Volume 7
Issue 4
2007

# 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

ISSN 1444-5212

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

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

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

**Aims**

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

**Correspondence:**
Jim Smith
Editor, Environmental Health
P O Box 225
Kew, Victoria, 3101
Australia

Telephone: 61 3 9855 2444
Fax: 61 3 9855 2442
Email: jim@infocusmg.com.au
Website: www.aieh.org.au

**Editorial Team:**
Heather Gardner
Email: gardner@minerva.com.au

Jaclyn Huntley
Email: Jaclyn@infocusmg.com.au

***For subscription and memberships details visit our website: www.aieh.org.au***

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

ABN 58 000 031 998

ISSN 1444-5212 (Print), ISSN 1832-3367 (Online)

***…linking the science and practice of environmental health***

The Australian Institute of Environmental Health gratefully acknowledges the financial assistance and support provided by the Commonwealth Department of Health and Aged Care in relation to the publication of Environmental Health. However, the opinions expressed in this Journal are those of the authors and do not necessarily represent the views of the Commonwealth.



Published by Environmental Health, The Journal of the Australian Institute of Environmental Health.

Correspondence to: Jim Smith, Editor, P O Box 225 Kew, Victoria, 3101, Australia.

**Cover Design by:** Motiv Design, Stepney, South Australia

**Design & typeset by:** Mac-Nificent, Northcote, Victoria

**Environmental Health © 2007**

ISSN 1444-5212 (Print), ISSN 1832-3367 (Online)

# 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.

### Correspondence

Jim Smith
Editor, Environmental Health
PO Box 225 Kew, Victoria, 3101, AUSTRALIA
Guidelines for Authors can be obtained from the Editor
Telephone: 61 3 9855 2444
Fax: 61 3 9855 2442
Email: jim@infocusmg.com.au

# Environmental Health Officers

## *Your Gateway to Working in the UK!*

We are the leading Environmental Health Recruitment Consultancy in the UK and are ideally placed to find you work and provide the support you will need to make your stay a success.

**We can offer you:-**

- Short & Long Term Contracts to suit you
- Opportunities throughout the UK
- Flexible working hours
- Continuing Professional Development Training Courses
- Expert help and advice from our experienced consultants
- Excellent rates paid weekly

**Register with us NOW! and we'll be ready with assignments for you to choose from BEFORE your arrival.**

**Contact us for more information:-**
**Email: aus@or-environmentalhealth.com**
**Tel: 00 44 (0) 207 580 1500**

**Osborne Richardson**
ENVIRONMENTAL HEALTH RESOURCING

Fourth Floor Circus House, 26 Little Portland Street, London W1W 8BX

# Contents Environmental Health, Volume Seven, Number Four, 2007

# Contents Environmental Health, Volume Seven, Number Three, 2007

# Contents Environmental Health, Volume Seven, Number Two, 2007

# Contents Environmental Health, Volume Seven, Number One, 2007

This issue of the Journal contains a range of contributions concerning the science, policy and practice in environmental health. The first article is concerned with the evaluation and management of wastewater within constructed wetlands. Joseph et al. provide an argument and evidence for the use of a simpler mathematical model for predicting the Biochemical Oxygen Demand in natural and constructed wetlands. As stated by the authors, having the ability to quantify nutrient retention in constructed wetlands is an important task in the context of enhancing water quality and therefore its potential for re-use. As natural and constructed systems are more energy efficient than conventional sewage treatment plants this model might assist in improving the efficiency of current wetlands and new systems. The points raised by the authors are particularly timely when many areas of Australia are in drought, there is demand for the use of wastewater, and there is a renewed global attention on energy use, greenhouse emissions and pollution targets to replace the Kyoto Treaty.

The next two articles, by Lawson and He Wang, concern the public health implications and impact of asbestos. In the first paper the authors review the occurrence and predictions of asbestos related disease in different countries including Australia. Despite knowing about the dangers of asbestos for decades, it was not until 2003 that there was a prohibition on all forms of asbestos use in Australia. However, the authors point out that even though the world production of asbestos has been declining dramatically this is not the case in India and Asia where it is increasing. The authors observe that the public health impact of asbestos is not over as exposure might still occur from asbestos in buildings built prior to the banning of asbestos. The death of Mr Bernie Banton in November has reminded us of the consequences of asbestos exposure and that it continues to be a public health hazard. The second paper by the authors moves from the epidemiological perspective to the toxicological impact of asbestos exposure. The paper examines the physiochemical properties that relate to fibre toxicity and the mechanisms for asbestos toxicity. The authors discuss the six leading mechanisms for asbestos toxicity. Given that the public health impacts of asbestos related disease are still continuing there is a need to continue research into the mechanisms of toxicity.

The fourth article, by Gaskin, Bentham, Cromar and Fallowfield, examines the zoonotic potential of dogs in Aboriginal communities in Central Australia. The authors review the potential health burden to Central Australian Aborigines of speculative zoonoses originating from dogs. Observational studies were undertaken in seven camps the results of which indicate that, among other things, human infection with zoonotic organisms varies depending on the type of organisms and there is a need for utilising molecular techniques to identify the specific factors involved. The authors also comment on the cultural importance of dogs to Aboriginal communities and that environmental health interventions to improve health need to take into account these cultural characteristics.

The fifth article, by Lawler et al., based on a qualitative study also examines an environmental health hazard: exposure to ultraviolet radiation in the outdoor environment and the promotion of sun protection policies and practices in outdoor sports. The authors note that an important

determinant of health status is physical exercise as participation in outdoor sports might increase exposure to the sun and subsequently skin cancer risk. Thus sun protection policies, environments, practices, and attitudes in sporting clubs might be significant determinants of sun exposure among adult sporting participants. The study undertaken showed that sun protection was a high priority in surf life saving clubs but not so in other sporting clubs. The authors concluded that it is essential to address the resource, logistical and practical barriers to sun protection that is unique to each individual sport at the outset.

The paper by Jackson, Robertson and Verrinder examines the part that experiential learning plays in the development of future public and environmental health practitioners, academics and field mentors through two field experience units delivered as part of a public health degree program. The authors point out that field placements are irrelevant if the program is not integral to the whole course and planned so that participants have the opportunity to reflect on experience. The authors see providing environmental and public health students with the appropriate workplace skills and experiences as vital to the public and environmental health professions' future. It is particularly critical due to the advent of the new public health challenges associated with bioterrorism and pandemics. This paper is also important from the perspective of workforce and skill shortages being experienced, particularly in the environmental health arena and for policy development by professional accrediting organisations. The final paper, by Little et al., provides insights into the role of Health Impact Assessment at the local government level. The opportunity is provided by two concurrent proposals which are contiguous to each other: the expansion of a large landfill and the development of a large site for housing.

The papers in this issue all have implications for environmental health professionals, whether it is in service delivery, policy development, or research. If you wish to make a comment or respond to any of the published papers in this or previous issues please do so by contacting the Editor. Contributions are most welcome.

