assemble the data pertaining to the selected indicators together with related explanatory information;

- Publish the indicators and promote them to the previously identified

***Figure 1: A Methodology for the Development of Indicators of Sustainability at the Local Level***



clients, users and audiences; and

- Establish formal mechanisms regularly to gather the necessary data to update the indicators and periodically to review the indicator set.

*Adapted and modified from Andrews 1989; Dilks 1996; Tyler Norris Associates, Redefining Progress & Sustainable Seattle 1997.*

## Key Issues in the Development of Effective Indicators

The development and usage of IOS offer a number of likely benefits that are closely tied to their potential functions such as those mentioned above. For example, their capacity to assist a community to establish a meaningful baseline of data, set targets, and measure progress toward these targets must be seen as a potential long-term benefit (Hawe, Degeling & Hall 1990). There is a growing awareness of the need to adopt mechanisms to foster community understanding of, and responsibility for, the local connections between development, the environment and health. Thus, it could be argued that the most consequential benefits of IOS should be located in the process of developing the indicators. A participative process that involves a broad cross-section of the community, members of local government, industry and interest groups has the potential to play a significant role in promoting "community consciousness" of local issues relating to sustainability. It is in this context that the development of IOS may be a catalyst for unifying community interest in, and ownership of, the process of creating healthy and sustainable communities.

However, the process of developing indicators is a difficult and complex undertaking and there are many issues confronting participants in the process. The following key issues might benefit or hinder this process.

### *Benefits and problems associated with benchmarking*

There is considerable interest in, and dialogue on, the use of IOS for the purposes of benchmarking. Within this debate it is possible to identify two broad types of benchmarking. First, a city (region or nation) might benchmark against itself over time. In this regard, indicators offer a means of establishing a baseline of data, setting targets and measuring progress toward these targets (Euston 1995; Hawe, Degeling & Hall 1990). For a community or local government this form of benchmarking offers a means of quantifying whether the activities being undertaken have made a difference and what changes need to be made. It also represents a means of determining numerical targets and thereby creates the opportunity to establish timeframes for specified improvements in phenomena of interest (Euston 1995). For example, a target could be established relating to the amount of waste going to landfill and appropriate strategies would then be implemented to meet this target. The usages of IOS for this purpose is fulfilling their primary purpose to chart and track the course toward a sustainable future (OECD 1991, p. 8).

The second form of benchmarking, which may be of considerable interest to some local governments, is the process of comparison with other municipalities or communities. This form of benchmarking represents a method "for identifying and importing best practices in order to improve performance" (Keehley & MacBride 1997, p. 75). Used in this manner, benchmarking would be an important means of gaining insights into more effective and efficient methods of dealing with local problems, such as crime, water consumption and waste management. Further, it is a means of opening a dialogue with similar communities, sharing ideas and forming new partnerships (Hutton 1993).

However, there are several problems with this form of benchmarking. First, it can

degenerate into a largely political process wherein the motivation is not to create a more sustainable community or improve performance but to "score points" (Keehley & MacBride 1997). By this it is meant that the comparison of selected indicators between communities can become a method for self-promotion at the expense of other communities rather than a means of encouraging constructive dialogue, mutual learning and collaboration.

Second, the validity of benchmarking with other communities is problematic. The concerns and needs of a community are spatially and temporally specific and thereby contextually dependent (Dixon, 1995; Hayes & Willms 1990). Thus, the circumstances of a particular community, which have contributed to the conditions that are to be measured, differ from those in other communities. Hayes & Willms argue that "neither the baselines, nor the processes, are truly comparable" (1990, p. 165).

Nevertheless, benchmarking between communities offers opportunities to form new partnerships with similar communities and to open constructive dialogue about methods to enhance community sustainability. Thus, while communities and local government must be cautious of the pitfalls of this endeavour, the potential benefits of this process should make it a worthwhile undertaking.

### *Clearly defined project purpose*

A clearly defined and accepted project purpose is crucial to guide the process of an IOS development project (Andrew 1989). It is also critical to the overall coherence and effectiveness of the indicator set developed (Tyler Norris Associates, Redefining Progress & Sustainable Seattle 1997, p. 13). Indeed, for an indicator to be relevant it must verify something and to do this "it must be directly related to an issue and to a place" (Ebbs 1996, p. 246). Further, a clearly defined purpose of the indicators is central to the setting of the project's parameters, such as users of the indicator set, audience, level of indicators, process of indicator development, and steering committee membership.

However, the development of IOS is a complex, and active process involving participants of different backgrounds and interests. As the project evolves over time, different ideas about the use of the indicator set might emerge or participants might want to expand the use of indicators to serve a variety of purposes. Thus, it is necessary for an indicator development project to revisit regularly and confirm the project purpose and direction. An activity of this nature would serve to focus those involved on the task, and enable changes of direction to be clarified and incorporated into the project's process in a consensual and timely manner.

### *Balancing comprehensive with limited*

Another potential barrier to developing effective IOS is the difficulties associated with determining how many indicators should be selected to represent adequately the subject of interest. This is a difficult matter to deal with as a set of indicators should include measures of all of the issues that are important to the phenomena of interest (Healthy City Toronto 1994). Indeed, "the greater the number of indicators, the more precise is the description of reality" (Jung 1997). However, indicators are intended to present "an indication" of the subject of interest and not a complete measurement of all its aspects. In this regard, the intrinsic value of indicators is their capacity to communicate crucial pieces of information without the burden of information overload. Thus, while a strength of indicators is their capacity to simplify an issue into a few crucial pieces of information, it is also a weakness as the complexity of an issue might be neglected. Thus, the development of a set of indicators requires a balance or trade-off between the need for comprehensiveness and the desire for clarity and convenience.

### Project commitment and coordination

The success of any project is dependent upon the efforts, commitment and accountability of those involved. Factors such as the broad participatory nature, support from leaders, and duration of a project have the potential to, over time, impact upon the commitment and motivation of those involved. To ensure project commitment and effective coordination, it is essential to devote effort to secure commitment from relevant decision makers at the highest level possible. Many Healthy Cities projects involve the establishment of project management structures that link to the highest level of local government (WHO 1997). This sort of structure is of great value in the development of IOS. It would establish local government support for the project at a senior level and, in so doing, ensure the project retains a high profile, cooperation from different departments, and access to resources such as meeting rooms, and available data. It can also strengthen links between the community and local government and legitimate the community's efforts.

### Data availability and collection

Data availability is a key issue in the selection of indicators. It has been proposed that the data for indicators at the local level should be "relatively inexpensive and easy to collect" (Healthy City Toronto 1994, p. 4). However, our experience revealed that the collection of new data could be an expensive, frustrating and time-consuming endeavour. Therefore, existing data should be utilised whenever possible. Nevertheless, the acceptance that each community will have its own particular vision and contextually specific issues may require existing data to be supplemented with new data (Costongs & Springett 1995a, p. 5, Healthy City Toronto, 1994, p. 4). In this regard, it is important that the selection of indicators should not be constrained by current or anticipated data availability.

There are several reasons why data for a selected indicator might not be available. The three most likely reasons are that it is not being collected, the costs associated with procuring the data, and an unwillingness on the part of the holder of the information to release it. The third reason might be particularly frustrating for members of an indicator development project and highlights the need to enlist the support and encourage the involvement of key community stakeholders, including government departments in a project of this type.

### The aggregation of indicators

There is considerable interest within local government in creating highly aggregated indicators that could be used to reflect such phenomena as livability and sustainability. However, there is also a good deal of debate over whether it is desirable, valid or worthwhile to aggregate indicators into a single composite score (Johnston 1988; Liu, 1974; Waddell 1995). In this regard, it is difficult to justify aggregating such disparate indicators as crime, infant mortality, and waste to landfill into a single composite score of "sustainability" or "quality of life". Further, it is hard to determine what the aggregated score could mean. Waddell argues that aggregation neglects the need for indicators to be accessible and relevant to individuals. Thus aggregation, while perhaps attractive, has significant limitations. Accordingly, before investing resources in developing highly aggregated indicators, communities and local governments should consider carefully the purposes indicators of this type could serve. An alternative to developing highly aggregated indicators is to supplement an indicator set with a few accepted and meaningful aggregated indicators such as the "Ecological Footprint" (Boothroyd et al. 1994).

In contrast to the calls for the aggregation of indicators there is also a need to consider the geographic disaggregation of indicators to the neighbourhood level. As

each neighbourhood has its own particular environmental and social problems that require action at the neighbourhood level (Omuta 1988). This is particularly relevant in Australia, as Australian cities do not suffer from the "doughnut effect" whereby the poor and needy are concentrated in the inner city suburbs (State of the Environment Advisory Council 1996). Instead, the processes of suburbanisation and re-urbanisation has resulted in the manifestation of "pockets of poverty" that are distributed throughout the cities (State of the Environment Advisory Council 1996). In this regard, the process of local area planning conducted by many local governments in Australia represents an appropriate avenue to develop and utilise indicators that are neighbourhood specific. These indicators could complement those developed at the citywide level and together present a hierarchical system that would enhance the comprehensiveness, coherence and sensitivity of an indicator package.

### *Meaningful presentation of indicators*

To maximise the contribution of IOS, it is important to present indicators effectively and meaningfully to the community. A review of indicator presentations reveals there is a wide range of reporting styles, which vary dramatically in their effectiveness to communicate information about the indicator and topic of interest. The presentation of a series of graphs or tables without meaningful explanation is not appealing or engaging for the majority of readers. In contrast, the reports that choose to couple the reporting of their indicators with background information, an explanation of the data presented, and a review of what is being done about the problem, stand out as being particularly user-friendly. This style of reporting offers a structured and logical layout that provides the reader with sufficient information to gain an understanding of the issue of concern. Further, it is also important to present indicators in a visually pleasing way that captures and holds the reader's attention.

For our project report, we developed a presentation format that is accessible and easy to navigate for most potential readers. The format enables us to convey to readers why the issue is important, and reports the facts and trends of the indicators, and what is being done to effect positive changes (see Appendix A for an example). The example, "solid waste management", is an issue of considerable concern to environmental health professionals who commonly gather the data for the indicators that have been chosen. The issue of solid waste management is presented as it is widely recognised as an indicator useful in reflecting consumption practices; a key aspect of the process of sustainability. This indicator also demonstrates that measures might not have to be novel or different from what is presently being collected, but that their inclusion and presentation should entail a process, such as the methodology presented in this paper, that encourages broad community ownership of the indicators and, in turn, the actions necessary to effect change in the issue of interest.

## Conclusion

### *Indicators of sustainability and locally appropriate actions*

Local governments, environmental health professionals, and community members have a pivotal role to play in the process of local, and thereby global, sustainability. Since many of the problems, and therefore solutions, relating to sustainability have their origins at the community level of society, the development of IOS at the local level represents an important undertaking in quantifying local issues. It also demonstrates a growing awareness, at the municipal level, of the need for communities and local government to assume a central role in changing the societal patterns of consumption and production to ensure a viable future for humankind (Harris & Wills

1997; Korten, 1995). This paper has established a rationale for the development of indicators at the local level and contributed a broad methodology for indicator development at this level. It has also identified and discussed the key issues in the development of IOS that communities engaging in such an endeavour need to be aware and explicitly address to promote success. However, the development of indicators should not represent an end in itself.

IOS offers a means of establishing a baseline of data, setting targets and charting progress toward these targets, thus enabling local government and communities to gain a better understanding of the local issues and actions needed. While the development of IOS may be useful in directing resources and setting the agenda, the process does not per se improve local conditions. It is imperative that the development of IOS is coupled with locally developed and appropriate programs of action such as those advocated through the Healthy Cities or Local Agenda 21 Movements. It is in this context that environmental health professionals, by facilitating the development and utilisation of IOS, can contribute to creating momentum, guiding action and measuring progress for changes in local efforts to secure a viable and livable future.

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# Appendix A An example of the meaningful presentation of an IOS for the community

## Solid Waste Management

### *Why is this important?*

Waste is produced as a result of nearly all human activities. Solid waste includes all waste generated during the acquisition of raw materials, throughout the manufacturing and refining processes, and when products are used by consumers. To reduce the negative impacts associated with waste and therefore, make a significant contribution to the achievement of a sustainable society, it is imperative that waste is properly managed. The process of waste management includes minimising the amount of waste generated, controlling harmful waste emissions, recovering material and energy resources from the waste stream, and disposing of waste in a manner that protects human health and minimises environmental harm. The challenge to implement effective waste management strategies will increase as population growth, urbanisation, and technological development continue into the next millennium.

### *Indicators:*

- Tonnes of waste to the local council (LC) Landfill per annum
- Total domestic waste to the LC Landfill per capita
- Amount of domestic waste recycled per capita

### *What was found*

One of the most common and widely used waste management strategies is landfill waste disposal (Kharbanda & Stallworthy 1990). Landfill is an operation where waste is used to fill up excavations of natural hollows in the ground (Kharbanda & Stallworthy 1990). However, as recognition of the need to move towards a sustainable society emerges, alternatives to landfill are being favoured. Recycling is one alternative that reduces the amount of waste requiring disposal, thereby reducing the environmental harm that waste disposal creates (Waite 1995). Considering domestic waste alone, it is estimated that one half of all household waste is potentially recyclable (Waite 1995).

Within this project, landfill and recycling have been selected as solid waste management indicators for Brisbane. Data for tonnes of waste to the LC Landfill per annum, the total domestic waste to the LC Landfill per capita, and the amount of waste recycled per capita were obtained for the period 1993/94 to 1997/98. Figure 2 presents the tonnes of waste to the LC Landfill per annum. The figure shows that waste to the LC Landfill remained relatively stable at around 600, 000 tonnes for the period 1993/94 to 1996/97, but during the period 1996/97 to 1997/98 the amount of waste was reduced to 436, 000 tonnes. However, it is important to note that not all waste generated in Brisbane is managed by the LC and the reduction in waste to landfill may not reflect actual change. Figure 3 presents the total domestic waste to the LC Landfill per capita. This figure shows that domestic waste to the LC Landfill was steadily reduced per capita from 407.586 kgs in 1994/95 to 375.254 kgs in 1997/98. Figure 4 presents the amount of domestic waste recycled per capita. The figure shows that the amount of domestic waste recycled per capita peaked in 1994/95 at 73.378 kgs and since then the amount has declined to around 60 kgs (1996/97 60.126 kgs, 1997/98 62.084 kgs).

***Figure 2: Tonnes of waste to landfill per annum***

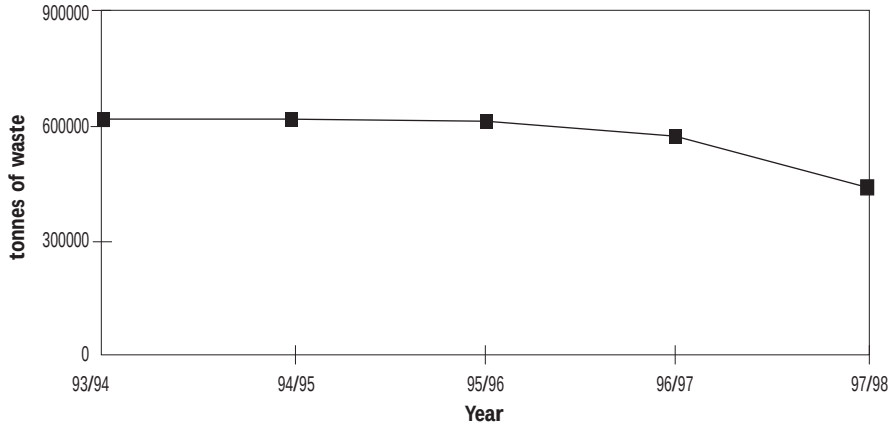



***Figure 3: Total domestic waste to landfill per capita***

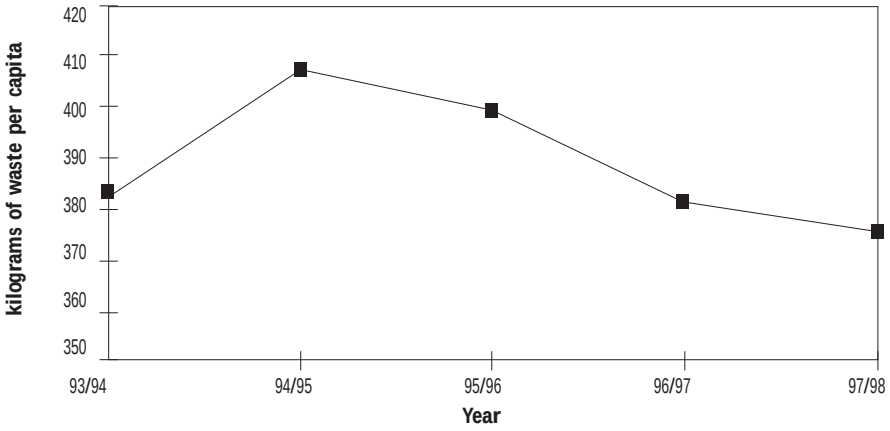
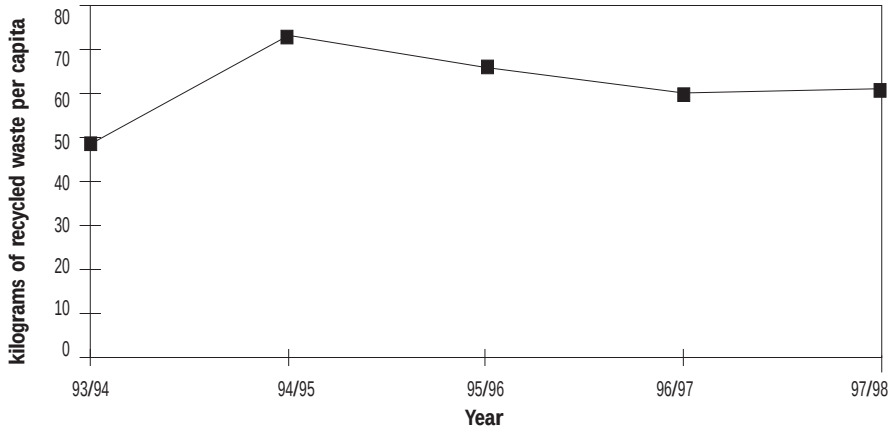



***Figure 4: Amount of domestic waste recycled per capita***



***What is being done about it?***

The LC recognises the need to cost-effectively manage and minimise the solid waste being discarded in Brisbane. It is committed to recycling and waste reduction in Brisbane. To achieve these goals the LC is involved in a diverse range of initiatives that include:

- Making landfill more environmentally friendly – the Brisbane Landfill at Rochedale was the first engineered landfill in Queensland. It is more environmentally friendly than a standard landfill site and is widely recognised as being "state of the art" and one of the best landfill sites in Australia.

- Minimising "green" waste to landfill – the LC operates a system at its landfill and transfer stations that enables it to divert green waste from landfill to other uses such as composting. It also assists in the distribution of worm farms and compost bins to the public in an effort to encourage the community to reduce waste by converting organic waste to compost.

- Educating people about waste management – there is an education centre at the Brisbane Landfill that provides information on waste in the form of information kits, slide shows and tours of the landfill site. School groups, tourists and international waste experts regularly visit the centre. In addition, the LC is currently preparing information about waste management that will be posted on its Internet site.

- Promoting sustainable recycling practices – the LC is actively looking for new markets for the milk and juice cartons, newspapers, magazines, cans, glass and some plastics that are currently accepted for recycling and other items that could be added to its recycling program. In this regard, in the near future cardboard could be added to the recyclable waste list as markets for its use are presently being investigated.

- Leading the way – the LC conducts a number of internal strategies to reduce the waste it produces and to utilise recycled products. For example, it is preparing to promote the usage of recycled goods by introducing a corporate "buy recycled goods" policy that will ensure the corporation chooses products made from recycled goods ahead of other products.

- Waste to energy – the Brisbane Landfill was designed so that the gas produced when the landfill waste is breaking down can be extracted and utilised as an energy source.

# Public Health Impacts of Outdoor Music Festivals: A Consumer Based Study

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*Outdoor music festivals that attract large crowds are regular events in Australia especially over the summer months. Public and environmental health impacts resulting from attending these events include deaths and injuries. Other public health considerations include access to water, food and first aid services. Strategic planning is undertaken to reduce these and other public health impacts at outdoor music festivals. The study reported here was undertaken to identify the level of concern for public health issues at outdoor music festivals and determine if experience contributes to a reduction in levels of concern between study participants who are festival patrons and those who are non-attenders. Participants identified a wide range of public health issues as of high concern, including access to drinking water, toilets and safe food; transportation to and from the venues; the size of the crowds; and having valuables lost or stolen. Specifically, the participants regarded safety in the mosh pit as the most important public health issue that needs to be addressed. The experience of attending outdoor music festivals did reduce the level of concern for many of the public health issues canvassed in the study. Consequently, this gives an indication that current planning approaches and management strategies are having some success. It is suggested that planning approaches will reduce concern for public health issues with increased communication between the event managers, assessment agencies and the festival patrons.*

**Key Words:** *Music Festivals, Event Management, Public Health Issues, Environmental Health*

Outdoor music festivals that attract large crowds are regular events, especially over the summer months, in Australia. These festivals are growing in popularity as an affordable method of hearing many different performers in a carnival-like atmosphere. However, outdoor music festivals also increase the audience's exposure to numerous public and environmental health issues[1].

The most notorious public health impacts resulting from outdoor music festivals are death and injuries. Other issues are generally seen by patrons as impacting more directly on comfort and enjoyment while having public health implications for the authorities and promoters. These include access to toilets, protection from the weather and ultraviolet rays (UVR), areas for recovery and rest, impacts of alcohol and social drug consumption, access to water and to food that will not cause food poisoning, as well as easy and safe access to and from the venues.

Recently, there has been an increased focus on public health impacts at outdoor music festivals. This commenced in 2000 with nine deaths and 26 injuries resulting from a crowd surge at a festival in Denmark (Crowd Management Strategies 2001). Subsequently, a major festival in England was cancelled for 2001 with public safety identified as the primary cause (Avon & Somerset Constabulary 2000), and most recently, a young girl died at a festival in

Sydney in 2001. In each circumstance, insufficient planning and management of the events has been implicated as contributing to these incidents (Crowd Management Strategies 2001). However, considerable planning is undertaken for outdoor music festivals both internationally and in Australia.

Current Australian approaches to planning for outdoor music festivals utilise risk management principles in order to provide a comprehensive framework for the management of public health impacts. Within these processes environmental and human health impacts are considered simultaneously. Ultimately, it is hoped that use of these frameworks will contribute to a change in the culture of the festival organisers in support of better public health outcomes (Whiting, Florence & McDonnell 1993). Examples of current planning approaches include a national framework developed by Emergency Management Australia [EMA] (1999), statewide frameworks such as the one utilised by the Liquor Licensing Division - Qld [LLD] (1999), and locally administered frameworks such as the one developed by the Brisbane City Council [BCC](1999).

The published literature on the public health impacts of outdoor music festivals is limited. Most of the available literature relates specifically to medical aspects (e.g., Fulde et al. 1992) with limited specific public health research (e.g., Commons, Baldwin & Dunsire 1999) relating to outdoor music festivals being identified in mainstream literature.

The study reported here was undertaken to identify the level of concern for public health issues at outdoor music festivals. The main aim of this study was to have a group of people from the demographic of festival patrons identify public health issues of high concern associated with attending outdoor music festivals. A secondary aim was to identify whether there were differences between the concern of study participants who have attended outdoor music festivals (festival patrons) and those who have not (non-attenders).

## Method

### *The Study*

A cross sectional design was utilised for this study (Morton, Hebel & McCarter 1990; Protney & Watkins 1993) involving a survey methodology for the collection of self-reported data from the study participants. The study was conceptualised as an exploratory study so no formal hypothesis testing was conducted. The results are presented in a descriptive form only in tables showing counts and percentages.

### *Sample*

Anecdotal evidence indicated that the demographic of festival patrons is similar to that of the alternative street magazines and the national youth network radio service "Triple J". The greater proportion of these readers and listeners are in the 18 to 25 year age group and has an interest in popular culture. These two mediums promote extensively to university students among others. It is for this reason that tertiary students were selected. For this study, the participants were recruited exclusively from the Queensland University of Technology while attending classes within the School of Public Health. A total of 123 responses were received with 75% being from students between the ages of 18 and 25 years.

## Survey Questionnaire

The questionnaire was developed to provide data on issues relating to attendance at outdoor music festivals. Prior to the study the questionnaire was piloted with a small sample of students ($n$=10) and modified before its use. An expert group of environmental health practitioners and researchers also reviewed the questionnaire throughout the development phase.

The questionnaire was designed to be completed in five to 10 minutes. It was

composed of three sections. The first section included basic demographic data including gender and age. The second section identified the respondent's attendance at outdoor music festivals. The third section of the questionnaire contained 25 key questions about public health issues. This section utilised a three point Likert scale - low, moderate and high. For the questionnaire, public health was conceptualised in its broadest context to include public safety, infrastructure, services, and personal protection. The issues have been categorised into three broad themes:

- Facilities and Services – including transport, toilets, food and beverages and access to first aid.
- Public Safety – including the impacts of alcohol and drugs, security, crowd size, access between stages and venues and throwing items into the crowd.
- Personal Protection – including having valuables lost or stolen, impacts of alcohol and drugs, being attacked or grabbed and getting sunburnt.

### *Statistical methods*

The associations between variables are summarised in tables showing counts and percentages. As this was exploratory and hence a descriptive study, little statistical testing was employed. The degree of concern was considered overall, by sex, and finally by whether or not the study participants had experience of attending outdoor music festivals. Discussion of results is based on contextually and statistically meaningful ($p < 0.05$, two tailed test) differences. Comments in the results about gender or experience, specific differences are only made where differences existed.

## Results

Demographic data were collected from section one of the questionnaire. The sex distribution in the study was 62.6% ($n$=77) females and 19.5% ($n$=24) males with 17.9% not providing information about their sex. Of the female study participants, 60% ($n$=46) were classified as festival patrons compared with 46% ($n$=11) of the male study participants. The overall median age distribution for the study participants was 20 years of age with a range of 17 to 44 years. There were no differences between festival patrons and non-attenders.

The second section identified the study participants' experience attending outdoor music festivals to clarify the relationship between experience and level of concern. Fifty-six percent (56%) of the study participants had been festival patrons with a broad cross section of outdoor music festivals being identified, covering both national and international festivals indicating an extensive range of experiences. The study participants classified as non-attenders consistently indicated greater concern than the festival patrons with 54% of the issues revealing significant differences.

The study participants identified their level of concern for 25 issues in the third section of the questionnaire, 48% of the issues were clearly endorsed as of high concern, 4.0% were considered of moderate concern and 36% were of low concern. For the remaining 12.0% of the issues, no clear trends could be identified.

The following results have been grouped according to the three main areas within this section: facilities and services, public safety, and personal protection. Only the issues that were of particular interest have been reported in depth.

### *Facilities and services*

Overall, the study participants regarded all but two of the issues on facilities and services provided at outdoor music festivals as of high concern. These two issues were, waiting to enter the festival (considered a moderate concern) and access to "chill out" or rest areas (considered a low concern). Refer to Table 1 below.

***Table 1: Facilities and Services Issues***

| Issues | Level of Concern | | | Totals |
|---|---|---|---|---|
| | Low | Moderate | High | |
| Drinking water | 18(15%) | 32(26%) | 72(59%) | 122(100%) |
| Toilets | 24(20%) | 28(23%) | 71(57%) | 123(100%) |
| Safe food | 35(28%) | 28(23%) | 60(49%) | 123(100%) |
| Waiting for drinks, food and toilets | 30(25%) | 34(28%) | 57(47%) | 121(100%) |
| Transport leaving the site | 28(23%) | 36(30%) | 57(47%) | 121(100%) |
| First Aid | 37(30%) | 31(25%) | 54(45%) | 122(100%) |
| Transport to the site | 37(30%) | 35(29%) | 50(41%) | 122(100%) |
| Waiting to enter the festival | 42(35%) | 47(38%) | 33(27%) | 122(100%) |
| Chill Out or Rest Areas | 52(43%) | 36(30%) | 33(27%) | 121(100%) |

### *Water*

Access to water was considered a priority for the patrons of outdoor music festivals to prevent dehydration and reduce alcohol consumption. The most common access to water at outdoor music festivals identified by the study participants was to purchase bottled water from outlets at the venues. The study participants considered this expensive and said that lining up to purchase the water took up valuable time. Others indicated that they brought their own water whenever possible. A low percentage of the respondents (15%) indicated the issue was of low concern because they had "no problems accessing water" and that there are "usually plenty around the grounds".

### *Toilets*

Overall, the study participants (57%) considered this issue of high concern because "there never seems to be enough [toilets]". A respondent commented that "people don't know how to use toilets properly" resulting in the conclusions by two others that "the toilets seem to get dirty so quickly" and "there is never any toilet paper". Portable toilets commonly used to supplement the number of existing facilities have attracted the criticisms that "they always flood and are disgusting".

### *Food*

Almost half of the study participants (49%) considered this issue of high concern. The main comments raised in relation to food were that it "takes too long to line up and it's [food] too expensive" and "the food is crap". Others indicated that: "[I] usually don't eat food there if I can help it" and "I don't really like to eat the food at these events because I don't like getting sick because food poisoning can wipe you out for a week". However, 28% of the respondents indicated a low concern for this issue, supported by comments such as "I love the food" and "bring on the Pluto Pup".

### *Waiting for drinks, food and access to specific areas at festivals*

Queuing for toilets, food, water and accessing alcoholic drinks was considered a high concern by 47% of the respondents. Two respondents provided some insight into this issue by indicating "You pay to see bands and you end up standing in queues all day" and "missing bands sucks".

### *First Aid*

As one study participant indicated "you never know what could happen". More than half of the non-attenders in the study (57%) considered this a high concern compared to approximately one third of the festival patrons (37%). However, two study participants who had experienced the first aid facilities added, "[I] have been in an accident and was able to get medical attention easily" and "personally I have never used them but my friends have and they were easily accessible".

Other respondents viewed this issue differently in that they "don't think about seeing them" or "never needed them so far". A further comment that "I don't really think I've ever needed it [first aid] because I am extra careful and don't go into the mosh pit" would indicate an association with higher risks in the mosh pit.

### Public safety

Overall, study participants regarded that people throwing items into the crowd, the presence of rubbish, and safety in the mosh pit as high concerns. The size of the crowd and negative impacts of alcohol indicated no clear trends. The negative impacts of drugs, the effects of security staff, and access between the stages and venues were endorsed as low concerns (refer to Table 2 below).

**Table 2: Public Safety Issues**

| Issues | Level of Concern | | | Totals |
|---|---|---|---|---|
| | Low | Moderate | High | |
| Throwing | 33(27%) | 25(21%) | 63(52%) | 121(100%) |
| Mosh Pit | 41(34%) | 24(19%) | 57(47%) | 122(100%) |
| Rubbish | 37(31%) | 31(25%) | 53(44%) | 121(100%) |
| Crowd Size | 36(29%) | 42(35%) | 44(36%) | 122(100%) |
| Alcohol | 46(38%) | 29(23%) | 47(38%) | 122(100%) |
| Drugs | 46(46%) | 25(20%) | 41(34%) | 112(100%) |
| Security | 57(49%) | 33(28%) | 27(23%) | 117(100%) |
| Access between stages & venues | 56(46%) | 30(25%) | 35(29%) | 121(100%) |

### Throwing

Items thrown into the crowd was identified as "very common" and "We see it all the time and it's dangerous", with the respondents generally considering this a high concern. Further, 61% of the non-attenders compared with 45% of the festival patrons considered this a high concern issue. One respondent explained that "large items like wheelie bins and bread crates are the real problem". As items being thrown in the crowd were a common issue for people in the mosh pit, one study participant stated that there should be "zero tolerance and the culprits should be thrown out". However, this level of concern was not shared by all the study participants with two refuting it completely: "it's fun, what's wrong with that?" and "it's bad if injury is caused but silly stuff like that is all part of the day".

### The mosh pit

The mosh pit was endorsed by 47% of the overall study participants as a high concern. One respondent said "it is dangerous, a lot of my friends have been hit and badly cut from being in the mosh pit". Another stated "It is a nightmare if you fall down and get stood on" and one female respondent revealed that she had "lost her top by being in the mosh pit".

However, some of the respondents described this issue as a low concern because "I would be mad to go into the mosh pit", or "[I've] never been in the mosh pit and "[I] don't want to get squashed".

A portion of the study participants genuinely considered this issue of low concern due to comments such as "I love the mosh pit, it 'kicks ass', getting bruises just makes it a more memorable event" (20 year old male).