*Jim Smith*
*Editor*

Back to TOC

# Biochemical Oxygen Demand (BOD) Removal Modeling for Constructed Wetlands

**Benny Joseph[1], N. K. Ambujam[1], and S. Chandran[2]**

***[1]Centre for Water Resources, Anna University, Chennai, India & [2]Thiagarajar College of Engineering, Madurai, India***

*A mathematical model based on mass balance is proposed for predicting the Biochemical Oxygen Demand (BOD) removal in constructed wetlands, assuming the constructed land is made up of a single continuous flow stirred tank reactor (CFSTR). To improve the accuracy of the predictive equations for site specific cases especially in tropical regions, provision to take care of the effect of water loss from the system due to evaporation and evapotranspiration is incorporated. The model is validated using the data from a constructed wetland in Listowel Canada. For comparison purposes other contemporary models including the plug flow model by the US Environmental Protection Agency (USEPA) were used. The results of the comparison establish the accuracy of the proposed model over the existing ones in spite of its simplicity.*

**Key words:** *Constructed Wetland; Biochemical Oxygen Demand (BOD) Modeling; Biochemical Oxygen Demand (BOD) Removal; Continuous Flow Stirred Tank Reactor; Low Cost Wastewater Treatment; Plug Flow; Evapotranspiration*

## Notations

- $A$ - Fraction of BOD not removed as settleable solids at the wetland headworks
- BOD - Biochemical Oxygen Demand
- $C$ - Effluent BOD5 of the system - mg/L
- $C_0$ - Influent $BOD_5$ - mg/L
- $D_S$ - Dispersion coefficient - $m^2/h$
- $DT$ - The actual detention time for the subsystem which can be determined in the field trough tracer studies - h
- $F$ - Fraction of the BOD remaining in the system at any time
- $K_T$ - Temperature dependent first order BOD reaction rate constant - $d^{-1}$
- N - Porosity of the soil
- $p$ - The fraction of the discharge remaining after losses
- Q - Discharge of sewage entering/leaving the system. - $m^3/sec.$
- $t$ - Hydraulic residence time - days
- V - Volume of the land considered. - $m^3$
- $v_1, v_2, v_n$ - Are the volumes of the subsystems 1,2 and n - $m^3$
- $v$ - Velocity of flow - m/h
- $\tau$ - Transport detention time (TDT) of the subsystem - days

Increasingly, natural or constructed wetlands are used for removal of pollutants from wastewater or for treatment of stormwater runoff from agricultural lands and other non-point sources (Kadlec & Knight 1996). Constructed wetlands are considered as low-cost alternatives for treating municipal, industrial and agricultural wastewater (Pant et al. 2001). There has been an increasing interest in reuse of wastewater in agriculture over the last few years due to increased demand for fresh water. Population growth, increased per capita use of water, the demands of industry and of the agricultural sector all put pressure on water resources. Treatment of wastewater provides an effluent of sufficient quality that it should be put to beneficial use and not wasted. The reuse of wastewater on a wide array of crops and increases in crop yields from 10-30% have been reported (Asano 1998). Constructed wetlands serve as a means of low cost wastewater treatment and are divided into two basic types: free water surface (FWS) and subsurface flow

(SF) wetlands. During the last two decades attention has focused particularly on the use of constructed wetlands for the treatment of domestic sewage (Ji et al. 2002).

Constructed wetlands are among the recently proven efficient technologies for wastewater treatment. Compared to conventional treatment systems, constructed wetlands are low-cost, are easily operated and maintained, and have a strong potential for application in developing countries, particularly by small rural communities (Kivaisi 2001). They provide high removal of organics, suspended solids, and microbial pollution. The construction cost equals that for conventional treatment systems but the operation and maintenance costs are much lower (Vymazal 2002).

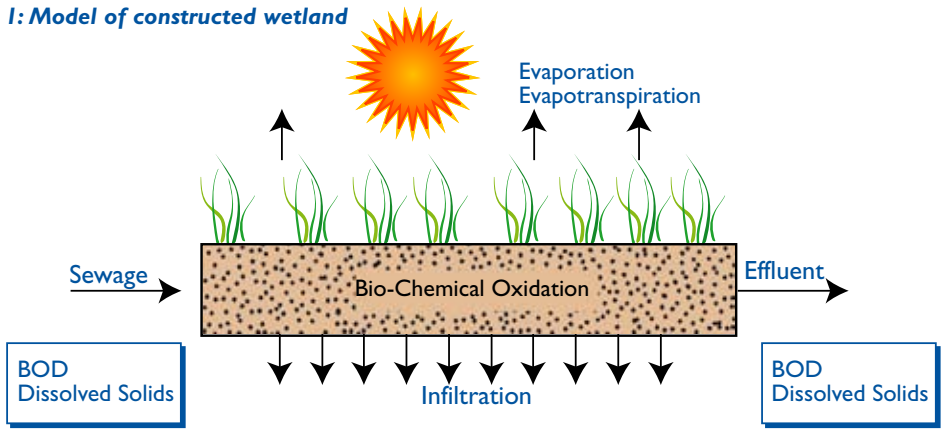
Constructed wetlands are highly complex systems that separate and transform contaminants by physical, chemical, and biological mechanisms that may occur simultaneously or sequentially as the wastewater flows through the system (USEPA 2000). Quantifying nutrient retention in natural and constructed wetlands is an important scientific and environmental task, in the effort to enhance water quality (Vymazal et al. 1998). Biochemical oxidation of an aerobic nature can be assumed as the primary factor responsible for the changes in the biochemical characteristics of effluent from constructed wetlands. As a result of the aerobic decomposition, the organic matter is converted to stable inorganic compounds of which many are nutrients for the plant. The remaining could be present in the form of dissolved solids at the outlet. The first-order removal model is widely used in constructed wetland design (Goulet et al. 2001). For the design of constructed wetlands as such there is no foolproof method as the physiochemical processes involved are so complex that a pilot plant study is the only reliable method to judge performance.

## Mathematical Model for Performance Evaluation of Wetlands

The flow through the constructed wetland is most likely to be non-ideal plug flow and hence it may be considered a continuous flow stirred tank reactor (CFSTR) to best represent the non-ideal flow pattern. It has been reported by Scott et al. (2000) that concentration of salts results from evaporation from wastewater in the irrigation field and hence there will be an increase in electrical conductivity down stream of fields irrigated with wastewater. The above observation substantiates the necessity for incorporating the effect of evaporation and evapotranspiration in the model.

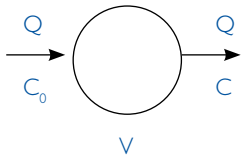
Assuming biochemical oxidation as the primary mechanism for the removal of organic mater in a constructed wetland, a model definition sketch incorporating the various physical phenomena and the external environmental factors is shown in Figure 1.

***Figure 1: Model of constructed wetland***



When we consider the constructed wetland as a CFST and applying the principle of mass balance, the mass balance equation for the entire system for the first order reaction rate of BOD removal can be written as equation (1) by referring to Figure 2.

***Figure 2: Schematic definition sketch of constructed wetland for the application of materials mass balance analysis***




$$V\frac{dC}{dt} = QC_0 - QC + (-K_T)CV \qquad (1)$$

Where Q - Discharge of sewage entering and leaving the system; $C_0$ - Influent $BOD_5$, mg/L; C - Effluent $BOD_5$ of the system mg/L; V - Volume of the system; $K_T$ - BOD reaction rate constant.

The mass balance equation (1) while neglecting the BOD reaction can be written as

$$V\frac{dC}{dt} = QC_0 - QC \qquad (2)$$

In the constructed wetlands considerable loss of water takes place due to evaporation and evapotranspiration and as a result of this the pollutant concentration in the effluent could change. The earlier models proposed by Chen et al. (1999), Vogler and Scherfig (2000) and Reed et al. (1995) have not considered this aspect. If '*p*' is the fraction of influent discharge left out after evaporation and evapotranspiration then equation (2) can be written as

$$V\frac{dC}{dt} = QC_0 - pQC \qquad (3)$$

Rewriting and simplifying the equation (3) yields

$$\frac{dC}{dt} = \frac{Q}{V}(C_0 - pC) \qquad (4)$$

Integrating between the limits of 0 and C and 0 and t yields

$$\int_0^C \frac{dC}{(C_0 - pC)} = \frac{Q}{V}\int_0^t dt \qquad (5)$$

Solution of above yields

$$C = \frac{C_0}{p}\left[1 - \frac{e^{-\frac{Q}{V}t}}{p}\right]$$

$$C = \frac{C_0}{p}\left[1 - \frac{e^{-\frac{t}{t_0}}}{p}\right]$$

Where $t_0 = \frac{V}{Q}$ the theoretical detention time in the constructed wetland.

$$C = \frac{C_0}{p}\left[1 - \frac{e^{-\theta}}{p}\right] \qquad (6)$$

Where

$$\theta \frac{t}{t_0}$$

### *Correction factor for evaporation and evapotranspiration losses*

The losses from evaporation can be calculated using an empirical formula such as Meyer's formula. The losses from evapotranspiration can be calculated using formulae such as Penman's Equation making use of the climatological data.

Making use of the above mentioned equations the total water loss due to evaporation and evapotranspiration from a field can be calculated and hence the fraction of the discharge leaving the field can be calculated as '*p*'.

### *Mass balance equation for constructed wetland as a CFST reactor for BOD taking into account evaporation and evapotranspiration losses*

The equation (1) after applying the correction for losses due to evaporation and evapotranspiration may be written as

$$V\frac{dC}{dt} = QC_0 - pQC - K_TCV \qquad (7)$$

Where $p$ is the fraction of the discharge remaining after losses while passing through the system.

Denoting $\frac{dC}{dt}$ with C' and dividing both sides with V yields

$$C' = \frac{Q}{V}\left(C_0 - pC\right) - K_T C \qquad (8)$$

Rearranging the equation (8) yields

$$C' + C\left[K_T + \frac{pQ}{V}\right] = \frac{Q}{V} C_0 \qquad (9)$$

Multiplying both sides with $e^{\alpha t}$ where $\alpha = \left[K_T + \frac{pQ}{V}\right]$

$$e^{\alpha t}\left(C' + C\alpha\right) = \frac{Q}{V} C_0 e^{\alpha t} \qquad (10)$$

The left side of the equation can be written as a differential as follows

$$\left(Ce^{\alpha t}\right)' = \frac{Q}{V} C_0 e^{\alpha t} \qquad (11)$$

Removing the differential sign by integrating the expression yields

$$Ce^{\alpha t} = \frac{Q}{V} C_0 \int e^{\alpha t} dt \qquad (12)$$

Integrating the equation (12) yields

$$Ce^{\alpha t} = \frac{QC_0}{V\alpha} e^{\alpha t} + Z \qquad (13)$$

Dividing the equation (13) by $e^{\alpha t}$ yields

$$C = \frac{QC_0}{V\alpha} + Ze^{-\alpha t} \qquad (14)$$

When t = 0, C = $C_0$ hence

$$Z = C_0 - \frac{QC_0}{V\alpha}$$

Substituting the value of Z in equation (14) and simplifying yields

$$C = \frac{QC_0}{V\alpha}\left(1 - e^{-\alpha t}\right) + C_0 e^{-\alpha t} \qquad (15)$$

When $t \rightarrow \infty$ the equation (15) will become

$$C = \frac{QC_0}{V\alpha} = \frac{QC_0}{V\left[K_T + \frac{pQ}{V}\right]} \qquad (16)$$

Simplifying the equation (16) will yield

$$C = \frac{C_0}{p + K_T\left(\frac{V}{Q}\right)} \qquad (17)$$

Where $\frac{V}{Q} = t_0$ and $t_0$ is the theoretical detention time

$$\frac{C}{C_0} = \frac{1}{p + K_T\left[\frac{V}{Q}\right]} \qquad (18)$$

Using the equation (18) for any constructed wetland the effluent BOD can be predicted more accurately incorporating evaporation and evapotranspiration losses. The value of 'V' can be calculated from the following equation.

$Q \times DT = V$

Where *DT*- the actual detention time for the subsystem which can be determined in the field trough tracer studies; *Q* - the discharge entering the subsystem.

## Model Validation

Over the years a large number of studies have been carried out on the performance of natural systems treating wastewater, which in turn resulted in many mathematical models on the performance of wetlands. A few of the recent models are used here for comparative purpose.

The new model developed in this study is validated with actual data from the constructed wetland, Listowel in Canada reported in the USEPA design manual, *Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment* (USEPA 1988), and is compared with the simulated values using the other models. Table 1 gives the measured values for the summer.

***Table 1: Measured values of BOD for the constructed wetland, Listowel, Canada (summer)***

| Distance M | $C/C_0$ Actual |
|---|---|
| 0 | 0.52 |
| 67 | 0.36 |
| 134 | 0.41 |
| 200 | 0.30 |
| 267 | 0.27 |
| 334 | 0.17 |

### Plug flow model by EPA

The plug flow reactor (PFR) model by the EPA describes the BOD removal in the wetland by the following first order model.

$$\frac{C}{C_0} = Ae^{-\left[0.7K_T (A_v)^{1.75} + \frac{LWDN}{Q}\right]} \quad (25)$$

Where C - Effluent $BOD_5$ (mg/L); $C_0$ - Influent $BOD_5$ (mg/L); $A$ - Fraction of BOD not removed as settleable solids at the wetland headworks. (This factor is included to take care of the removal of BOD usually achieved in the pretreatment facilities such as oxidation ponds ahead of the constructed wetlands). From Table 1 it is evident that 48% of the BOD is removed in the pretreatment facilities.

$K_T$ - Temperature dependent first order BOD reaction rate constant ($d^{-1}$); $A_v$ - Specific surface area of the soil for microbial activity ($m^2/m^3$); L - Length (m); W - Width (m); D - Depth (m); N - Porosity of the soil; Q - Average flow rate ($m^3/d$)

The parameter values used for the computation of $C/C_0$ using the various models are given in Table 2.

### Model by Chen et al.

Chen et al. (1999) have proposed a new concept of transport detention time (TDT) to describe solute transport processes in constructed wetlands as CFSTRs in series. Their rigorous model solution by method of Laplace transform and transfer function provides an analytical solution for BOD removal that produces results that are closer to observed values from two treatment wetlands than results from the USEPA PFR model.