### Rubbish

Overall rubbish as an issue was generally considered a high concern for the respondents. This is mostly due to 57% of the non-attenders compared with 34% of festival patrons in the study considering this an issue of high concern. There were a number of different dimensions to this issue with one respondent stating "it is really unattractive [litter] and ruins your time when you want to sit on the ground" and another adding "you can cut yourself if you accidentally fall". Most of the respondents who considered rubbish to be a high concern had not attended an outdoor music festival. Those who had generally thought this issue was well managed noting that there were usually "plenty of bins, especially recycling bins" and "there is usually no glass permitted".

### Crowd size

Two thirds of the study participants indicated the size of the crowd was a moderate or high concern with 44% of the non-attenders and 30% of the festival patrons in the study considering this an issue of high concern. Concerns raised regarding crowd size include: "[to] avoid

being crushed, especially in the mosh pit" and "going with friends then losing them in all the people" or "not getting lost". The opinions of most of the study participants were summarised by one study participant in that "too crowded is no fun but a big crowd equals a great concert and a better atmosphere". Not all the study participants who indicated the crowd size was a high concern were concerned about safety with one stating "the bigger the better because I have to crowd surf".

### The effects of alcohol

Sixty two percent (62%) of the respondents endorsed this issue as of low or moderate concern. One of the respondents indicated that "it's all part of the atmosphere" and another suggested that "I'll be drunk as well" while a third explained that drunks are of "no concern until they become complete jerks".

Forty eight percent (48%) of non-attenders in the study consider this issue of high concern. Reasons given include: "drunks are annoying and dangerous for others", "it wrecks my whole day to have to deal with drunks", "it doesn't just affect me it affects everyone" and "drunks scare me". A study respondent believed that as long as "they don't hurt me they can do what they want" while another advised that problems occurred "when they become over enthusiastic in the mosh pit".

### Personal protection

The study participants endorsed as high concerns having valuables lost or stolen. The responses for getting sunburned and safety leaving the festival site were split between high and low concern thus indicating no clear trend. Overall, being attacked or grabbed, personal behaviour and the potential to get into a fight were considered of low concern. Refer to Table 3 below.

**Table 3: Personal Protection Issues**

| Issues | Level of Concern | | | Totals |
|---|---|---|---|---|
| | Low | Moderate | High | |
| Valuables Stolen | 30(24%) | 30(25%) | 62(51%) | 122(100%) |
| Losing Valuables | 36(30%) | 26(21%) | 60(49%) | 122(100%) |
| Getting sunburned | 47(38%) | 28(23%) | 48(39%) | 123(100%) |
| Safety leaving | 44(36%) | 32(26%) | 46(38%) | 122(100%) |
| Being attacked | 46(39%) | 33(28%) | 40(33%) | 119(100%) |
| Being grabbed | 46(39%) | 33(28%) | 40(33%) | 119(100%) |
| Fighting | 72(61%) | 18(15%) | 29(24%) | 119(100%) |
| Personal Behaviour | 86(72%) | 19(16%) | 15(12%) | 120(100%) |

### Valuables lost and stolen

Having valuables stolen or lost "happens quite a lot" according to a number of respondents and was endorsed by half of the respondents as of high concern. Approximately two thirds of the non-attenders considered both these issues of high concern compared to less than half of the festival patrons in the study. One respondent revealed that "I have had a lot stolen" and another said that "if you lose something in the mosh pit you can never get it back". But others indicated that having items stolen was "always a concern when you go out" and a further respondent admitted that "I always worry about stuff like that".

### Getting sunburned

At outdoor music festivals "there is usually no shade protection in most areas" and "sunburn is always a concern when outdoors". Sixty two percent (62%) of the study participants indicated a moderate or high concern supported by comments such as "I hate sun so I take a hat and sun screen and use them" or "I have fair skin so any outdoor venue poses a problem".

A proportion of the respondents who indicated low concern considered that getting sunburnt was not an issue "as long as I am enjoying myself, it doesn't matter" and it is "no concern until it happens, I am there to have fun". One female study participant added "get more tanned, man - but we always use sunscreen".

### *Being attacked and grabbed*

Overall, both of these issues were of high concern for the female study participants with 66% indicating a moderate to high concern, while most males (61% for both) identified them as of low concern. Also, there were differences between festival patrons and non-attenders in the study. Approximately half of the non-attenders indicated a high concern for both issues compared to less than a quarter of the festival patrons with the same level of concern. Being attacked drew very few comments from the study participants, however, one did indicate that "my sister has been attacked".

Being grabbed was identified as very common at outdoor music festivals because it is "always a girl's concern" and "it happens all the time in the mosh pit". One female study participant indicated that this issue had a significant effect on her, in that "it shows disrespect and makes me feel uncomfortable".

### *Safety leaving the venue*

Sixty two percent (62%) of the overall responses endorsed this issue as being of moderate to high concern. One respondent explained "it's usually dark and large crowds can be unsafe if there is no security staff". Further, 52% of the non-attenders considered this issue as a high concern compared to 28% of the festival patrons in the study. Also 66% of the female study participants indicated that this issue was of moderate to high concern as apposed to 50% of the male study participants indicating a low concern.

### *Fighting*

Overall, 60.5% of the study participants endorsed this issue as a low concern stating "it never happens" and "no problems". The majority of the festival patrons (69%) indicated a low concern as well. However, 40% of the non-attenders still considered this an issue of high concern. One respondent who indicated a high concern for the issue explained that "if too many people get involved the situation can get out of control".

## Discussion

There were two aims in this study. The first aim was to ascertain the study participants' concern for public health issues at outdoor music festivals. Analysis of the data revealed that half of the public health issues in the study were of high concern. The major issues included, among others, access to drinking water and toilets and safe food; items being thrown into the crowd; safety in the mosh pit and the size of the crowd.

The second aim was to identify whether there were differences in the level of concern based on experience attending outdoor music festivals: that is, were there differences in the level of concern between the festival patrons and the non-attenders? For more than half of the public health issues in the study there were noticeable differences in the level of concern that related directly to experience. Examples where the level of concern differed surrounded issues relating to being attacked, grabbed or getting into a fight. Interestingly, concern for other issues such as access to toilets, water and safe food remained the same irrespective of festival experience.

Anecdotal evidence indicates that the public health risks and impacts are greater for female festival patrons, however, this was not clearly evident in this study (Crowd Management Strategies 2001). Only the results from three of the issues identified in this study indicated distinct differences between the level of concern between the male and female study participants. The female study participants indicated a much greater level of concern for being grabbed or attacked and safety leaving the venues than the male study participants.

Overall, the study participants had concerns about the mosh pits at outdoor music festivals. These concerns have been summarised by Wertheimer (cited in Radel 2000, p. 1), a crowd management specialist,

who has described the atmosphere in the mosh pits at outdoor festivals in the following way:

> *Mosh pits range from a type of communal chaos with etiquette to violent, churning and brawling spectacles played out before approving bands and performers. The current trends show moshing environments too often are allowed to become places of wanton recklessness and violence. That is why today's mosh pits cannot be guaranteed safe for those people in them and on the perimeter.*

Additionally, the mosh pit was also associated with issues related to being grabbed, the need for first aid, being struck by items thrown into the crowd, the large size of crowds, losing valuables, and over enthusiasm created by alcohol consumption. As a result, safety in the mosh pit was probably the most important public health issue for the study participants. This finding is supported by the number of deaths and injuries that have been attributed to mosh pits throughout the world (Crowd Management Strategies 2001; EMA 1999). Therefore, organisers and assessment agencies should consider festival patrons' safety in the mosh pits as a priority planning and management issue. However, all the high concern issues identified within the study need to be addressed to improve public health outcomes at outdoor music festivals.

Detailed planning and a comprehensive consultation process have been shown to improve management strategies and produce successful events (LLD 1999). Extensive preparation prior to an outdoor music festival, including involvement of appropriate personnel and the commitment of suitable and adequate resources, should greatly reduce the potential for concerns and improve public health outcomes at outdoor music festivals. However, there is considerable variation in the quantity and quality of planning for these events (EMA 1999). Further, there is little evidence of consumer based research into the effectiveness of these approaches.

This study was intended to provide some insight into the effectiveness of current planning approaches using the study participants' experience attending outdoor music festivals as the measure. In other words, significant reductions in the level of concern for the public health issues between the festival patrons and the non-attenders should provide an indication of the effectiveness on public health issues of the planning approaches and management strategies used at outdoor music festivals. As considerable differences were identified in more than half of the public health issues, it would appear that current planning strategies do have positive impacts on the level of concern for public health issues at outdoor music festivals.

The National Environmental Health Strategy (1999) suggests that risk management approaches should involve the communication of risks throughout the entire planning process. Essential to current planning approaches is the consultation between organisers and assessment agencies and key stakeholders such as the Police and Transport Departments and Ambulance Services (BCC 1999; EMA 1999; LLD 1999), but they do not involve the festival patrons. In order for approval to be given for an outdoor music festival, the organisers must estimate and evaluate public health risks then propose strategies to control these risks. The assessment agencies then carry out an assessment of the strategies against standardised measures or previous experience (EMA 1999).

In spite of this assessment process, the study participants have regarded half of the public health issues surveyed in this study as of high concern. Of further concern, there were a considerable number of issues having no significant differences in the level of concern due to experience. Consequently, the study has identified that current planning approaches and management strategies are having some success but are falling short of meeting all of the study participants' concerns regarding public health issues at outdoor music festivals.

As festival patrons are not directly included at any stage of this process, one suggestion is to improve the risk communication between the organisers, assessment agencies and the festival patrons. This improved communication would increase understanding for the organisers and assessment agencies of the festival patrons' actions on two levels. First, there would be better understanding of the choices that patrons make when deciding to attend the festival and second, the choices made regarding public health risks while inside the venue (Strickland 1998). The festival patrons make choices about public health risks while attending festivals based on a set of values. These values are formed through an association with the benefits or consequences of actions derived from experiences and/or information. Consequently, understanding the rationale behind those choices would be critical in determining acceptable behaviour while at the events and as a result should be integrated into the planning processes (Stoneham 1999).

As limited research material is available on the festival patrons' risk perceptions, there is a need for further research in this area. Another opportunity for research could be to evaluate the planning approaches in place at a number of different outdoor music festivals using comparisons of the assessment, event, police, security and emergency service personnel perceptions. In addition, research could be undertaken to ascertain the level of concern related specifically to a given event and clarify the impact of management strategies using pre and post-testing on the festival patrons attending that event. All of these research opportunities would contribute to a better understanding of the effectiveness or shortfalls of planning approaches in relation to outdoor music festivals.

## Conclusion

The participants in this study have identified a wide range of public health issues as of high concern. Overall, event managers and assessment agencies of outdoor music festivals should consider improving planning in relation to: access to drinking water, toilets and safe food; delays in access to services (drinks, food and toilets); transportation to and from the sites; items thrown into the crowd; safety in the mosh pit; rubbish; the size of the crowd and having valuables lost or stolen. Specifically, the participants identified safety in the mosh pit as the most important public health issue that needs to be addressed.

The experience of attending outdoor music festivals did reduce the level of concern for a considerable proportion of the public health issues within the study. Consequently, this study has identified that current planning approaches and management strategies are having some success but are falling short of meeting all of the study participants' concerns. One suggestion to improve current planning approaches and reduce concern for public health issues is to increase communication between the organisers, assessment agencies and the festival patrons.

### Endnote

1. Public health is taken to include environmental health in this paper.

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# Control of Greenhouse Gas from a Local Landfill Site

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***City of Port Adelaide Enfield***

*The paper outlines the procedures taken in respect to the "Post Closure" of the Cavan landfill site located in the Adelaide Metropolitan area in accordance with Environmental Protection Agency (EPA) requirements. The emphasis of this report is placed on the control of landfill gas on the site to ensure a safe environment.*

**Key Words:** *Greenhouse Gas, Landfull Site, Safe Environment*

## History of the Site

The Cavan Landfill was first leased by the City of Prospect for household waste disposal in 1940. Early attempts at trench disposal of refuse failed because of the high groundwater table, and throughout the 1940s and 1950s waste was stockpiled, burnt and rolled. This practice led to some nuisance fires, and it appears that an improved method of landfilling in lifts of 1.0 - 1.5 m followed by covering with clean fill was adopted in order to avoid fire problems in adjacent properties.

In 1984, the then South Australian Waste Management Commission (SAWMC) identified the Cavan landfill depot as being one of those which should be phased out, and in order to hasten the process and to provide a landfill facility for the then City of Enfield, the Councils of Prospect and Enfield formed a joint venture to operate the landfill for the remainder of its life. Since 1985, the site has been operated subject to the provisions of the Waste Management Plan prepared by Fargher Maunsell (1984).

Between 1985 and 1999 the Cavan Solid Waste Depot received the following waste streams from the Cities of Enfield and Prospect:

- Domestic soft (street bin collection) and hard waste - approximately 25,000 tonnes/year
- Council waste (including construction/demolition) waste - approximately 20,000 tonnes /year.

Landfilling has taken place on the Cavan site since the 1940s, however, peak landfilling rates occurred between 1985 and 1999. It is not known how much waste was deposited in trenches prior to 1984, however, it is conservatively estimated that between 700,000 and 800,000 tonnes of waste have been deposited on the site in the course of its history as a solid waste landfill depot. The site stopped taking waste in June, 1999.

## Landfill Gas Production

Landfill gas is produced in landfills because the organic matter in the refuse is decomposed by bacteria under anaerobic conditions. Methane production typically begins 6-12 months after waste placement and might last for decades. The composition of landfill gas varies from 40-60% methane, 20-40% carbon dioxide, and 2-20% nitrogen. There are also traces of hydrogen sulphide and oxygen.

The actual mixture of the major and minor components of landfill gas is to a large extent dependent upon the particular landfill and the waste materials that were deposited. The composition of the gas, and hence its quality can be affected by the management of the landfill and the gas extraction operation. Table 1 shows the

typical composition of landfill gas.

***Table 1: Typical Composition of Landfill Gas***

| | |
|---|---|
| Methane ($CH_4$) | 40-60% |
| Carbon Dioxide ($CO_2$) | 20-40% |
| Nitrogen ($N_2$) | 2-20% |
| Hydrogen Sulphide ($H_2S$) | 40-100 ppm |
| Organic Sulphur | 400-600 ppm |
| Heavier Hydrocarbons | <1% |
| Complex Organics | 1000-2000 ppm |

*Source: Landfill Management Services 2001, p. 2*

The gas generation within any landfill generally rises to a peak shortly after closure of the site and then declines at a rate that is dependent on waste placement, composition, moisture content and other environmental factors. Landfill gas production may vary significantly from landfill to landfill and from area to area. Variability is due to the importance of site specific factors such as waste quantity, composition, moisture, temperature, age of waste and pH levels.

Even with the current data and knowledge available, Australian landfill sites continue to generate landfill gas for a minimum of 30 years after closure. Although waste generation is similar in all states the amount of rainfall and other site-specific factors can lead to varying levels of gas production. On average, every million cubic metres of typical landfill waste in Australia results in a recovery yield of 600SCMH (Standard Cubic Metres per Hour) of landfill gas. These data have been obtained from sites that have been operating gas extraction since 1982 and cover a wide selection of landfill sites around Australia (Landfill Management Services [LMS] 2001).

On the basis of projected limits by LMS until 2020, landfill gas production from the Cavan Landfill peaked in the year 2000, approximately one year after the site ceased to accept waste.

## Control of Landfill Gas

One of the consequences of the disposal of waste in landfill sites is the production of landfill gas. It is a basic requirement of waste management practices to control landfill gas, whether from new landfill sites, current operating sites or old abandoned sites. Landfill gas must be controlled and monitored during the operating life of the landfill and then for a minimum of approximately 30-50 years after closure.

Complete closure of the Cavan Landfill site occurred in mid-1999, without landfill gas extraction the revegetation program will not be able to be achieved successfully, due to landfill gas emissions from the site. Cavan Landfill is a producer of landfill gas and landfill gas control was warranted at this site. The implementation of a gas extraction system and flaring facility provided landfill gas control and essential data for analysing energy utilisation options (LMS 2001).

It was estimated that a gas yield of approximately 170 cubic metres per hour (4,080 cubic metres per day) at 50% methane was achievable. As the site is closed, gas production will decline with the ageing landfill. The energy utilisation options for the Cavan Landfill are limited. On site utilisation of energy is the most attractive option, however, the gas yields will need to be confirmed before any energy utilisation option can be considered.

The fundamental objective of any landfill gas project should be achieving landfill gas control first and foremost. There are many data from overseas' incidents that highlight the possibilities of dangerous events occurring if the safety hazards of landfill gas are ignored. Landfill gas is an environmental problem and needs to be addressed. It impacts on ground water, air pollution, revegetation, the community and public health. These issues have to be the first concern when addressing the management of landfill gas.

Sanitary systems such as landfilling have been established to ensure that public health and safety and the natural environment are not compromised by the effects of waste generation. However, landfill sites are now recognised as a potential source of

environmental contamination, unless they are properly sited and subject to stringent controls. LMS was commissioned by the City of Port Adelaide Enfield in 1998 to conduct an evaluation of the Cavan Landfill, to evaluate EPA compliance, and to investigate landfill gas options.

Surface monitoring of the site was carried out and results showed that gas was emitting from a number of areas around the site. One such area was located next to the temporary caravan located at the top centre of the site. Landfill gas was also visibly emitting from surface cracks. Surface probes installed during the evaluation clearly showed that landfill gas was migrating through the landfill cap.

With the installation of a landfill gas extraction system and "state of the art" LMS Clean Burn Enclosed Flare, the Cavan Landfill is currently combusting 2,400$m^3$/day. This is equivalent to the following environmental benefits:

- Greenhouse gas emission reduction of 5,500 tonnes of carbon dioxide equivalent emissions per year; or
- Equivalent to the removal of 1,500 cars from the road per year; or
- Equivalent to the reduction in use of 17,000 barrels of oil per year; or
- Equivalent to planting 650 hectares of trees per year (US Environment Protection Agency 1998, p. 4).

With the installation of an extended landfill gas extraction system, LMS conservatively estimate that 200$m^3$/hour will be available. The benefits of this are shown below:

- Greenhouse gas emission reduction of 11,030 tonnes of carbon dioxide equivalent emissions per year; or
- Equivalent to the removal of 3,000 cars from the road per year; or
- Equivalent to the reduction in use of 34,000 barrels of oil per year; or
- Equivalent to planting 1,300 hectares of trees per year (US Environment Protection Agency 1998, p. 10).

## Landfill Gas Monitoring Program

Landfill gas is monitored and recorded on a weekly basis as a site-specific monitoring program was established at this site. The aim is to provide information and assess whether landfill gas is likely to impact on public health and safety or the environment. Monitoring programs should continue until gas production ceases.

To achieve the objectives of landfill gas management, monitoring is undertaken as follows:

- Site inspection is undertaken on a weekly basis;
- Analysis of methane, carbon dioxide and oxygen along with temperature and pressure readings;
- Gas well tuning on weekly basis;
- Pressure trials implemented;
- Zone of influence testing;
- Surface monitoring carried out;
- All extraction equipment on site monitored for efficiency;
- Service and maintain all gas extraction equipment;
- Buildings on site checked for methane and carbon dioxide;
- Action to either ventilate the building or control the source of gas will be taken if methane exceeds 1%;

- Liaison with EPA officials to ensure compliance with regulations; and

- Provide notification every six months, or as required by the EPA, detailing results and recommendations.

These procedures are regularly evaluated as changing climatic and operational conditions can have an effect on the results obtained. If results are not conclusive in controlling gas, notification will be provided before the initial six-monthly report is due detailing areas of concern and recommendations. The monitoring and balancing of a gas field are extremely important for controlling gas migration and oxygen ingression, as the possibility exists for potential explosive levels of oxygen and methane.

Data from testing during July 2000 to December 2000 showed that approximately 2405 cubic metres of landfill gas per day at approximately 53.5% methane is being extracted from the Cavan site. Carbon dioxide levels have remained constant at an average of 38.5%, and no oxygen was monitored at the flare during the reporting period.

Landfill gas composition will change with fluctuating barometric pressure and seasonal changes affecting gas production and recovery. Table 2 shows the average analysis of landfill gas at the flare for each month since July 2000.

***Table 2: Landfill Gas Analysis – Cavan Landfill Flare Monthly Average – July 2000 to December 2000***

| Month | Methane % | Carbon Dioxide % | Oxygen % | Flow m3/hour |
|---|---|---|---|---|
| July | 60 | 40 | 0 | 86 |
| August | 55 | 39 | 0 | 88 |
| September | 54 | 38 | 0 | 86 |
| October | 50 | 37 | 0 | 115 |
| November | 50 | 38 | 0 | 116 |
| December | 52 | 39 | 0 | 110 |

*Source: LMS Monitoring Report for Cavan Landfill July 2000 to December 2000, p. 7*

To ensure that off site migration of methane is not taking place, 16 monitoring wells have also been installed at the Cavan Landfill. These will detect any methane at the perimeter of the site.

## Landfill Gas Dispersal Options

### *Venting*

Passive systems rely on natural pressure and convection mechanisms to vent landfill gas to the atmosphere. Because of the unpredictability of gas movement in landfills the use of passive venting is declining worldwide. In areas where there may be a risk of methane accumulation in buildings, passive systems are not reliable enough to be the sole means of protection. The unpredictability of gas movement in landfills renders passive recovery ineffective in gas control. Active gas collection systems remove landfill gas from the landfill and/or the surrounding soils with a vacuum pump. It is far more effective in gas recovery than a passive system and can achieve a high standard of gas control.

Passive venting of gas does not resolve odour and safety hazards, and still contributes to global warming. The only time passive venting should be encouraged is when landfill gas levels have declined to a point where gas is no longer combustible.

### *Flaring*

Flaring landfill gas is vital in achieving the safety requirements associated with gas control. “Flare” is when landfill gas is collected and burned destroying harmful pollutants, which is known as “flaring”. The critical combination of combustion with rate of gas extraction are key elements in balancing the gas field to achieve safe control. From a global perspective, the most significant environmental benefit of flaring landfill gas is the reduction of greenhouse gas (methane) emissions to the atmosphere.

The correct design of a flare must include the design parameters of the gas extraction system and ensure combustion of

volatile organic compounds. The correct design of equipment and installation are vitally important in achieving desired results and specialist advice should be sought.

There are two types of flares, open and closed. Open flares were originally used, however, emission and safety requirements have developed the enclosed flare. Recommendations around the world are now suggesting the elimination of the total use of open flares.

Enclosed flares are specifically designed to meet emission and safety requirements, and the flare is enclosed in the combustion chamber. The cost of a permanent flare is dependent on emission requirements. At the Cavan Landfill an electrically driven LMS Clean Burn Enclosed Flare has been installed for noise attenuation benefits and for a continuous reliable source.

### *Landfill gas energy options*

Most major landfill sites in Australia are practising landfill gas utilisation in the form of converting waste to energy projects. More than 95% of these have resulted in power generation. Landfill gas can offer the opportunity of utilisation of a waste resource through energy recovery and considerable environmental and safety benefits through gas control.

Landfill gas energy resources can be utilised in the following processes:

- Gas lighting
- Direct gas energy use to industry
- Electricity generation
- On site energy use
- Upgrading landfill gas to pipeline quality (LMS 2001, p. 9).

### *Gas lighting*

The utilisation of landfill gas for lighting at the Cavan Landfill will involve a large quantity of gas lights to consume the available gas being generated at the site. A standard gas lantern consumes 2m3/hour of landfill gas. Gas lights are costly (approximately $2,000 each) and also require the gas to be dried and supplied at a constant pressure. Gas lights would still need to be used in tandem with a flaring facility. This technology is still being developed and was not a cost effective approach for the City of Port Adelaide Enfield.

### *Direct energy use*

Direct energy use is only a viable option if the user is located in close proximity to the site. When gas is transported off site condensate removal is required and the cost of transporting the gas is expensive (approximately $150,000 per kilometre). This involves the use of a gas drier or heat exchanger and a blower to supply the gas at positive pressure to the user. Gas control requires the gas to be utilised at its rate of production. Therefore the flaring facility will be required to flare the gas if the user does not consume the required volumes 24 hours per day.

Prior to gas being conveyed off site it requires condensate removal. This involves the use of a gas drier or heat exchanger and blower. The gas must then be delivered to the end user at a suitable delivery pressure. The Cavan Landfill is located in close proximity to a new and developing industry and there was some expression of interest in utilisation of landfill gas in drying rooms for spray painting.

To achieve landfill gas control, landfill gas needs to be combusted at the rate of gas production. When investigating direct energy use it is important to consider that the end users' requirements may fluctuate and therefore an additional combustion facility would also be required to combust any unused gas.

Prior to the City of Port Adelaide Enfield entering into an agreement for off site landfill gas utilisation it is recommended that the gas extraction system be implemented and landfill gas flared to evaluate gas production from the Cavan Landfill. This approach should be adopted in any utilisation project.

### Electrical power generation

Predicted landfill gas volumes from the site indicate sufficient landfill gas production for under half a Mega Watt. Gas production is on a declining scale and therefore electrical generation rates would also decline. The cost of conversion into the grid can vary from $100,000 to $500,000 depending on upgrading required and control mechanisms for electrical production. The ongoing operation and maintenance, and guarantee of capacity for electrical supply through long term contracts, leave this option in an undesirable position for this site.

### Upgrading landfill gas to pipeline quality

Upgrading landfill gas to high quality pipeline gas has been tried previously and while successful in proving membrane technology the difficulties incurred in the separation of nitrogen from methane resulted in previous projects becoming financially non-viable. The cost of these projects is in the range of several millions and is not considered an option.

### Emission trading

Carbon Dioxide Emission Trading puts a value on carbon dioxide (or carbon dioxide equivalent) emission reduction (currently quoted at $10/tonne of carbon dioxide, or equivalent saved) and treats it as any other commodity which can be traded on the stock exchange. It is a concept in its early stages but generating a great deal of interest from brokers, industry and government. It is a global concept and a framework for Australia. By harnessing and extracting the landfill gas, the revenue from Emission Trading could be considerable in the future.

### Environmental effects

Millions of cubic metres of environmentally damaging methane from landfills are currently emitted throughout Australia. An important environmental consequence of landfill gas production is the increase made to greenhouse gas emissions in the atmosphere. Carbon dioxide and methane are recognised for their significant contribution to global warming.

When landfill gas is collected and burned, harmful pollutants are destroyed. Landfill gas control and combustion has the potential to reduce significantly the risk of global warming. Methane is an important greenhouse gas and a major environmental pollutant. Reducing methane emissions is one of the most effective ways of mitigating global warming in the near term. Each tonne of methane released into the atmosphere has a Global Warming Potential (GWP) of more than 21 tonnes of carbon dioxide. This means that a tonne of methane has the same warming effect as 21 tonnes of carbon dioxide (LMS 2001, p. 12).

These emissions represent a substantial amount of environmental degradation. It is technically feasible, depending on site specific design and waste factors, to recover up to 90% of methane produced in landfills by extracting and combusting landfill gas.

Landfill gas is a mixture of gases that can burn or cause explosions, can asphyxiate and has a less than pleasant odour. It also causes adverse conditions in surrounding soils and therefore inhibits the natural growth of local vegetation. From a public safety point of view, the most dangerous aspect of landfill gas is its potential to migrate to areas surrounding the landfill. This essentially means that the landfill gas follows lines of weakness in the surrounding soil. There have been a number of incidents where the explosion of uncontrolled landfill gas has caused death and considerable property damage (LMS 2001 p. 13).

## Conclusion

Authorities around Australia are in the process of introducing controls that are required to minimise the safety and environmental hazards that landfill gas presents.

To ensure gas control, the gas must be actively recovered 24 hours a day and a site specific monitoring program should be established at every site where waste has been deposited. The aim is to provide information and assess whether landfill gas migration is likely to impact on public health or the environment.

Monitoring and control of landfill gas should achieve three major objectives:

1. Protection of public health and safety
2. Protection of the environment
3. To ensure the extraction system is achieving gas control (LMS 2001 p. 14).

The energy utilisation options for the Cavan Landfill are limited. On site utilisation of energy is the most attractive option, the gas yields will need to be confirmed before any energy utilisation option can be considered.

The installation of a gas extraction system and flaring facility are needed to confirm the energy available and more importantly to control the landfill gas being produced at this site to ensure compliance with EPA. Once the gas is controlled and evaluated energy utilisation projects can be further investigated. Due to the type and quantity of waste at the Cavan Landfill a gas control system has been implemented.

A gas control system together with a gas management strategy will eliminate a number of current potential landfill gas hazards associated with the Cavan site. Resolution of the following hazards to public safety and the environment should be addressed:

- Gas migration off site,
- Uncontrolled release of landfill gas,
- Safety hazards,
- Risk and liability, and
- Greenhouse gas emissions.

The implementation of an effective gas control system is the first step to be taken towards any utilisation project. The installation of a flaring facility will eliminate the risk and hazards that landfill gas is imposing and give a period of controlled extraction to evaluate actual sustainable gas yield. There may be an added incentive with greenhouse gas emission reduction credits that may be available through the capture and combustion of landfill gas.

Installation of a gas extraction system and flaring facility will reduce greenhouse gas emissions currently being emitted into the atmosphere from the landfill and allow the revegetation program to succeed. As greenhouse gas emissions credit trading is introduced, the City of Port Adelaide Enfield would be in a position to trade its credits.

Once gas yields are evaluated additional income could be generated through utilisation of landfill gas or through co-generation utilising waste heat from the flaring facility.

Flaring landfill gas will ensure the Council's liabilities are met and rehabilitation of the site can take place. Greenhouse gas emission trading, if implemented, will provide Council with a return on capital invested and a possible revenue whilst landfill gas is being generated from the Cavan Landfill.

Flaring is the only real option available for the Cavan Landfill. Passive venting of landfill gas is not an option as it does not meet EPA compliance, contributes to odour, continues to release greenhouse gas emissions, and does not resolve the safety hazards of landfill gas. The first step is to install a landfill gas extraction and combustion system to control landfill gas and alleviate the impacts and hazards that landfill gas presents.

### Acknowledgments

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# Isolation of Pathogenic Bacteria and Opportunistic Pathogens from Public Telephones

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*A survey of 20 randomly selected public telephones in the central business district of Melbourne, Australia, revealed the presence of contaminating pathogenic bacteria and opportunistic pathogens. Bacteria were recovered from all telephones sampled: 40% were contaminated with coagulase-positive* Staphylococcus aureus *and 80% with lactose-fermenting and non-fermenting bacteria, indicating possible faecal contamination. Further identification revealed the presence of the following enteric and non-enteric bacteria:* Acinetobacter anitratus, Enterobacter cloacae, Escherichia coli *and* Pantoea agglomerans *(formerly* Enterobacter agglomerans*). A viridans Streptococcus, most probably from the* "S. mitis" *group, was recovered from one of the telephones. All these bacteria are pathogens or opportunistic pathogens. Inoculation of one of the* S. aureus *isolates onto an inert plastic surface and incubation at room temperature indicated that, although a significant reduction in the recovery of viable bacteria was observed after one day, over 10% of bacteria survived for up to seven days. This was reduced to less than 5% survival after 14 days. Our results suggest that telephone surfaces may serve as potential reservoirs for the transmission of disease-causing bacteria.*

**Key Words:** *Telephones, Bacterial Contamination, Disease Transmission, Fomites*

Numerous studies have demonstrated the survival and persistence of bacteria and viruses on various environmental surfaces (Abad, Pinto & Bosch 1994; Bean et al. 1982; Cozanitis, Falsey & Walsh 1993; Davies et al. 2000; Grant & Makela 1978; Musa, Desai & Casewell 1990; Noskin et al. 1995; Rafferty & Pancoast 1984; Rogers et al. 2000). These fomites can act as transmission vehicles for pathogens and can be the cause of nosocomial infections in hospitals and intensive care units (Cozanitis, Grant & Makela 1978; Davies et al. 2000; Noskin et al. 1995). Personal contact, especially through contaminated hands, and aerosols are also known to be important in the transmission dynamics of many diseases (Maki 1989). Many studies have investigated disease transmission in hospital settings and day care centres, although common domestic surfaces are also known to be the source of potential pathogens. Such studies have focussed on hospital settings primarily because of the concern of opportunistic nosocomial infections especially in immune compromised individuals (Quinn 1998; Rogers et al. 2000).

There have been few studies of the role of telephones, a common item in commercial, domestic and health care environments, as fomites. The majority of these studies have also focussed on hospital settings. One study found 7% of hospital telephones sampled contained potentially pathogenic bacteria including *Klebsiella, Enterobacter, Pseudomonas and Aeromonas* (Rafferty & Pancoast 1984) while potentially pathogenic bacteria have been recovered from telephones in an intensive

care unit (Cozanitis, Grant & Makela 1978). Another study demonstrated that vancomycin-resistant enterococci (VRE) experimentally contaminated onto fingertips and environmental surfaces commonly encountered in the health care setting (including telephones) survived for at least 60 minutes (Noskin et al. 1995). This suggested that environmental surfaces could serve as potential reservoirs for transmission of VRE. Telephones can also be a source of contamination with pathogenic viruses (Butz et al. 1993). The potential importance of telephones in the transmission of infectious diseases was recently demonstrated by Rusin et al. (2000). This study showed that the transfer efficiency of bacteria and viruses from a telephone receiver to the hand (39% and 66%) was greater than the transfer efficiency from a faucet handle (28% and 34%).