The dispersive and convective behavior of $BOD_5$ in a constructed wetland can be predicted with the developed model. When samples are taken at different locations along the wetland and if the longitudinal distances between these points are equal the following equation can be used to predict the outlet $BOD_5$.

$$C_1 = \frac{C_0}{1 + \tau K_T}\left(1 - e^{-[(1+\tau K_T)/\tau]t}\right) \quad (26)$$

Where $C_1$ - Effluent $BOD_5$ concentration of 1st subsystem; $C_0$ - Influent BOD; $K_T$ - BOD decay rate constant ($h^{-1}$); - Time (h); τ

**Table 2: Parameter values (Listowel, Canada wetland, summer) for models**

| Sl. No. | Parameter | Value | Remarks |
|---|---|---|---|
| 1 | $A$ | 0.52 | |
| 2 | $K_{20}$ | 0.0057 $d^{-1}$ | |
| 3 | $A_v$ | 15.7 $m^2/m^3$ | |
| 4 | N | 0.75 | |
| 5 | T | 17.8°C | |
| 6 | Q | 35 $m^3/d$ | |
| 7 | W | 4m | |
| 8 | D | 0.14m | |
| 9 | $D_s$ | 65.1 $m^2/h$ | |
| 10 | t (for the first cell) | 19.2384 h | $t = \frac{L \times W \times D \times N}{Q} = \frac{66.8 \times 4 \times 0.14 \times 0.75}{35} = 19.2384$ |
| 11 | $\tau$ (for the first cell) | 10.8 h | $\tau = \frac{2D_s}{v^2} = \frac{2 \times 65.1}{\left(\frac{66.8}{19.238}\right)^2} = 10.798$ |
| 12 | $K_T$ | 0.0167 $h^{-1}$ | For all models other than EPA model |
| | | | $K_T = K_{17.8} = K_{20}(1.1)^{(T-20)} A_v^{1.75} \times 0.7 = 0.0167$ |
| | | 0.0046 $d^{-1}$ | For the EPA model |

- TDT of the subsystem.

$$\tau = \frac{2D_s}{v^2}$$

Where $D_s$ – Dispersion coefficient ($m^2/h$); $v$ – Velocity of flow (m/h)

Equation (26) can be modified as follows

$$\frac{C}{C_0} = \frac{A}{(1 + \tau K_T)}\left[1 - e^{-\left(\frac{1}{\tau} + K_T\right)t}\right] \quad (27)$$

Where C - Effluent concentration of the cell; $C_0$ - Influent concentration of the cell; A - Fraction of the influent BOD not settled at the head works of the wetland.

The various parameters as reported by the USEPA design manual (USEPA 1988) for Listowel, Canada are given in Table 2.

### Model by Vogler and Scherfig

Vogler and Scherfig (2000) have proposed the following simplified model considering the wetland as made up of number of CFSTRs.

$$\frac{C_N}{C_i} = \frac{A}{(1 + K_T\tau)^n} \quad (28)$$

Where $C_N$ - BOD from the $n^{th}$ cell; $C_i$ - Influent BOD; A - Percentage of influent BOD not settled at the head works of the wetland; $K_T$ - BOD reaction rate constant; $\tau$ - Transport detention time; $n$ - Number of cells

### Proposed model

The equation (15) can be modified as follows to predict the $C/C_0$ values.

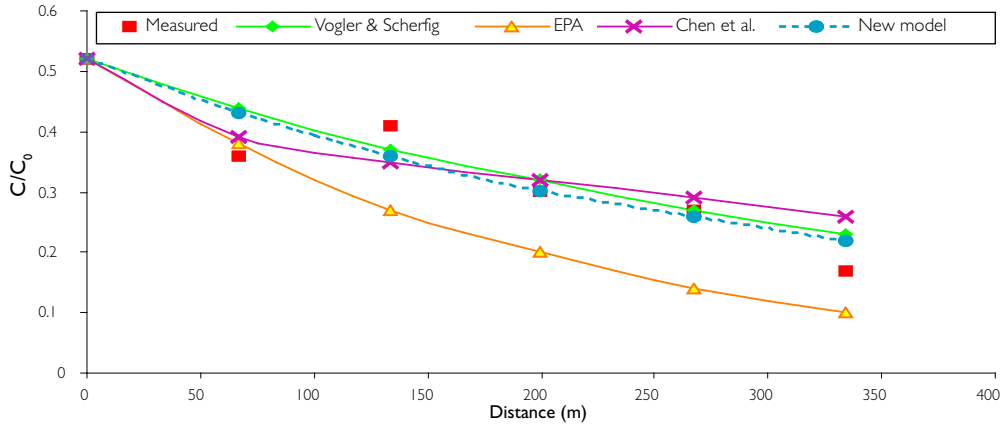
$$\frac{C}{C_0} = \frac{AQ}{V\alpha}(1 - e^{-\alpha t}) + e^{-\alpha t} \quad (29)$$

During the simulation using the new model, the effect of evapotranspiration is neglected and the equation is applied for individual units of constructed wetland with a length of 67m. Measured values of BOD and predicted values of BOD using various models are illustrated in Figure 4.

## Results and Discussion

Table 3 shows the predicted values of various models and their variations from the measured values. The predicted $c/c_0$ values using various cotemporary models against the measured values from the constructed wetland at Listowel is plotted in Figure 4. From the graph it is evident that the predictions using the plug flow model of EPA yields results far from reality, essentially due to the fact that ideal plug flow does not exist in most of the constructed wetlands due to pounding and cross flows. The models by Chen et al. and Vogler and Sherfig yield acceptable results, however, the rigorous mathematical work behind the Chen et al. model seems unnecessary when compared with the simple model by Vogler and Sherfig. The values from the proposed model are still

***Figure 4: Measured values of BOD and predicted values of BOD using various models for the constructed wetland, Listowel, Canada (summer)***



closer to the measured ones compared to other models. The accuracy of this model could be attributed to the concept that continuous flow stirred tank reactor best represents the field condition of constructed wetlands. In fact considering the unit as made up of a number of CFSTRs could further improve accuracy. As the decentralised natural systems are more energy efficient when compared to conventional sewage treatment plants, due to resource crunch many are forced to look at such options especially in developing countries and hence simplified models for natural systems are the need of the hour for promoting low cost waste treatment and resource recovery techniques. In this context, the proposed model could be of use for evaluating the potential of existing constructed wetlands for improving their efficiency and for the design of new systems. In the error analysis results there is no marked difference between the proposed model and the contemporary models; however, the graph in Figure 4 shows the clear trend that the proposed model more closely follows the actual phenomena.

## Conclusion

There are five main conclusions from the research. These are listed below:

- A mathematical model was developed to simulate the contaminant transport and decomposition through the constructed wetland by considering it as made up of a number of CFSTRs rather than the conventional plug flow pattern.
- Loss of water due to evaporation and evapotranspiration has been identified as a major cause of increase in concentration of dissolved solids in the effluent and hence corrections have been incorporated in the model to take care of the same for specific sites.
- The performance of any constructed wetland can be simulated for varying influent characteristics with the proposed model and hence this can be made use to optimise the performance of the existing systems as well as the design of new ones.
- The proposed model proves that the non-ideal plug flow pattern of flow in constructed wetlands can be best represented by a number of CFSTRs in series.
- The proposed model was validated against measured values of BOD for a constructed wetland at Listowel, Canada, and compared with the simulated results using other models. It has been found that the new model gives quite reliable results in spite of its simplicity.