Given the potential for telephones to act as vehicles for disease transmission, we have investigated the presence and nature of bacteria contaminating public telephone surfaces, specifically the hand contact area and the mouthpiece. We have investigated the occurrence of common pathogens normally present on human hands and faces, and looked for evidence of faecal contamination.

## Methods

### Study design and sampling

Twenty (of the approximately 120) public telephones in the central business district of Melbourne, Australia, were selected by random sampling for investigation. All sampling was carried out within a two-hour time period of a normal business day. Two samples were obtained from each telephone, one from the hand contact area and one from the mouthpiece. Sampling was carried out by swabbing the area with a sterile swab moistened with sterile saline. The tip of the swab was broken, transferred to a sterile tube containing 3 ml of Nutrient Broth (NB) (Oxoid Ltd., Basingstoke, UK) and transported to the laboratory on ice. The NB culture was incubated at 37°C for 24 hours to enrich for any bacteria present.

### Microbiological media and procedures

All media used in this study were from Oxoid Ltd. and were prepared according to the manufacturer's instructions. The media used were Baird-Parker Medium (BPM), Eosin-Methylene Blue Agar (EMB), Mannitol Salt Agar (MSA) and MacConkey Agar No. 2 (MAC2). After enrichment, all samples were inoculated onto EMB (for detection of *E. coli*), MAC2 (for detection of enteric bacteria and enterococci) and MSA (for detection of staphylococci). Presumptive coagulase-positive staphylococci were sub-cultured onto BPM. All media was incubated at 37°C for 24-48 hours.

### Biochemical and confirmatory tests

The Gram reactions and cellular morphology of all isolates were determined. Presumptive *Staphylococcus aureus* isolates were tested for catalase activity, from colonies grown on BPM, using 3% hydrogen peroxide on a glass slide and observing for vigorous bubbling (Koneman et al. 1997). The Staphytect Plus (Oxoid Ltd.) latex slide agglutination test was used to confirm coagulase-positive staphylococci. The presence of the cytochrome enzyme oxidase was determined using Oxidase Identification Sticks (Oxoid Ltd.). Oxidase-negative bacteria were identified using the Microbact™ 24E computer aided bacterial identification system (Medvet Science, Adelaide, Australia). The Streptococcal Grouping Kit (Oxoid Ltd.) latex agglutination test was used to classify presumptive streptococci into groups A, B, C, F or G. Further identification of streptococci was carried out by testing for growth in NB plus 6.5% (w/v) NaCl and for hydrolysis of aesculin in NB containing 0.1% (w/v) aesculin. The type of haemolysis on horse blood agar (HBA) was also determined.

### Bacterial survival experiments

To investigate the survival of *S. aureus* on telephone surfaces, 10µl of an overnight NB culture of one of the *S. aureus* isolates was centrifuged and the cell pellet resuspended in 1 ml of sterile saline. Samples (10µl) were inoculated onto a sterile inert plastic surface (to simulate a telephone hand contact area) and allowed to dry. Sterile swabs were used to sample each area after incubation for 0, 1, 2, 7 and 14 days at room temperature (under sterile conditions). Swabs were plated onto NA plates and incubated at 37°C overnight. The procedure was carried out in triplicate.

## Results

The findings of the bacteriological survey of 20 public telephones are presented in Table 1. Overall, pathogenic bacteria or opportunistic pathogens were recovered from 13 (65%) of the telephones. For three of the telephones, bacteria were recovered from both the hand contact area and from the mouthpiece. For the others, six had bacteria recovered only from the hand contact area and four only from the mouthpiece. Bacteria were recovered on MSA from all telephones, however, only data for confirmed *S. aureus* (Gram positive cocci, catalase-positive, coagulase-positive) is presented in the table. Bacteria other than confirmed *S. aureus* were presumed to be coagulase-negative non-pathogenic staphylococci. *S. aureus* was recovered from eight telephones (40%), with three of these having the organism present on both the hand contact area and the mouthpiece.

Sixteen (80%) of the telephones were contaminated with bacteria which were isolated on MAC2. The majority of these fermented lactose, indicating the presence of enteric bacteria and possible faecal contamination. A selection of lactose-fermenting and non-fermenting, oxidase-negative isolates were sub-cultured and identified using the Microbact™ 24E system as *A. anitratus*, *E. cloacae*, *E. coli* and *P. agglomerans* (Table 1). The presence of *E.coli* was also indicated by the recovery of characteristic colonies on EMB and confirmed by Gram reaction and microscopic examination.

***Table 1. Pathogenic and opportunistic pathogenic bacteria isolated from public telephones (hand contact area and mouthpiece)***

| Telephone | Hand contact (A) Mouthpiece (B) | Bacteria isolated[1] |
|---|---|---|
| 1 | A | *S. aureus* |
| | B | *S. aureus* |
| 2 | A | - |
| | B | - |
| 3 | A | *E. coli*, *P. agglomerans* |
| | B | - |
| 4 | A | - |
| | B | - |
| 5 | A | - |
| | B | *E. cloacae* |
| 6 | A | - |
| | B | - |
| 7 | A | *P. agglomerans* |
| | B | - |
| 8 | A | - |
| | B | - |
| 9 | A | *A. anitratus* |
| | B | - |
| 10 | A | *S. aureus* |
| | B | - |
| 11 | A | *S. aureus* |
| | B | - |
| 12 | A | *S. aureus*, *P. agglomerans* |
| | B | *S. aureus*, *E. coli*, *P. agglomerans* |
| 13 | A | *S. aureus* |
| | B | - |
| 14 | A | - |
| | B | *A. anitratus*, *E. coli* |
| 15 | A | - |
| | B | - |
| 16 | A | - |
| | B | - |
| 17 | A | - |
| | B | *S. aureus* |
| 18 | A | *S. aureus E. coli* |
| | B | *S. aureus*, *A. anitratus*, viridans streptococci |
| 19 | A | - |
| | B | - |
| 20 | A | - |
| | B | *S. aureus* |

[1] *A. anitratus = Acinetobacter anitratus, E. cloacae = Enterobacter cloacae, E.coli = Escherichia coli, P. agglomerans = Pantoea agglomerans, S.aureus = Staphylococcus aureus.*

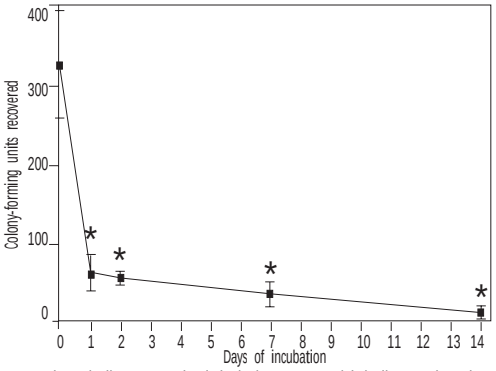
***Table 2. Survival of* S. aureus *isolate on inert plastic surface***

| Length of incubation (days) | CFU recovered (Mean ± SD) | Percent survival |
|---|---|---|
| 0 | 327± 67 | 100.0 |
| 1 | 59 ± 19 | 18.0 |
| 2 | 58 ± 8 | 17.7 |
| 7 | 36 ± 15 | 11.0 |
| 14 | 14 ± 7 | 4.3 |

One isolate from MAC2 was further examined because of its characteristic growth that suggested the presence of enterococci, hence faecal contamination. However, the isolate was not identified as group D, exhibited a-haemolysis on HBA, did not hydrolyse aesculin and did not grow in NB + 7.5% (w/v) NaCl. On the basis of these characteristics, the isolate was identified as a member of the *"S. mitis"* group of viridans streptococci (Koneman et al. 1997).

The potential for telephones to act as a vehicle for the transmission of pathogenic bacteria is dependent on the survival of such bacteria on a nutritionally inert surface. The survival of *S. aureus* on the surface of a telephone was investigated as described (see Methods). The number of colony-forming units (CFU) recovered at each sample time are shown in Figure 1. The survival of *S. aureus* was determined from the percentage of CFU recovered after 1, 2, 7 and 14 days relative to the 0 time point. Table 2 shows that there was a significant reduction in viable bacteria after one day, however, over 10% of bacteria survived for up to seven days. After 14 days, the survival rate was reduced to 4.3%.

***Figure 1: Recovery of* S. aureus *isolate from an inocluated plastic surface incubated at room temperature***




*Error bars indicate standard deviation. An asterisk indicates that the difference between the time point and the 0 time point is statisitclly significant ($p<0.05$; paired t-test)*

## Discussion

Our survey of bacterial contamination of 20 randomly selected public telephones indicated that 65% were contaminated with pathogenic bacteria or organisms that are able to act as opportunistic pathogens. Forty percent of the telephones were contaminated with *S. aureus*, an established human pathogen commonly found in the nasal cavity and in nasal secretions, which is the causative agent of a variety of skin infections and diseases (Noble 1998) and an important food-borne pathogen (Dinges, Orwin & Schlievert 2000). A viridans group Streptococcus was recovered from one telephone. The characteristics of this isolate suggested that it belonged to the *"S. mitis"* group, which is also part of the normal upper respiratory tract flora and has been associated with bacterial endocarditis (Koneman et al. 1997).

A number of opportunistic pathogens were recovered from eight telephones. The role of *E. coli* as an opportunistic pathogen, in particular in urinary tract infections (UTI), is well established (Faro & Fenner 1998). The presence of this bacterium is also an indicator of faecal contamination. Other enteric and non-enteric bacteria were isolated, including *Acinetobacter anitratus*, *Enterobacter cloacae* and P*antoea agglomerans*. Members of the genus *Acinetobacter* are implicated in various nosocomial infections, particularly bacteraemia, secondary meningitis and UTI (Towner 1997). *E. cloacae* and *P. agglomerans* (formerly *E. agglomerans*) are found in water, sewage, soil and vegetables and as part of the commensal enteric flora. They have been associated with a variety of opportunistic infections of the urinary and respiratory tracts and can cause septicemia and meningitis ( Koneman et al. 1997; Maki et al. 1976).

Although this study has demonstrated that public telephones are contaminated with a variety of bacteria, there is no direct evidence that the use of public telephones is an infection hazard. However, given that

telephones have recently been shown to be an efficient transfer vehicle for bacteria and viruses (Rusin et al. 2000), it is conceivable that the contaminated surfaces may serve as potential reservoirs for transmission of pathogenic microorganisms. In addition, we have demonstrated that *S. aureus* is capable of survival on an inert plastic surface for up to 14 days. It is therefore conceivable that potentially pathogenic bacteria can survive on nutritionally inert surfaces for extended time periods. If the surface was also contaminated with organic matter (e.g., blood or mucous in a hospital environment), the potential for survival would increase. Further studies could therefore involve survival studies of *S. aureus* and other bacteria under different incubation conditions (temperature and presence of organic matter). Similarly, sampling of telephones could be carried out over a wider time interval to investigate whether seasonal variation contributes to the survival and variety of recovered species.

Another limitation of the present study is that this survey was not quantitative and, therefore, did not yield information about the numbers of bacteria present and whether they posed an infection hazard. However, given that evidence of faecal contamination was obtained and large numbers of pathogens can be shed in the stool of an individual, it is possible that small amounts of contamination indicate a potential health risk. It might, therefore, be informative to carry out direct sampling and plating procedures from telephone surfaces to yield quantitative data about the level of bacterial contamination.

## Conclusion

The typical design of a telephone and the normal usage practices are conducive to the transfer of infectious agents. There is considerable opportunity for contamination given the contact with hands, face and lips. In this study, telephone users were observed coughing, sneezing and laughing into the mouthpiece thereby facilitating the contamination of telephone surfaces by nasal and oral aerosols. In addition, it is not common practice for users to wash their hands before or after telephone use. For these reasons, this study could be extended to include a survey of viral pathogens present on telephone surfaces. This could be achieved by subjecting swabbed material to polymerase chain reaction analysis for specific viruses or by attempting to culture viruses.

The present study may act to increase public awareness of the importance of good hygiene practices after any activity, which has the potential to transfer infectious agents, such as the use of public telephones. Reducing the microbiological hazards associated with contaminated surfaces is particularly important in environments where susceptible individuals are likely to be found, such as hospitals. The results of similar and wider studies may help to identify and reduce the hazards of common sources of bacterial contamination in domestic environments.

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# Mortality Trends for Deaths Related to Excessive Heat (E900) and Excessive Cold (E901), Australia, 1910-1997

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*Mortality trends for deaths related to excessive heat and excessive cold over the period 1910-1997 in Australia were studied. It was found that there was a declining trend for deaths related to exposure to excessive heat during the study period, with a large increase in the number of deaths in 1939, 11.5/100,000 in males and 5.3/100,000 in females, compared with death rates of 4.4/100,000 and 2.5/100,000 in 1910, respectively. The narrowing of the sex differential was apparent from the early 1940s. For deaths from the effects of excessive cold, there was an identified sex difference in the mortality rates, with higher rates seen in males. The mortality rates varied for different years in males, but for females, they were consistently low. It is postulated that global warming might bring about more deaths due to excessive heat. However, improvements in working conditions and health care, and increased use of air conditioners, might act to reduce future mortality rates for excessive heat and cold in Australia. Studying the mortality trends due to exposure to excessive heat and cold and exploring potential risk or protective factors will help to develop environmental health policy to improve the occupational environment and work place protection measures, and will therefore assist with reducing such mortality.*

**Key Words:** *Excessive Heat, Excessive Cold, Mortality, Australia*

Deaths due to exposure to excessive heat and excessive cold are coded to categories E900 and E901 in the International Classification of Diseases, 9th version (ICD-9). These codes are included in the External Causes of Injury and Poisoning Chapter of the ICD-9, which permits the coding of environmental events, circumstances and conditions as the cause of injury, poisoning and other adverse events (World Health Organization 1979). External causes coded to these categories include exposures to extreme weather conditions and also to "man-made heat", such as that produced in boiler rooms, furnace rooms, vehicles and kitchens, or to "man-made cold", such as in deep freezers, refrigerators, or by exposure to dry ice and liquid hydrogen or nitrogen (WHO 1979). Analysis of these types of deaths are of particular importance in Australia because of our participation in many outside activities including recreation at the beach, snow sport and occupational exposures. Among the recent studies of extreme weather conditions and human mortality, most research has focused on climate variability and its effects on certain causes of death, such as cardiovascular and respiratory diseases (Kalkstein & Davis 1989; Kunst, Looman & Mackenbach 1993; Langford & Bentham 1995; Piver et al. 1999; Rogot & Padgett 1976; Saez et al. 1995; Saez et al. 2000). Most mortality trend studies have focused on the diseases, rather than their causes (Armstrong, Conn & Pinner 1999; Taylor et al. 1998).

Studying the mortality trends due to exposure to excessive heat and cold and exploring potential risk or protective factors will help to develop public health policy, improve the occupational environment and work place protection measures and therefore assist with reducing such mortality. This paper focuses on mortality trends due to exposure to excessive heat and cold, as defined above, from 1910 to 1997 in Australia. Periods of decline, increase and stagnation are identified over this period, and possible explanations for these patterns are provided.

## Methods

### *Sources of data*

Annual summary death data for exposures to excessive heat and excessive cold (E900 and E901 in the ICD-9) from 1910 to 1997 were provided by the Disease Register Unit, the Australian Institute of Health and Welfare (AIHW). Although originally coded in various earlier revisions of the classification, the data had been forward mapped to the ICD-9 by the AIHW to ensure consistency of interpretation. Data prior to 1910 are not readily available in electronic form from the Australian Bureau of Statistics (ABS), which was the original source of the AIHW data. 1997 represents the last year in which the ABS coded deaths manually, prior to the introduction of an automated coding system. Only underlying cause of death was coded and reported by the ABS during the study period, with the World Health Organization rules for mortality coding directing that the external cause be considered the underlying cause for cases of injury, poisoning or other adverse effects (WHO 1979). In Australia, death certificates certified by a medical practitioner or coroner form the basis of reported death statistics. Deaths, which are the result of unnatural circumstances or accidents, are required to be reported to a coroner and a coronial inquest is performed. All circumstances surrounding the death are considered before the death certificate is completed and thus it is believed that the quality of the source documentation from which the codes are assigned by the ABS is reasonably good. Mortality data have been processed, coded and published by the ABS since 1900 using successive revision of the ICD.

The coded data for all deaths analysed in this study have been mapped to the applicable ICD-9 codes by the AIHW to allow for comparison of deaths over time. Although such a mapping process may potentially have an effect on the quality of the data under study, comparison of the codes used in the ICD revisions over the study period indicated that the classification of deaths from exposure to excessive heat and cold has been consistent, with a 1:1 map for these codes between each revision.

### *Population data*

The population data used in this study for the period 1900-1970 have been extracted from the censuses in 1901, 1911, 1921, 1933, 1947, 1954, 1961 and 1966, and arithmetically interpolated to form the populations between the censuses. Since 1971, annual mid-year estimated resident populations have been used. The data were provided by the ABS.

### *Statistical methods*

Crude death rates (CDR) present the total number of deaths in a population. The rates calculated are expressed as number of deaths per 100,000 population. Age and sex-specific mortality rates are expressed for narrow bands, which can make comparison more accurate. Sex and age-standardised mortality rates combine and summarise the specific rates using a comparative population as the standard population. The 1991 Australian population was used as standard population in this study. Chi-square tests have been applied in significant tests among different groups in this study.

## Results

### *Trends in deaths from excessive heat in Australia, 1910-97*

Figure 1 shows that although year-to-year variations existed, there was generally a declining trend for the mortality from exposure to excessive heat between 1910 and 1997, both in male and female groups. In the male group, the mortality rate ranged from 4.4/100,000 in 1910 to 0.1/100,000 in 1997. Female mortality rates were consistently lower than that of the male group, with 2.5/100,000 in 1910 and 0 in 1997. A significant increase was observed in 1939, with 11.5/100,000 in males and 5.3/100,000 in the female group, respectively. A large decline can be seen in both male and female groups since the middle of the 1970s, with the mortality rate from exposure to excessive heat close to 0/100,000 in both groups in later years. Also, three periods of stagnation are seen in both males and females, between the periods 1941-1959, 1961-1972 and 1974-1997. The narrowing of the sex differential is apparent from the early 1940s.

### *Trends in deaths from excessive cold in Australia, 1910-97*

It is shown in Figure 2 that there was a sex difference in the rates for deaths due to excessive cold between male and female groups, with higher rates in males. The mortality rates varied in males, from 0.3/100,000 in 1910 to 0.1/100,000 in 1997 with the highest in 1927 (nine deaths, with a mortality rate of 0.7/100,000) and 1917 (eight deaths with the rate of 0.6/100,000). There was a period of year-to-year variation from the middle of the 1930s to the early 1980s, with no deaths from excessive cold in some years. A period of stagnation followed over the years 1982-97. In the female group, the mortality rates have always been low, ranging from zero in 1910 to zero in 1997, with the highest annual death rates being 0.1/100,000 in several years, such as in 1915, 1923, and several years in the 1980s and 1990s. The highest number of actual deaths occurred in 1995, with 12 deaths recorded. However, in most of the years examined in this study, the mortality rates for females were zero.

***Figure 1: Mortality trends from excessive heat in Australia, 1910-1997***

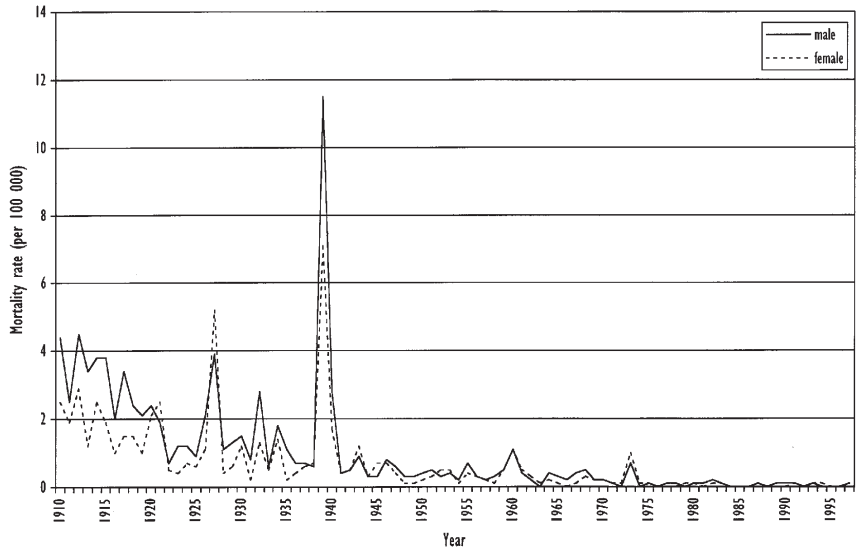
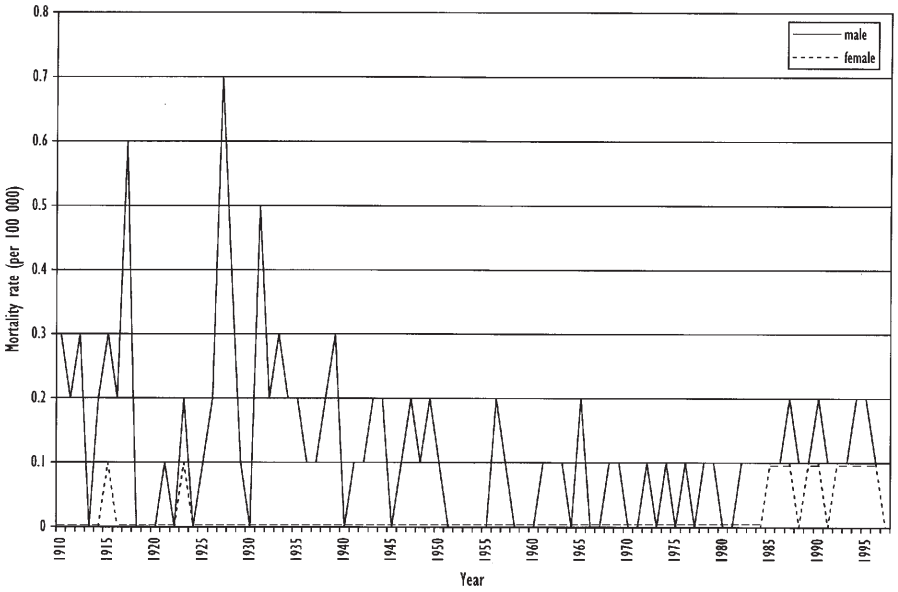


***Figure 2: Mortality trends from excessive cold in Australia 1910-1997***




The data shows that there was a significant difference in the mortality rates between deaths due to excessive heat and those due to excessive cold, with more deaths in the former group.

## Discussion

There were year-to-year variations in deaths from exposure to excessive heat over the period 1910 to 1997 in Australia, with a declining trend during this period. The average reduction rate was 0.049/100,000 per annum in males and 0.029/100,000 per annum in females. The major decreases in deaths from excessive heat started from the middle of the 1970s. This decrease is similar to the pronounced decline in Australian all-causes mortality for males and females in the same period (Taylor et al. 1998), labelled 'phase III' by d'Espaignet (1991). According to the criteria for code assignment, the code for exposure to excessive heat (E900) includes patients who died as a result of exposure due to extremes of weather conditions and due to exposure to heat of "man-made" origin, including occupational exposure. Prior to 1997, it was not possible to identify the injury or disease that resulted from these exposures to excessive heat or cold, due to the limitations inherent in the ABS only coding underlying cause of death. In a significant step forward for public and environmental health researchers, the Bureau implemented an automated coding process in 1997 which has allowed it to code "multiple causes of death", that is all diagnoses, events and conditions recorded by a certifier on a death certificate can now be coded and made available for researchers. Future research will be able to analyse not only the exposure to excessive heat and cold, but also the effects that these have had on the deceased. Combined with information about measures that have been undertaken to mediate climatic conditions, such as the introduction of air conditioners, improvements in occupational health and safety measures and housing conditions, this should prove a rich source of data for research.

The data in this study show a narrowing sex differential in the mortality rates for deaths from excessive heat since the 1940s. This might be due to differential exposure prior to this time, for example, larger numbers of females stayed at home while males worked in outside occupations, or

males enjoyed greater participation in outside activities. The improvements in working environments and residential conditions, as well as increasing numbers of women working outside the home, could be possible reasons for the narrowing sex differential. Also, data on smoking habits, pre-existing respiratory and cardiovascular diseases, working practices, medications, exercise habits, physiological status and air pollutant concentrations might be required to explain fully the differences between males and females (Piver et al. 1999). These data, however, were not available for this work and need to be addressed in further research.

Exposure to excessive heat can be classified as either exertional or classic. The former is more likely to be observed in healthy people who have been working or playing too hard during periods of high temperature and high humidity, and is usually observed in younger and middle-aged populations. The classic type results from prolonged exposure to high air temperature and high humidity and occurs most often in elderly adults, the very young, and the chronically ill of all ages. It was not possible, unfortunately, to distinguish between these types of excessive heat from the data provided, as the ICD-9 does not distinguish between the two types of exposure.

The ICD-9 codes include sub-groupings of "due to weather conditions", "of man made origin", "other specified origins" and "unspecified". Further research is necessary to analyse the data according to these breakdowns, as well as the resulting injuries and diagnoses. This will assist in the investigation of the types of exposure and provide data to support the development of preventive strategies. Unfortunately, this level of detail was not available to us in the dataset obtained from the AIHW.

There is a growing recognition that global warming could have an important impact on human health. A direct consequence of such warming might be a sharp rise in heat-related mortality (Kalkstein 1993; McMichael 1993). Extreme temperature increases, so-called heatwaves, are associated with increases in mortality for specific causes such as cardiovascular, cerebrovascular and respiratory diseases, probably through heat exhaustion and heat stroke (Kalkstein 1993; Kalkstein and Davis 1989; Piver et al. 1999). Australian annual mean temperatures have increased since the early 20th century (CSIRO 1996; Torok & Nicholls 1995). The recent two decades have been particularly warm with many of the warmest years on record having occurred during the 1980s and 1990s (CSIRO 1996; Torok & Nicholls 1995). However, the mortality rates due to exposure to excessive heat during this period were decreasing compared to the early stages of the 20th century. It therefore seems that the impact of global warming on the mortality rates due to excessive heat might have been offset by the introduction of air-conditioners and other climate control devices (Kalkstein 1993) and improvements in occupational protection. Overall improvements in health care, demographic changes (Kalkstein 1993), and changes in social and economic spheres, might also be responsible for the decreasing trend. However, more research is required to understand fully the consequences of exposure to excessive heat and excessive cold and the potential changes in mortality rates due to possible global warming.

This study shows that the mortality rates following exposure to excessive cold were much lower than that due to excessive heat in Australia during the last century. The increase of minimum temperatures (0.9°C) in this century in Australia might be one of the potentially protective factors for the decrease in excessive cold mortality rates. The possible rise in Australia's mean temperature by 0.3-1.0°C along the north coast, 0.3-1.4°C along the south coast, and 0.4-1.4°C inland by the year 2030 (CSIRO 1996; Torok & Nicholls 1995) might play a

role in reducing deaths from exposure to excessive cold in the future.

Similar to the trends for excessive heat mortality, the data show a decrease in rates for excessive cold until the early 1930s, then a year-to-year variation in the period to the early 1980s, with zero mortality rates in some years. From 1982 to 1997, a period of stagnation is evident. Because the rates of mortality following exposure to excessive cold in the study period were extremely low, such fluctuation might not reflect any real changes.

There were sex differentials in the excessive cold mortality rates, although the gap has become increasingly narrow since the 1970s. Because the female mortality rates in many years were zero, it is hard to explain this difference.

There are two possible artefacts in the year-to-year fluctuation in both mortality rates for exposures to excessive heat and excessive cold over the study period (Taylor et al. 1998). First, there was a sudden fall in the death rate in 1930 compared to the previous year, 1929. There is evidence that this fall was an artefact, and was due to staff retrenchment in the ABS for the first few years of the Great Depression. Death certificates were received, but there were too few staff to process all of them. Unprocessed certificates were held over and registered in the following years. This could potentially have affected the data used in this study. Second, persons who died between September 1939 and June 1947 while overseas as members of the armed forces were not counted in the death records. Accordingly, death rates for men during World War II are underestimated (d'Espaignet et al. 1991). During the war of 1914-18, Australian forces overseas were treated differently; military personnel were excluded from both the population and death statistics (Taylor et al. 1998).

## Conclusion

Declining trends for the death rates for exposure to both excessive heat and excessive cold in Australia can be seen over the period 1910-97. The major decreases occurred from the middle of the 1970s, which could possibly be due to better residential conditions, and to the introduction of air-conditioners and improvements in working environments reducing occupational exposures. It is possible that global warming might bring about more deaths from exposure to excessive heat in the future while reducing mortality from the effects of exposure to excessive cold.

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# Preventing Skin Cancer in Queensland: An Evaluation of a Community Shade Creation Project

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*Organisational and community approaches to sun safe environments are emerging in response to Queensland's high incidence of skin cancer. An evaluation of a community-based shade creation initiative, "SUNbusters", was undertaken in Queensland, Australia. This program provides seeding grants to create shade structures by community-based, non-profit organisations, which cater for children. The evaluation assessed the aims, objectives and strategies of SUNbusters; the outcomes from a health promotion perspective; and made recommendations for the overall future direction of "SUNbusters". In-depth interviews were conducted with health promotion program facilitators; grant recipients received questionnaires; and shade quality audits were undertaken. Each grant funded the construction or planting of shade, however, few structures afforded high quality shade protection. Despite this, the program was effective in promoting community development and action at the local level, as a means to encourage healthy environments. The program has the potential to be a responsible strategy towards the development of healthy public policy. The formation of local collaborative groups that took responsibility for skin cancer prevention, community action and the promotion of organisational change, and the creation of sustainable supportive environments, demonstrated health promotion best practice. The evaluation led to the recommendation that "SUNbusters" continue and be expanded into a statewide skin cancer prevention strategy.*

**Key Words:** *Skin Cancer, Shade Creation, Healthy Public Policy*

Australia has the highest incidence of skin cancer of any country in the world (Australian Institute of Health and Welfare [AIHW] 1998; Gies et al. 1998; Maclennan et al. 1992). Exposure to ultraviolet radiation (UVR) in the first 18 years of life has been associated with the development of melanoma in later life (Kripke 1994; Boyle, Maisonneuve & Done 1995; Rhodes et al. 1987). More than half of our lifetime exposure to the sun occurs before the age of 18 years (University of British Columbia 1998) and reducing exposure to UVR would, therefore, contribute to the reduction of the incidence of skin cancer.

It is neither practical nor desirable to discourage people from leading an active life that includes outdoor recreational activities. As a result, there is a need for a comprehensive approach to reduce exposure to UVR that includes the combination of personal responsibility for protection, together with structural and environmental changes. The Ottawa Charter for Health Promotion, advocating for the development of supportive environments, recognised the links between people and their environment and providing safe, stimulating, satisfying and enjoyable living conditions (World Health Organization [WHO] 1986). Further, the Ottawa Charter recognised that organisational change needs to be supported by the adoption of healthy public policy. The provision of shade at public facilities

supported by sun safe policies which embrace the total ecology are specific strategies to create and sustain supportive environments at the community level.

Sun safe strategies incorporating the creation of shade and organisational policies have been endorsed by the Australian Cancer Society (1993), by National Cancer Control Planning documents, by the National Health and Medical Research Council (NHMRC 1996), by Queensland Health in Outcome Area Team (OATS) Plans (1998), by the Queensland Cancer Fund (QCF) (1996) in its policy guidelines for organisations. Professional associations such as the Public Health Association of Australia (PHAA) and the Australian Institute of Environmental Health (AIEH) also endorse this approach.

Shade creation can be undertaken by natural means through the planting of trees or through artificial means such as built shade structures. Scientifically, shade has been defined as that level at which UVR of wavelengths between 280-400 nanometres is screened (AIEH 1996). It should be noted that shade only reduces the level of direct exposure to UVR; it does not offer 100% protection. Nevertheless, as indicated above shade is promoted as an integral component of Australia's sunsafe message.

The "SUNbusters" project in Queensland is one project that aims to increase the provision of shade and encourage the development, adoption and implementation of sun safe policies at a local level.