***Table 3: Variation of predicted $C/C_0$ values from the measured $C/C_0$ values***

| Distance | Measured | EPA | Vogler & Scherfig | Chen et al. | New Model |
|---|---|---|---|---|---|
| 0 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 |
| 67 | 0.36 | 0.38 | 0.44 | 0.39 | 0.43 |
| 134 | 0.41 | 0.27 | 0.37 | 0.35 | 0.36 |
| 200 | 0.30 | 0.20 | 0.32 | 0.32 | 0.30 |
| 267 | 0.27 | 0.14 | 0.27 | 0.29 | 0.26 |
| 334 | 0.17 | 0.10 | 0.23 | 0.26 | 0.22 |
| $\sum_{i=1}^{N}\left[\left(\frac{C}{C_0}\right)-Measured\right]^2$ | | 0.050 | 0.012 | 0.014 | 0.010 |

## References

Asano, T.H., Schroeder, E.D. & Tchobanoglous, G. 1998, 'Estimating the safety of wastewater reclamation and reuse using enteric virus monitoring data', *Water Environment Research*, vol. 70, no. 1, pp. 39-51.

Chen, Shulin, Guang, Te Wang & Xue, S.K. 1999, 'Modelling BOD removal in constructed wetlands with mixing cell method', *Journal of Environmental Engineering*, vol. 125, no. 1, pp. 64-70.

Goulet, R. & Pick, R. 2001, 'Changes in dissolved and total Fe and Mn in a young constructed wetland: Implications for retention performance', *Ecological Engineering* vol. 17, pp. 373-84.

Ji, G., Sun, T., Zhou, Q., Sui, X., Chang, S. & Li, P. 2002, 'Constructed subsurface flow wetland for treating heavy oil-produced water of the Liaohe Oilfield in China', *Ecological Engineering* vol. 18, pp. 459-65.

Kadlec, R.H. & Knight, R.L. 1996, *Treatment Wetlands*, Lewis Publishers, Boca Raton, Florida.

Kivaisi, K. 2001, 'The potential for constructed wetlands for wastewater treatment and reuse in developing countries: A review', *Ecological Engineering* vol. 16, pp. 545-60.

Pant, H.K., Reddy, K.R. & Lemon, E. 2001, 'Phosphorus retention capacity of root bed media of sub-surface flow constructed wetlands', *Ecological Engineering* vol. 17, pp. 345-55.

Reed, S.C., Middlebrooks, E.J. & Crites, R.W. 1995, *Natural Terms for Waste Management and Treatment*, MacGraw-Hill, New York.

Scott, A., Zarazua, J. & Levine, Gilbert 2000, *Urban Wastewater Reuse for Crop Production in the Water-short Guanajuato River Basin, Mexico*, International Water Management Institute, Research Report 041, Colombo, Sri Lanka.

US Environmental Protection Agency (USEPA) 1988, *Design Manual: Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment*, Rep. No. EPA 625/1-88/022, US Environmental Protection Agency, Office for Environmental Research Information, Cincinnati, Ohio.

US Environmental Protection Agency (USEPA) 2000, *Manual: Constructed Wetlands Treatment of Municipal Wastewaters*, National Risk Management Research Laboratory Office of Research and Development US Environmental Protection Agency Cincinnati, Ohio.

Vogler, T. & Scherfig, S. 2000, 'Modelling BOD removal in constructed wetlands with mixing cell method', *Journal of Environmental Engineering*, vol. 125, no. 1, pp. 782-85.

Vymazal, J., Brix, H., Cooper, P.F., Green, M.B. & Haberl, R. 1998, *Constructed Wetlands for Wastewater Treatment in Europe*, Backhuys, Leiden, The Netherlands.

Vymazal, J. 2002, 'The use of sub-surface constructed wetlands for wastewater treatment in the Czech Republic: 10 years experience', *Ecological Engineering* vol. 18, pp. 633-46.

Correspondence to:
Benny Joseph
Centre for Water Resources
Anna University
Chennai - 600 025
INDIA
Email: bennyjosephk@gmail.com

Back to TOC

# Public Health Implications of Asbestos: Epidemiological Aspects

**Graeme Lawson and He Wang**

***Discipline of Public Health, University of Adelaide***

*Asbestos includes amosite, chrysotile, crocidolite, and the fibrous varieties of tremolite, actinolite and anthophylite. Different types of asbestos occur naturally in the environment and are mined from metamorphic rocks. Between 1945 and 1980 in Australia, it has been widely used in different industries, especially the construction industry. Fibro cement has been used in home building, insulation, fireproofing, pipes, ceiling tiles, and roofing material which contains mixtures of crocidolite, amosite and chrysotile. It was not until the mid-1970s that the wider public was alerted to the dangers of asbestos. The prohibition of all forms of asbestos use in Australia took effect at the end of 2003. Inhalation of asbestos fibres has no perceived irritant effects in the respiratory system in the early stage, and asbestos-related diseases develop insidiously. Diseases that are linked to asbestos exposure are asbestosis, mesothelioma, and lung cancer. Recent research has shown that as many as 25% of the deaths from the diseases associated with asbestos, are in people who have spent some of their working lives in the building and maintenance trades. This paper reviews occurrences and predictions of asbestos-related diseases in different countries in the world. It is scandalous that the dangers of asbestos exposure were known as early as 1900 and nothing was done in the ensuing period to protect workers by the companies involved or by governments. It is hard to think of an industrial product that has had such a worldwide adverse impact as asbestos. There is hardly a country that has not been impacted. Much attention should be paid to future development of asbestos-related deaths in the next 40-50 years.*

**Key words:** *Asbestos; Asbestosis; Lung Cancer; Mesothelioma; Respiratory Disease; Construction Industry*

Asbestos is the name given to a group of six different fibrous minerals, amosite, chrysotile, crocidolite, and the fibrous varieties of tremolite, actinolite and anthophylite that occur naturally in the environment and are mined from metamorphic rocks (Agency for Toxic Substances & Disease Registry [ATSDR] 2001). Between 1945 and 1980 in Australia, asbestos was widely used in the construction industry, as well as in shipyards, power stations, boiler making and plumbing (ATSDR 2001). Fibro contains mixtures of blue asbestos (crocidolite), brown asbestos (amosite) and white asbestos (chrysotile). Fibro cement was used in home building, insulation, fireproofing, pipes, ceiling tiles and roofing material. The link between asbestos and lung disease has probably been known since 1900, but despite warnings from health authorities, little was done to avoid exposure. It was probably not until the mid-1970s that the wider public was alerted to the dangers of asbestos. The prohibition of all forms of asbestos use in Australia took effect at the end of 2003 (Lavelle 2004).

It has been well known that inhalation of asbestos fibres has no perceived irritant effects in the respiratory system. Workers exposed even to high levels of asbestos dust are generally free of symptoms during and for many years after exposure. There is a marked individual variability in occurrence of asbestos-related diseases.