## "SUNbusters"

Queensland Health (QH) health promotion staff, located in the regional city of Toowoomba, developed the SUNbusters project in 1992 in response to Queensland's undesirably high incidence of malignant melanoma. The word SUN in SUNbusters is an acronym for 'Stopping Ultraviolet Neglect'. The project has been funded by QH for the sole purpose of providing seeding grants (of up to $500) to non-profit children's organisations for the provision of shade structures. The project utilises a settings approach, targeting schools, preschools, sporting bodies and any community-based group providing services to young children. "SUNbusters" aims to establish local sun-protective environments that will also encourage behaviour change and sun protection activities, and ultimately, reduce the incidence, morbidity and mortality from skin cancer. Integral to this process is the encouragement to develop a shade creation policy at each of the funded organisations, but not as a stipulated requirement. In 1998, the project was extended to four other Health Districts in the Southern Queensland Zone (referred to hereafter as "the Zone") covering a population of approximately one million people. In 1999, a total of 107 projects had been funded.

## Evaluation Methods

This paper reports on an evaluation that first, assessed the aims, objectives and strategies of SUNbusters, second, assessed outcomes from a health promotion perspective, and third, made recommendations for the overall future direction of "SUNbusters" (Hawe, Degeling & Hall 1990).

### *Participants*

The study population included key QH health promotion staff based in Ipswich, Toowoomba and on the Gold Coast ($n$=5) currently facilitating the "SUNbusters" project, as well as grant recipients from the 1998/99 funding rounds ($n$=107). Data were collected by face-to-face interviews for the QH staff members and questionnaires were administered by mail to grant recipients. In addition, an assessment of 10 shade structures erected by grant recipients using the seed funding provided by "SUNbusters" was undertaken.

### Data collection methods

Face-to-face in-depth interviews with health promotion staff were based on 45 open-ended questions, designed around key themes, in a structured format. These themes included the grant process, grant outcomes, physical structures, diffusion, equity, sustainability, costs and resource uses. Interviews were audiotaped and transcribed to obtain summary points, and complemented with detailed notes from the research assistant.

A questionnaire was distributed by mail to all grant recipients throughout the Zone who were awarded grants during 1998 and 1999 (n=107). The questionnaire contained 23 short-answer questions that took approximately 15-20 minutes to complete. The questionnaire aimed to gather information on links made in the community, development of a local sun safety policy, evidence of visible behaviour change, sources of additional funding, resources required to erect shade and use of the shade structure. Recipients were given one month to return the questionnaires in reply paid envelopes, with one follow-up 'phone call to non-respondents after three weeks. The total number of completed surveys was 46 (43%).

Ten on-site shade assessments were completed from randomly selected shade structures but stratified to include two from each Health District. The selection of structures was stratified by geographic location to ensure an even sample across the Zone. A system data collection tool was used and photographs were taken as documentary evidence of the shade structure designs at each site (AIEH 1996).

### Data analysis

Thematic analysis was employed for the in-depth interviews and the units of analysis were "natural" text segments aligned to each question. These in turn addressed the key themes driving the evaluation. A matrix was developed to produce cells of data cross-matching respondents with key themes. A similar strategy was used for grant recipient questionnaires, but coding within each variable response occurred to allow more descriptive quantitative analyses. Data were stored and analysed using a statistical computer package and frequencies, cross-tabulations and graphical displays produced. Queensland Health staff and grant recipients had the opportunity to provide additional comments, outside the boundaries of the key themes and patterns.

## Results

### Health promotion staff

In summary, the health promotion staff reported that "SUNbusters" was simple, easy to manage, facilitated the development of improved community links and that shade structures generated high visibility for the project in the community. The main strengths of "SUNbusters" were believed to lie in the way that it contributed to community development and support. The weaknesses of "SUNbusters" were considered to be related to the limited pool of grant money, the sub-optimal quality of shade generated, and its reliance on a limited single-strategy approach to prevent skin cancer.

The health promotion staff advised that the majority of recipients received extra sources of funding and additional resource support to erect their shade structures. Organisations identified as responding to the "seeding" grants were local and state government departments, private sponsors, community members, regional nurses, and service clubs. Responses included additional funding, the provision of information and manual labour to erect the shade structures identified in "SUNbusters" applications.

In terms of evaluation, there was little follow-up by health promotion staff with grant recipients to evaluate the program or to confirm policy development. While a grant recipient self-administered evaluation form was developed, the return rate of these forms, including photographic evidence of

the completed shade structure, was low in most health districts.

Recipients who experienced difficulties completing the funding applications were referred to the QCF for assistance by the health promotion staff. The health promotion staff regarded the QCF as the principal exponent of policy development; the primary resource used for this purpose was a policy guide for organisations produced by the QCF (1999). Queensland Health also provided educational and planning resources.

Comments from health promotion staff on the quality of the shade structures ranged from "excellent" (e.g., a few solid roof structures) to "poor" quality shade (e.g., young trees planted). One staff member believed the quality of shade was an extremely important issue, which was not addressed in the "SUNbusters" project protocol. Most informants believed that limited shade was better than no shade.

A number of diffusion methods for the "SUNbusters" project were utilised by the health promotion staff. Principally, the spread of information about the project was achieved through local media releases, radio spots, word of mouth and the use of local government libraries.

Some of the Health Districts in which the project was conducted incorporated assessment criteria based on location, size and nature of the organisation, into the review process for grant applications. The remaining Districts did not discriminate between applicants on these criteria.

Opinions as to the sustainability of "SUNbusters" varied greatly between health promotion staff. One staff member stated that sustainability was directly related to the maintenance of a funding stream, while others mentioned the need to seek sponsorship deals and encourage policy development by the grant recipients.

### *Grant recipients*

The primary outcome of "SUNbusters" was the construction, or planting of shade. Sixty-three percent of grant recipients sought additional funding, with the average amount of additional funding raised being $980. Forty-one percent of respondents reported that volunteers were used to erect the shade structures, 33% used a tradesman, 11% used both and 15% used only the organisation's staff. The average labour time involved in the shade creation activities was 25 hours. While over half of the recipients (59%) did not receive discounts from shade-material providers, a substantial proportion (28%) did receive some form of discount (e.g., knowing the tradesmen, tax exemptions, and price at cost). Eighteen percent of respondents obtained private sponsorship to supplement the "SUNbusters" grant.

The majority of the respondents (59%) estimated the useful life of the shade structure to be 10 years. Five years was the shortest lifespan estimated (12%) and this extended to "indefinitely" by some respondents (12%) who built solid roof structures and planted trees. The shade created for each organisation appeared to be well used with the recipients advising an average of 60 people making use of these facilities during peak use times.

With regard to organisational policy development, for example, rules about "no hat no play", keeping out of the sun during the midday hours, diligent sunscreen use, and so on, nearly half (48%) of the recipients reported that they already had an existing sun protection policy in place. While about a quarter (26%) were developing one subsequent to receiving the grant. However, no data were collected on whether a policy was in fact implemented or not.

Thirty-eight percent of recipients heard about "SUNbusters" through their local newspapers and 24% heard through word of mouth. Other methods of diffusion identified by the grant recipients were mailouts from Queensland Health (20%),

grant submission workshops (9%), radio (4%), and organisations such as the QCF or local governments (4%).

Over two thirds of respondents (31/46 or 67%) took the opportunity to provide general comments and these have been summarised into key points in Table 1.

***Table 1: General Comments on SUNbusters by Grant Recipients***

| General comments about SUNbusters | *n* | % |
|---|---|---|
| Considered that SUNbusters was a worthwhile project | 14 | 30% |
| Expressed thanks and appreciation | 13 | 28% |
| Commented on necessity of funding due to scarce resources | 9 | 20% |
| Commented that the project should continue | 6 | 13% |
| Commented on the grant leading to other sun safe activities | 6 | 13% |
| Commented on the reinforcement of sun safe activities by their organisation | 3 | 7% |

### *Shade assessments*

Ten of the funded shade structures were assessed for effectiveness of shade and design features. Four new shade structures complemented the existing natural shade on site, however, the majority of new structures provided the main source of shade coverage. Ranges of 5-60% of site surface areas were shaded by artificial or natural means. Most sites had only peripheral trees that were too far away from the main activity to be used by spectators. Nine of the structures audited used shadecloth as a roof material and one structure was portable. All of the structures audited had concave edges, which reduces effectiveness. They also lacked adequate overhangs and signage to encourage continued use of personal protective measures. The most common type of surface shaded by the new structures was grass that reflects UVR at 2-5% (AIEH 1996). Some shade structures partly covered sand or concrete surfaces that reflect UVR at much higher rates (12-18%) (AIEH 1996). Equipment was well positioned under the structures to make maximum use of the shade provided.

## Discussion

The evaluation of the SUNbusters project found that the provision of funding had led to the construction of shade creation at public facilities thereby contributing to local supportive environments. All the study participants considered this outcome to be an important achievement of "SUNbusters". This outcome relates not only to physical shade creation itself, but also to the strengthening of community action within the organisation.

Without numerous volunteers, organisational networks and fund-raising efforts, shade would not have been created. The project led directly to the promotion of community action and involvement, and increased awareness and social responsibility for preventing skin cancer. "SUNbusters" is clearly much more than a shade creation project. It has attempted to extend educational and public awareness programs aimed at enhancing personal skills and has combined this with a community and environmental approach to health promotion.

### *Policy creation*

Directing *behaviour change* towards increasing sun safety is a major public health and cultural challenge. Healthy public policy is seen as a key mechanism to achieving such behaviour change (WHO 1986). In this context, a major outcome associated with "SUNbusters" is the substantial number (74%) of grant recipients who are either developing or have already adopted *Sun Safe Policies*. These policies support changes in sun safe behaviours such as changing uniform design; rescheduling sporting fixtures to avoid the midday sun; and encouraging the use of sunscreen. Further, such polices target young children who are particularly vulnerable to skin damage and lay the foundation for sun protective behaviours for life.

### Community action

The experiences gained from participating in the "SUNbusters" project has also contributed to capacity building within the organisations. The evidence indicates that "SUNbusters" was successful in enabling small community groups who are usually unable to access funds, the opportunity to fund shade creation and to establish or enhance sun protection activities at the local level.

### The application process

Health promotion staff and recipients of the grants indicated that the grant application process for "SUNbusters" is relatively uncomplicated. However, it became apparent that the continuing quality of "SUNbusters" is reliant on the management efforts and the commitment of the health promotion staff. Clearly, due to time constraints there was limited follow-up on the policy development process and there was a low-level return of evaluation forms. In terms of sustainability, a regular review of the project as well as greater encouragement to generate and support policy formulation at the local level would enhance the existing program.

### Program sustainability

Further suggestions from the health promotion staff and the grant recipients to increase the sustainability of "SUNbusters" in Queensland included: increasing the individual grant amounts; providing mandatory sun safety workshops for grant applicants; obtaining private sector sponsorship; being part of a comprehensive skin cancer policy program for Queensland; confirming the commitment of QH funding; and obtaining wider representation from other local organisations.

### Health promotion and environmental health

The "SUNbusters" project clearly supports many principles of health promotion. The project encourages motivation for shade creation for people in the context of their everyday life and it addresses the environmental determinants of health. It also combines a range of complementary approaches within its perspective including education, communication, and organisational change and community development. In terms of "empowerment", recipients retain the power and control over their health initiatives and activities, and the health promotion staff participates in the project with the community, rather than on them.

### Partnerships

The evaluation identified the need to maintain partnerships to support the "SUNbuster" program. This includes the continued involvement of organisations such as the QCF, particularly for the provision of education, training and policy tools. An increased role for local government could include the improvement of the diffusion of "SUNbusters" into local communities, the assessment of grant applications and support for policy development. Local government could also share responsibility for community shade creation by including shade in planning decisions at venues such as sporting fields.

### Program limitations

A number of limitations of the "SUNbusters" project were also identified from the evaluation process. For example, the project was not coordinated between and across the five participating Health Districts. Also data collection and record management need to be streamlined and improved. Such data would greatly assist the evaluation processes and outcomes-based planning for future health promotion programs.

A centralised recording system covering measures that deal with aspects of distribution, saturation, quality and outputs, would certainly improve planning, management and evaluation of the

"SUNbusters" project. However, the management of this database requires resourcing, potentially from the health promotion staff. Such a database would enable systematic comparisons across the geographical areas, would be a useful tool to assist other health promotion professionals, and would also be informative for project partners and potential private sponsors.

A further limitation was the effectiveness of shade provided. As most shade structures were constructed of shadecloth the shade quality was relatively poor. The effects of material colour, weathering and tight stretching of shadecloth may alter the UV absorption property, and therefore reduce UVR protection (University of Queensland 1999). Features such as overhangs of a minimum of one metre, vertical sides and avoidance of concave edges can increase the effectiveness of a shade structure (Toomey, Gies & Roy 1995). However, shade cannot be 100% effective. It is therefore necessary to complement shade with personal protective behaviour to ensure adequate protection from UVR.

### *Shade quality*

As indicated above, most structures audited had no overhangs, concave edges reducing maximum efficiency, and there was no signage to encourage continued use of personal protective equipment. On a positive note, however, most of the equipment being shaded (e.g., play gym apparatus or sandpits) was located in the middle of the structure. This is the ideal placement as shade is deepest at this point and at it is most protective, given the sun's movement across the sky during the day (University of Queensland 1999).

If high quality shade creation was the sole outcome of "SUNbusters", the project could not be considered a "success". Nevertheless, an important recommendation for the improvement of "SUNbusters" is the inclusion of shade design criteria and advice as to suitable construction materials that would increase UVR protection.

## Conclusion

In summary, the evaluation has led to the recommendation that "SUNbusters" continue. The project clearly has the potential to be an excellent vehicle to encourage healthy public policy development in the form of sun safety policies. Good health promotion and environmental health practice was demonstrated through the formation of local collaborative groups taking an important responsibility for skin cancer prevention, increased community action, and the contribution to organisational change, as well as the creation of sustainable supportive environments. While the project had limitations and improvements were possible, overall this project exemplifies the value of local action as a means to promote the health of the community. The lessons learned from "SUNbusters" are clearly applicable to other community-based programs, which seek to develop supportive environments. While limited in scope, such community-based programs have great potential to promote health and prevent disease, to an extent out of all proportion to the investment of human and financial resources.

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# Non-Governmental Position Paper on Critical Needs to Address Children's Environmental Health Problems

*This Position Paper was generated in January 2001 to help bring the issue of children's environmental health to the attention of the international community, especially the United Nations Special Session on Children, which will be held between September 19-21, 2001 in New York. The Paper was circulated to delegates of a Preparatory Committee meeting for the Special Session and formed the basis of a Non-Governmental Organisation (NGO) statement delivered on the floor of the Preparatory Committee. Since then a coalition of advocacy and science-based NGOs has emerged to bring the issue onto the global agenda, including the 'Rio +10' Summit on Sustainable Development in Johannesberg in 2002.*

## A. Children's Environmental Health: An Overview

### *A threatening environment for children*

Globally, inadequate fresh or clean water supplies, contaminants and pollutants in the ambient air, exposures to hazardous and unsafe products, and poor waste disposal practices, are the major causal factors in determining the impact of the environment on children's health. As these environmental factors rise, a growing body of scientific and medical evidence suggests that they are linked to many premature deaths and illnesses in children.

Experts now believe that the single largest cause of death for children globally, estimated to be nearly five million a year, is from acute respiratory diseases that arise from or are exacerbated by constant exposures to highly polluted indoor and outdoor air (airborne particulates, sulfur dioxide, ozone). In addition, more than three million children die each year from waterborne diseases caused by ingesting bacterially contaminated water.

Dramatic increases in population, technology, trade, and material goods mark the transition to a new millennium. While many of these changes have benefited children, they have also raised new concerns and created serious new health issues. New environmental factors are threatening children's health. For instance, synthetic chemical substances such as pesticides and solvents, and heavy metals, such as mercury and lead in our environment, can impair a child's nervous system. PCBs and dioxins disrupt the body's hormonal balance. Radiation, asbestos, and arsenic contribute to the onset of cancer.

### *Definition of children's environmental health*

Environmental health comprises those aspects of a child's life that are determined by interactions with physical, chemical, biological and social factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling and preventing those factors in the environment that may adversely affect the health of present and future generations.

### *Children's burden of disease in developing regions*

These newly emerging environmental health threats significantly add to the current burden of diseases by affecting a child's immune system; the child's ability to fend off diseases. This is especially the case in countries in Asia, Africa and Latin America where many children are still not immunised against common childhood diseases and many do not have access to basic health care. In addition, poor children

on diets deficient in vitamins, minerals, and protein are especially vulnerable to the toxic effects of chemicals, due to reduced capacities to ward off or eliminate environmental toxins from their bodies.