Asbestosis (an irreversible scarring of the lungs that causes a decrease in elasticity), mesothelioma, and lung cancer have been cited as diseases that are causally related to exposure to asbestos. The most common form

of mesothelioma is pleural mesothelioma. This is a condition where cancer affects the lungs and protective lining and cavity of the lungs. A rare form of mesothelioma is peritoneal mesothelioma, in which cancer affects the stomach and abdomen. Many of those now suffering from asbestos-related diseases were exposed to very high levels of asbestos in the more traditional industries such as shipbuilding, construction, and boiler making work. Recent research has shown that as many as 25% of the deaths from the diseases associated with asbestos, are in people who have spent some of their working lives in the building and maintenance trades. These people often worked without knowing that they have repeatedly been exposed to asbestos fibres when they disturb contaminated building materials (Health & Safety Executive [HSE] 2006). This is still a danger to home renovators who unknowingly disturb asbestos fibres.

The main sources of environmental, non-occupational exposure to asbestos fibres are in industrial plants in which asbestos was used in the production process, or asbestos in buildings or contaminated soil. The association of these exposures with increasing risk of mesothelioma has been documented since 1960 in many geographical regions. Sites with asbestos fibres in soils are characterised by low concentration levels of airborne fibres. The type of fibres found are mainly amphiboles, while both natural and industrial environmental asbestos or abestiform fibre exposures increase potential risk for mesothelioma (Pasetto et al. 2005).

Malignant mesothelioma (MM) is a cancer associated with exposure to asbestos. MM may be associated with low level asbestos exposure because there is no dose-response relationship between asbestos exposure and mesothelioma development. The estimated mean induction period is 25 years and can be as long as 60 or more years (Bertazzi 2005). In the USA, malignant mesothelioma incidence increased sharply from the 1970s, peaked in 2000-2004, then levelled off and is expected to return to background levels by 2055 (Bertazzi 2005). World production of asbestos has been declining markedly in recent years, however, increases have been occurring in India and Asia (Bertazzi 2005).

The British mesothelioma register contains all deaths from 1968 to 2001. Standardised mortality ratios (SMR) were calculated for local authorities, unitary authorities and counties by McElvenny et al. (2005). The annual number of mesothelioma deaths has increased from 153 in 1968 to 1848 in 2001. It was found that occupations with the highest proportionate mortality ratio (PMR) were metal plate workers (503), vehicle body builders (526), plumbers (413) and carpenters (388). It was also discovered that occupations associated with high exposures to asbestos in the past continue to drive the mesothelioma epidemic in Great Britain. However, the trends over time suggest a change in the balance of risk away from traditional asbestos exposure industries to industries where they could be described as secondary, such as plumbers, carpenters, and electricians (Mc Elvenny et al. 2005). Poisson regression analysis was used to model male mesothelioma deaths from 1968 to 2001 as a function of the rise and fall of asbestos exposures during the 20th century and can therefore be used to predict numbers of male deaths in 2002-2050 (Mc Elvenny et al. 2005). By using this analysis we predict that the number of deaths in Great Britain between 2011 and 2015 will be approximately 2150. Between 1968 and 2050, it was predicted that there will be approximately 90,000 deaths from mesothelioma in Britain, 65,000 of which will occur after the year 2001 (Hodgson et al. 2005).

Darnton et al. (2006) estimated the number of asbestos-related lung cancers among males by modelling relative lung cancer mortality among occupations in Britain by smoking status, mesothelioma mortality and occupation type. Proportional mortality ratios

for lung cancer and mesothelioma for 1980 to 2000 were calculated for occupational groups. Smoking indicators were derived from household surveys conducted during the 1980s and 1990s. Poisson regression analysis was used to estimate the number of asbestos-related lung cancer by estimating the number of lung cancer deaths in each occupation. The estimate of the number of asbestos-related lung cancers is between two thirds and one death for every mesothelioma death, equivalent to between 11,500 and 16,500 deaths during the years 1980-2000. The authors suggest asbestos-related lung cancer accounted for 2-3% of all lung cancer deaths among males in Britain over this period.

Several cases of malignant mesothelioma were recognised in the Province of Bresicia (Italy) after a surveillance program carried out during the years 1980-1999 (Barbieri et al. 2001). In this study, a large proportion of the cases involved workers occupationally exposed to asbestos. The annual incidence ratio based on the Italian population census of 1981, was calculated for the years 1980-1999 and showed an increasing trend for location of cancer in the pleura. In the 1996-1999 period the incidence ratio was 2.95 for males and 1.35 for females. Although, in Italy malignant mesothelioma was included in the list of compensable occupational diseases by law since 1994, a large number of cases are still not recognised by their National Insurance Institute.

In another study conducted by Gennaro and co-workers (2005), it was found that between 1996 and 2002, 945 pleural malignant mesothelioma cases due to asbestos exposure (757 males and 188 females), were recorded in the Ligura Region (Italy), corresponding to an age standardised (using the European population as standard in the same period) incidence rate of 8.51 per 100,000 for males and 1.43 per 100,000 for females. Higher incidence rates were reported in the provinces with larger industrial and harbour areas, including shipyards, dockyards, building activities, chemical and heavy industrial activities. Asbestos exposure was unlikely for 57.3% females and 15% males. Therefore, a major role of environmental asbestos exposure in the aetiology of pleural malignant mesothelioma is hypothesised by the authors for females and for a minor proportion of males.

A cohort of 889 men and 1077 women employed for at least one month between 1946 and 1984 by a former Italian asbestos textile company, characterised by extremely heavy exposures often for short durations, was followed up until 1996, for a total of 53,000 person-years (Pira et al. 2005). It was observed that 222 cancer deaths had occurred compared with 116.4 expected (Standardised Mortality Ratio, SMR = 191). The highest ratios were found for pleural (SMR= 4105), peritoneal (SMR= 1817) and lung (SMR= 282) cancers. It was observed that there was a direct relationship with duration of employment for lung and peritoneal cancer, and with time since first employed, for lung cancer and mesothelioma. The authors suggest that this confirms the central role of latency in pleural mesothelioma and of cumulative exposure in lung cancer (Pira et al. 2005)

A recent study by Luberto and co-authors (2004) looked at a cohort of 3358 workers employed in 10 asbestos cement production plants in the Italian region Emilia-Romagna. The cohort included 2712 males and 646 females. Overall mortality was significantly increased (SMR= 131). Excess mortality was observed for all malignant neoplasms (SMR= 131), and for respiratory diseases (SMR=153), with three deaths due to asbestosis. Mortality for all respiratory tract neoplasms (SMR=179), pulmonary cancer (SMR=157), and pleural cancer (SMR=1922) were significantly increased.

For many decades and until recently, asbestos was commonly found in most sectors of South African industry. Kgalamono and co-workers (2005) showed that 141 cases of

asbestosis were identified from patient records for the years 1980-2000. In this study, only one patient was exposed in an industry where asbestos was incidental to the main operation of the company, while 54% of cases were due to exposure in primary asbestos industries. The mean reported duration of exposure was found to be 17.5 years. Mesothelioma, a malignant disease caused by asbestos exposure, in Cairo (Egypt) appears to be mainly attributed to environmental origin with a high incidence of women and young adults affected (Gaafar et al. 2005). Since it is well known that low level exposure of asbestos can cause mesothelioma before asbestosis formation, it is likely that the incidence of mesothelioma appears to be on the increase in Egypt according to the authors.

Studies have indicated a possible elevation of cancer risk in population groups exposed to drinking water contaminated with asbestos from natural sources or water from pipes made of asbestos cement (Browne et al. 2005). The authors claimed that in 1985, asbestos contamination was discovered in the public water supply of the town of Woodstock, New York. Contamination was due to asbestos-cement pipes installed during the 1950s. The New York State Department of Health established the Woodstock Asbestos Exposure Registry (WAER) in 1986 to monitor rates of cancer among individuals who drank the water between 1960 and 1985. A follow-up study for the years 1980-1998 was consistent with the expected lag of 20-30 years for the development of asbestos-related cancers. No cases of mesothelioma were observed among WAER participants. The general pattern did not demonstrate a link between exposure to asbestos in the drinking water and cancer occurrence.

A cohort of 726 lighthouse keepers in Norway, first employed between 1917 and 1967 (some of whom were exposed to asbestos in drinking water) were followed-up for cancer incidence from 1960 to 2002. Risk of stomach cancer was elevated in the whole cohort, the standardised incidence ratio (SIR) was 1.6, in the subgroup with definite asbestos exposure (SIR=2.5) and when the group was followed for 20 years or more after first possible exposure (SIR=1.7). It was suggested that there may be an association between ingested asbestos and gastrointestinal cancer, in particular stomach cancer (Kjaerheim et al. 2005). In Poland, an east European country, an increased risk of asbestos-related cancer was also shown (Wilezynska 2005).

A retrospective cohort and follow-up study covering 15 years (1987-2001) was carried out in a small town in Yunnan Province (China) to investigate the risk of developing malignant neoplasm in a cohort with a history of environmental exposure to crocidolite asbestos (Luo et al. 2005). The authors suggest the risk of developing mesothelioma is significantly increased in a population with environmental exposure to crocidolite.

Former workers and residents of Wittenoom (Australia's only source of asbestos), with known amounts of asbestos exposure, x-ray and smoking information, who participated in a cancer prevention program were investigated to determine if the presence of asbestosis is a prerequisite for lung cancer (Reid et al. 2005). The authors suggest that in their cohort, asbestosis is not necessarily a precursor for asbestos-related cancer.

Bang et al. (2006) looked at demographic, geographic and occupational distribution of mesothelioma mortality in the USA for the years 1999 to 2001. Data were obtained from the National Centre for Health Statistics. Mortality rates (per million per year) were age-adjusted to the 2000 US standard population, and proportionate mortality ratios (PMRs) were calculated. It was found that the overall age-adjusted mortality rate was 11.52, with males (22.34) showing a 6-fold higher rate than females (3.94). Geographic distribution of mesothelioma mortality was found to be mainly limited to coastal areas, probably due to the higher concentration of heavy industry in these areas. Occupations with significantly

elevated PMRs included plumbers and mechanical engineers. Industries with significantly elevated PMRs included ship and boat building and their maintenance.

In Japan, the consumption of asbestos, which was equal to the amount of asbestos imported due to negligible mining capacity, was minimal before World War II. It increased dramatically during the post-war period, reaching a peak level of 350,000 tons per year in the mid-1970s. Since then it has fluctuated around 250,000 tons per year until 1990, at which time a rapid decrease began. In 2003, the Japanese government began amending the related laws and regulations to prohibit all asbestos use. The statistics available since 1995 show a growing number of mesothelioma deaths. Analyses predict there would be about 100,000 deaths in Japan due to pleural mesothelioma in the next 40 years (Murayama et al. 2006).

Some studies suggest that asbestos is a causative factor for the development of obstructive lung disease. Smoking is a well recognised risk factor of obstructive pulmonary disease and is a major confounder in pulmonary function studies of asbestos exposed workers, given the fact that a great number of asbestos workers also smoke, for example as many as 70% of male asbestos workers in China are smokers. Contrary to other studies that indicate there is a synergistic relationship between smoking and asbestos exposure, recent studies suggest that asbestos and smoking might play an independent part in causing respiratory physiological changes, in which asbestos causes a mainly restrictive impairment and smoking is a major factor responsible for airway obstruction in asbestos workers (Wang et al. 2006).

The risk of mesothelioma in the United States from inhalation of asbestos fibres remains high despite the fact that the use of asbestos has nearly ceased (Miller 2005). This might be attributable to the long latency period and the potential for this disease to be induced by relatively low levels of exposure. A study in California shows a dose-dependent association of asbestos exposure with mesothelioma risk (Pan et al. 2005).

As indicated in the studies reviewed above, it is clear that asbestos exposure has had a worldwide adverse impact on population health. There is hardly a country that has not been impacted. Even countries where there is no naturally occurring asbestos, have imported it to their detriment. Although asbestos products have been banned legally in developed countries, asbestos exposure might not be eliminated completely. The buildings built before the ban still exist and asbestos might become airborne if disturbed. Therefore, asbestos exposure will remain an important public health issue in both developing and developed countries in the foreseeable future.

## References

Agency for Toxic Substances & Disease Registry (ATSDR) 2001. *'ToxFAQs for Asbestos,'* Agency for Toxic Substances & Disease Registry, <http://www.atsdr.cdc.gov/tfacts61.html> 30 June 2006.

Bang, K.M., Pinheiro, G.A., Wood, J.M. & Syamlal, G. 2006, 'Malignant mesothelioma mortality in the United States, 1999-2001,' *International Journal of Occupational & Environmental Health*, vol. 12, pp. 9-15.

Barbieri, P.G., Lombardi, S., Candela, A., Pezzotti, C. & Binda, I. 2001, 'Incidence of malignant mesothelioma (1950-1999) and asbestos exposure in 190 cases diagnosed among residents of the province of Brescia,' *La Medicina Del Lavoro*, vol. 92, pp. 249-62.

Bertazzi, P.A. 2005. 'Descriptive epidemiology of malignant mesothelioma,' *La Medicinia Del Lavoro*, vol. 96, pp. 287-303.

Browne, M.L., Vararajulu, D., Lewis-Michl, E.L. & Fitzgerald, E.F. 2005, 'Cancer incidence and asbestos in drinking water, Town of Woodstock, New York, 1980-1998,' *Environmental Research*, vol.98, pp. 224-32.

Darnton, A.J., McElvenny, D.M. & Hodgson, J.T. 2006. 'Estimating the number of asbestos-related lung cancer deaths in Great Britain from 1980 to 2000,' *The Annals of Occupational Hygiene*,' vol. 50, pp. 29-38.

Dave, S.K. & Beckett, W.S. 2005, 'Occupational asbestos exposure and predictable asbestos-related diseases in India,' *American Journal of Industrial Medicine*,Vol. 48, pp. 137-43.

Gaafar, R.M. & Eldin, N.H. 2005. 'Epidemic of mesothelioma in Egypt,' *Lung Cancer*, vol. 49, pp. S 17-20.