### *Why are children more vulnerable than adults?*

Children's body size and unique physical characteristics make them generally more vulnerable than adults to many environmental health hazards. Because their nervous, respiratory, reproductive and immune systems are in the process of developing, children are in a dynamic, sensitive state of growth that lasts from the time in the womb through adolescence. This makes them more sensitive to environmental health hazards. In addition, their behaviours, the way they interact with their surroundings, can also put them at greater risk. Typical childhood behaviours, such as eating exclusively one kind of food, crawling, digging in dirt, and putting objects in the mouth, can all lead to increased exposures to environmental contaminants.

a) A child's first environment is the mother's womb. Many chemicals can cross the placenta and permanently damage the fetus. Damaging substances include lead, PCBs, methylmercury, and nicotine from environmental tobacco smoke.

b) On a body-weight basis, young children drink more water, eat more food, and breathe more air than adults. The average infant's daily consumption of formula or breast milk per kilogram of body weight is equivalent to an adult male drinking 50 eight-ounce glasses of milk a day.

c) Children spend more time outdoors than do most adults, often engaged in vigorous play. With their respiratory systems still developing, they can suffer greater exposure to, and adverse impacts from, air particulates and ozone. Young children also spend many hours close to the ground where they may be exposed to toxicants in dust, soil, and low-lying vapours such as radon or pesticides.

d) Children have a longer "shelf life". The earlier in life they are exposed to environmental hazards, the more time they have to develop environmentally triggered diseases such as cancer, Parkinson's disease and other chronic illnesses.

## B. Children's Critical Environmental Health Issues

### *Poverty, malnutrition and infectious diseases*

Poverty, malnutrition and infectious diseases are the major cause of illness and deaths in children living in many developing regions of the world. According to the 1995 World Health Report, 12 million children under the age of five die prematurely from preventable illnesses. WHO estimates that at present 160 million children suffer from mild to severe malnutrition, while infectious diseases account for a yearly toll of 13 million deaths in children and young adults. Even in a highly affluent country like the United States, a quarter of all children live in poverty, where they are hungry or malnourished and lack access to proper medical care.

### *Air pollution*

Exposure to unclean air has emerged as one of the most serious threats to a child's health. Respiratory diseases such as bronchitis, asthma and other chronic lung diseases are growing public health problems for children in many regions of the world.

These diseases persist throughout life, affecting health, productivity and welfare. Air pollutants such as particulate matter, ozone, sulfur dioxide and oxides of nitrogen, aggravate these diseases. Experts believe that early diagnosis and proper use of antibiotics could prevent from 30% to 60% of acute respiratory-related child deaths if families in developing countries had access to proper medical care and medicines. The top 10 large cities with degraded air quality for children below the age of five years are located in Mexico, China, India, Iran, Philippines and Brazil. But cities around the world are threatened by industrial pollution. In developed countries, asthma is now a growing health concern. In the United States alone it is the leading chronic disease among children, increasing from 5.8% in 1990 to 7.5% in 1995. Many believe that car exhaust, tobacco smoke, mould, house dust, and ground level ozone are key factors in the epidemic's staggering 129% increase.

### *Indoor air pollution from cooking fuels and heating sources*

Exposure to indoor air pollution is also a growing health concern in many developing regions. The World Health Organization and World Bank have found that indoor air pollution caused by cook stoves using traditional biomass fuels (wood, dung and crop residues) pose one of the largest risks to the health of children and women in developing countries. In India alone, where smoky stoves in inadequately ventilated homes are still extensively used, they account for almost half a million premature deaths a year.

### *Water pollution*

Microbial contaminants in water can lead to diarrhoea, malnutrition and sometimes death. Waterborne diseases are the second single largest category of communicable diseases, after acute respiratory diseases, contributing to infant mortality worldwide. Two million children die from dehydration each year because of diarrhoeal diseases and the problem becomes most acute for children without access to clean water supplies. Among the many water-related diseases, schistosomiasis, filariasis, guinea worm and intestinal worms have major incidence in debilitation. Schistosomiasis itself is indicated as responsible for 200 million people infected and over 200,000 deaths per year.

### *Toxins exposure and persistent organic pollutants (POPs)*

Chemical exposure is a serious concern globally. Mercury, arsenic and asbestos, contained in solvents and other materials, are increasingly linked to cancers and other diseases. Moreover, POPs are some of the world's most dangerous chemicals; they include highly toxic dioxins, PCBs and pesticides, such as DDT. POPs persist in the environment and in the tissues of living organisms. Many people now carry enough POPs in their body fat to cause serious health problems, including reproductive and developmental damage, cancer and immune system disruption. Recognising the danger to human health, 120 countries recently adopted a treaty to minimise and eliminate these chemicals.

### *Lead*

Lead poisoning continues to be a serious health problem in developing countries, especially affecting infants and young children living in urban areas. High levels of exposure can cause severe brain damage or death, while low levels of exposure in early childhood can cause loss of cognitive and motor skills, behavioural disorders, reduced attention span and hyperactivity, and significant lowering of IQ and academic performance. In many developing countries, the largest source of childhood lead exposure is from leaded gasoline used in motor vehicles, which accounts for up to 90% of airborne lead contamination in many urban areas.

## C. Role of International Agencies, National Governments and the Private Sector

### *Government commitments to protect children's Environmental Health under the Convention for the Rights of the Child and Agenda 21*

A child's right to develop in a healthy environment is protected under the UN Convention on the Rights of the Child (CRC) under: Article 6: …the right to life, survival and development, Article 24: …the right to the highest attainable standard of health. States, Parties shall take action to combat disease and malnutrition, [considering] the dangers and risks of environmental pollution. Parties shall ensure that all segments of society are informed about child health. Article 27: …the right to a standard of living adequate for the child's physical, mental and social development. Article 29: …the right to education directed at the development…of respect for the natural environment. Moreover, governments are committed to addressing environmental health concerns in the Program for the Further Implementation of Agenda 21 adopted in 1997, recognising that, protecting children from environmental health threats and infectious disease is particularly urgent since children are more susceptible than adults to those threats. These commitments require governments to develop programs and policies that recognise children's special vulnerability to unsafe chemicals and toxic substances, and to ensure that they can survive and develop at the highest attainable standard of health.

### *International aid programs, national health policies, and community health agencies must vigorously address the environmental problems that contribute to childhood diseases*

To prevent acute respiratory and waterborne diseases children must have access to clean water supply, clean air and nutritional food. Governments and international agencies should also work to better address the newly emerging health problems, caused in part by toxic exposure, moving beyond the current trend to react to these diseases and working to prevent them.

### *Governments should commit to mobilising the necessary resources for increased basic, applied and epidemiological research*

To ensure access by all countries to data and information, and to facilitate technology transfer, a global mechanism, such as an intergovernmental panel of scientific experts, should be established to collect and analyse linkages between the environment and children's health, development, and disease. An interactive exchange among health, environmental, and children's rights experts could lead to result in greater understanding of these linkages and in more coherent program development.

### *There is an urgent need for broader education, awareness and training to address environmental problems that exacerbate a child's risk of contracting disease*

Donor agencies should provide increased support to local and national governments in developing countries, and to NGOs, to educate and train community leaders, health care staff, and policy makers to develop child protective standards for water, food, housing, hygiene and sanitation.

### *Governments and international development assistance agencies should establish comprehensive Environmental Impact Assessment (EIA) guidelines*

These guidelines should recognise the special vulnerability of children, and support field staff in assessing the impacts of projects on children's environmental health, mitigating negative impacts and maximising potential gains.

***Governments should enforce ILO standards for children and legal workplace inspections on health and safety practices***

Work related abuses affect hundreds of millions of children in the workforce, some as young as age five years. Removing children from areas with high contamination and toxic exposure can limit workplace injuries and disease.

***Governments should establish standards for exposure to environmental contaminants that are protective of children rather than base standards on adult tolerance levels***

This includes working to phase-out all lead additives in gasoline products, reduce air and water pollution with stricter control measures and develop effective methods for hazardous waste disposal.

Nongovernmental Organisations supporting the Statement include:

- The Natural Heritage Institute
- Nautilus Institute for Security and Sustainable Development
- Institute for Children's Environmental Health
- National Council for Science and the Environment
- Human Rights Advocates
- Global Children's Health and Environment Fund

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For information on the UN Special Session for Children, www.unicef.org/specialsession/index/html

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# Food Hygiene Licensing and Registration in Queensland

**Food Services, Environmental Health Unit, Queensland Health[1]**

The scientific literature is divided on whether conducting routine inspections of food premises is an effective way to predict and therefore minimise food borne illness outbreaks (Cruz, Katz & Suarez 2001; Irwin et al. 1989). However, a number of studies have concluded that routine inspections (at a minimum of one per year) are effective in improving food hygiene practices and reducing the risk of food borne illness associated with the premises inspected (Campbell et al. 1998; Mathias et al. 1995; Riben et al. 1994).

One important mechanism that provides administrative support for routine inspections is the licensing and registration of food businesses and operators. In Queensland, Part 10 of the Food Hygiene Regulation 1989 contains a number of provisions that provide such a mechanism for local authorities to issue licences to conduct a food business and to register food premises and vehicles. Licensing and registration processes also have a role in ensuring compliance, in that they can be used to limit (or cease) the trading of unsatisfactory operators. As the Food Hygiene Regulation 1989 is due to expire on 31 August 2001, and as part of the national food reform process and the Queensland Government's obligations under the National Competition Policy, Queensland Health is currently undertaking a Regulatory Review and Public Benefit Test of this legislation.

One component of this review was a survey of local authorities in Queensland to determine the extent of licensing and registration activities undertaken in regard to food hygiene. The survey, the first of its type in Queensland, was conducted in December 2000. Information was collected from local government Managers of Environmental Health using a self-completed questionnaire and a follow-up telephone interview. Topics covered in the survey included: fee structures for licensing and registration; the frequency and content of routine food hygiene inspections; types of food businesses licensed or registered; temporary food stalls and charitable organisations; issues of particular importance to rural local authorities; and issues regarding the revenue raised from licensing and registration. From the 134 local government authorities in Queensland (including Community Councils), 94 responses were received. The following section provides a summary of the results.

## Results

Excluding community councils, all respondents licensed and registered food businesses and premises. However, the survey indicated that the way in which local government authorities interpreted the licensing and registration provisions of the Food Hygiene Regulation 1989 was variable.

### *Licensing and Registration fees*

- The licensing and registration fees charged by local governments varied widely, as did the criteria on which the fee schedule was based. The minimum average fee (across the food business categories and for both licensing and registration) charged by a local government was $25, while the maximum fee was $917 per year (mean = $143, median = $90). The larger local governments generally charged higher fees.

- 29% of local governments (most of which were small) combined the licensing and registration fee.

- Local governments determined their registration fee using the following criteria:
  - the average length of inspections (29%)
  - risk assessment (12%)
  - floor area (6%), and
  - a variety of other means, such as historical increases.

### *Food inspections*

- 19% of local governments used a risk-based method to determine the frequency of inspections. These were predominantly larger local governments (average population = 83,000).

- 30% of local governments had a fixed frequency of inspections. These were predominantly medium-sized local governments (average population = 43,000).

- 29% of local governments conducted inspections when needed and these were mainly smaller local governments (average population = 21,000).

- Using a risk assessment approach, the average inspection frequency for premises rated as high, medium, and low risk were three, seven, and 12 months, respectively.

- 59% of local governments used a pro-forma inspection tool.

- The local governments, which used an inspection pro-forma, spent on average 10 minutes less per inspection.

- 26% of local governments undertook a risk assessment when conducting an inspection. These types of inspections generally took slightly longer to perform than inspections that did not include a risk assessment component.

### *Temporary food stalls and charitable organisations*

- 39% of respondents issued permits for temporary food stalls. If fees were charged, they were generally of nominal value.

- 55% of local governments licensed and registered relevant community and charitable organisations. The majority (70%) of these local authorities offered discounted fees or fee exemptions to the community/charity organisations.

### *Rural issues*

- Many rural local governments took into account the fact that food premises in rural areas often have a comparatively lower cash flow compared to premises in more heavily populated areas, and therefore set their licensing and registration fees as low as possible to minimise financial impacts.

- The respondents indicated that a lack of financial resources available to rural local governments and increased inspection costs (due to long travel times) might also reduce the frequency of inspections and diminish other food safety activities such as training and food hygiene and safety resources.

### *Revenue*

- 43% of local governments used the revenue generated by these licensing and registration fees, for additional food safety activities. This was also the case for local governments whose costs in relation to food safety were greater than the revenue they raise from these charges.

- For many local governments, expenses incurred in conducting inspections and other food safety activities were significantly more than the income raised from the licensing and registration fees.

### *Other Licensing and Registration issues*

- 6% of local governments offered a fee reduction incentive for businesses that demonstrate a good level of compliance.

- 11% of local governments required food handlers to have undertaken a food hygiene/safety training course. An additional 11% of local governments either recommend training courses to all food premises, are trialing food safety training for food handlers, or intend implementing training requirements in the near future.

- 62 local governments provided information on the number of environmental health officers (EHOs) involved in food safety activities (e.g., routine inspections, plan approvals, complaint investigation). From a total number of 206 EHOs employed by these local authorities (mean number of EHOs per employer = 3.3), 152 were involved in food safety activities (mean=2.4), with the mean number of full-time equivalent EHOs (per local authority) involved in food safety calculated as 1.1.

## Summary

The results of the survey provide baseline data for the current regulatory review of the Food Hygiene Regulation 1989 and for the implementation of a national notification requirement contained in Food Safety Standard 3.2.2 and scheduled to commence during 2002 (Australia New Zealand Food Authority [ANZFA], 2001).

The survey has found that the licensing and registration fees charged by local governments in Queensland vary substantially and are based on a range of criteria. The frequency of routine inspections also varies with the majority of local authorities using a pro-forma inspection tool. The use of risk assessment methodologies seems to be becoming increasingly popular for both determining inspection frequency and for application during the inspection. The survey identified a range of issues for rural local authorities including comparatively lower fees, higher inspection costs, and a lack of resources that particularly impact on the frequency of inspections and limit the operation of council-run training courses. Much of the revenue raised from licensing and registration is used in additional food safety activities, despite the cost of undertaking inspections and these addditional activities generally outweighing the revenue raised by the fees.

Many of the respondents indicated that they considered the licensing and registration of food operations to be an important role of local government, but due to the substantial competition for resources, considerable restraints are placed on inspection frequency and duration.

### *Endnote*

1. Contributions to this report were made by: Matthew Melloy, Nick Varnes, David Larkings, Barbara Marendy, Kerry Bell, Katrina Smith and Thomas Tenkate.

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# The Economics of Nature: Managing Biological Assets

**By: G. Cornelis van Kooten and Erwin H. Bulte**

*Blackwell Publishers, 2000, 512 pp, paperback, $69.95, ISBN 0-631-21895-5*

The Economics of Nature is a comprehensive text on the management of natural resources and provides an in-depth discussion of the economic tools that can be applied to the policy analysis of these resources. The authors note that the book was written with three purposes in mind: first, as a text for senior level undergraduate or graduate students of natural resource economics and resource management; second, as a reference book for economists and professionals involved in resource management; and third, as a resource that provides a perspective from economics on the conservation of biological assets and sustainable development.

The text covers a wide range of technical and conceptual economic issues, with some of these at a quite advanced level. As such, a solid understanding of economic theory is required to comprehend fully a number of the sections.

The book is loosely divided into two parts: the first part describes economic tools that are relevant for assessing the value of biological assets, and the second part applies these concepts to specific case studies. The first six chapters examine the theory and application of cost benefit analysis (CBA). This includes discussions on measuring consumer and producer welfare, the measurement and capture of resource rents, valuation of non-market benefits (i.e., non-market traded commodities, such as biological assets), and evaluation of natural resource policy through the application of CBA. Chapter 7 then introduces the basic concepts of the economics of renewable resource management. The remaining chapters discuss the following issues from an economic perspective: sustainable development, biological diversity, threatened and endangered species, forest management, and topical deforestation. Central to this discussion is the application of economic concepts to real-life examples such as the African Elephant with bans on the ivory trade and poaching, and game ranching in Kenya to conserve wildlife.

Overall, the text certainly achieves the ambitious objectives of the authors. A consistent theme throughout the book is that natural resources should be considered as biological assets, and that the consideration and proper application of economic tools plays an important role in good management and better policy making for these resources. This text makes a welcome contribution to the field and should provide a significant resource for those involved in managing natural resources.

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