Gennaro, V., Ugolini, D., Viarengo, P., Benfatto, L., Bianchelli, M., Lazzarotto, A. et al. 2005, 'Incidence of pleural mesothelioma in Liguria Region, Italy (1996-2002),' *European Journal of Cancer*, vol. 41, pp. 2709-14.

Health & Safety Executive (HSE) 2006, 'Asbestos related disease,' *Health & Safety Executive*, <hhtp://www.hse.gov.uk/asbestos/disease.htm> 30 June 2006.

Hodgson, J.T., McElvenny, D.M., Darton, A.J., Price, M.J. & Peto, J. 2005, 'The expected burden of mesothelioma mortality in Great Britain from 2002 to2050,' *British Journal of Cancer*, vol. 92, pp. 587-93.

Kgalamono, S.M., Rees, D., Kierkowski, D. & Solomon, A. 2005, 'Asbestos in the non-mining industry on the Witwaterstrand, South Africa,' *South African Medical Journal*, vol. 95, pp. 47-51.

Kjaerheim, K., Ulvestad, B., Martinsen, J.I. & Andersen, A. 2005, 'Cancer of the gastrointestinal tract and exposure to asbestos in drinking water among lighthouse keepers (Norway),' *Cancer Causes & Control*, vol. 16, pp. 593-8.

Lavelle, P. 2004. 'Asbestos fact file,' *Health Matters Library* A-Z, ABC, <http://www.abc.net.au/health/library/asbestos_ff.htm> 30 June 2006.

Luberto, F., Amendola, P., Belli, S., Bruno, C., Candela, S., Grignoli, M. & Comba, P. 2004, 'Mortality study of asbestos cement workers in Emilia-Romagna,' *Epidemiologia & Prevenzione*, vol. 28, pp. 239-46.

Luo, S.Q., Mu, S.H., Wang, J.T., Zhang, Y., Wen, Q.B., & Cai, S.P. 2005, ' A study on risk of malignant neoplasm and environmental exposure to crocidolite,' *Journal of Sichuan University, China*, vol. 36, pp. 105-7.

McElvenny, D.M., Darton, A.J., Price, M.J. & Hodgson, J.T. 2005, 'Mesotheliomamortality in Great Britain from 1968 to 2001,' *Occupational Medicine*, vol. 55, pp. 79-87.

Miller, A. 2005, 'Mesothelioma in household members of asbestos-exposed workers: 32 United States cases since 1990,' *American Journal of Industrial Medicine*, vol. 47, pp. 458-62.

Murayama, T., Takahashi, K., Natori, Y. & Kurumatani, N. 2006, 'Estimation of future mortality from pleural malignant mesothelioma in Japan based on anage-cohort model,' *American Journal of Industrial Medicine*, vol. 49, pp. 1-7.

Pan, X.L., Day, H.W., Wang, W., Beckett, L.A., & Schenker, M.B. 2005, 'Residential proximity to naturally occurring asbestos and mesothelioma risk in California,' *American Journal of Respiratory & Critical Care Medicine*, vol. 172, pp. 1019-25.

Pasetto, R., Comba, P. & Marconi, A. 2005, 'Mesothelioma associated with environmental exposures,' *La Medicina Del Lavoro*, vol. 96, pp. 330-7.

Pira, E., Pelucchi, C., Buffoni, L., Palmas, A., Turbiglio, M., Negri, E., Piolatto, P.G.& La Vecchia, C. 2005, 'Cancer mortality in a cohort of asbestos textile workers,' *British Journal of Cancer*, vol. 92, pp. 580-6.

Reid, A., de Klerk, N., Ambrosini, G., Olsen, N., Pang, S.C. & Musk, A.W. 2005, 'The additional risk of malignant mesothelioma in former workers and residents of Wittenoom with benign pleural disease or asbestosis,' *Occupational & Environmental Medicine*, vol. 62, pp. 665-9.

Wang, X., Yano, E., Wang, Z., Wang, M., & Christiani, D.C. 2006, 'Adverse effectsof asbestos exposure and smoking on lung function,' *American Journal of Industrial Medicine*, vol. 49, pp. 337-42.

Wilczynska, U., Szymczak, W., & Szeyzenia-Debrowska, N. 2005, 'Mortality from malignant neoplasms among workers of an asbestos processing plant in Poland: results of prolonged observation,' *International Journal of Occupational Medicine & Environmental Health*, vol. 18, pp. 313-26.

Correspondence to:
He Wang
Discipline of Public Health
University of Adelaide
Level 9, Tower Building
10 Pulteney Street
Adelaide, 5005
AUSTRALIA
Email: hwang2@tulane.edu

Back to TOC

# Harmful Effects of Asbestos: Mechanisms of Toxicity

**Graeme Lawson and He Wang**

***Discipline of Public Health, University of Adelaide***

*Asbestos exposure has been implicated in causing asbestosis, and lung cancers. Asbestos is particularly toxic to mesothelial cells, the progenitor of the asbestos-induced tumour mesothelioma, but the mechanisms involved are not well understood. A variety of physiochemical properties govern fibre toxicity including size and shape, surface chemistry, solubility, bio-persistence and chemical composition. A number of mechanisms have been put forward as a mechanism of asbestos toxicity. These include cell DNA damage, reactive oxygen species, oxidative damage, apoptosis, the role of iron, and the induction of nitric oxide. Each of these mechanisms is briefly discussed.*

**Key words:** *Asbestosis;Toxicity; Mechanisms*

Asbestos exposure has been implicated in causing asbestosis, pleural diseases and mesothelioma, but the mechanisms involved are not well understood. Asbestos is internalised by alveolar epithelial cells (AEC) soon after exposure resulting in cellular injury, increased permeability and proliferative response (Panduri et al. 2003). Asbestos is particularly toxic to mesothelial cells, the progenitor of the asbestos-induced tumor mesothelioma. In in vitro studies with mesothelial cells, asbestos leads to inhibition of growth, disruption of mitosis, induction of DNA and chromosomal damage and disruption of the cell membrane consistent with necrotic cell death or apoptosis. Asbestos has been shown to have a myriad of effects in cultured cells, including mesothelial cells, such as induction of gene expression, production of growth factors and cytokines, induction of damage to chromosomes and DNA (Broaddus et al. 1996).

## Cell DNA Breakage

Dopp and Schiffmann (1998) have investigated mitotic disturbances caused by amosite, crocidolite and chrysotile in Syrian hamster embryo (SHE) fibroblasts and analysed micronucleus formation as a result of mitotic disturbances. It was found that all three fibre types induced micronuclei in SHE cells with a high frequency (up to 200 MN/2000 cells, dose 0.1-5.0 $\mu g/cm^2$) in a dose-dependent manner with a maximum between 48 and 66 hours. Kinetochore staining revealed that 48% of fibre-induced micronuclei reacted positively. The results show that asbestos fibres may cause both loss as well as breakage of chromosomes in the absence of direct interaction with spindle fibres.

Ollikainen et al. (1999) exposed transformed human pleural mesothelial cells to 1-4 $\mu g/cm^2$ crocidolite and up to 10-100 ng/ml tumor necrosis factor alpha (TNF-$\alpha$) for up to 48 hours and studied the induction of DNA damage using the Comet assay. DNA single strand breaks were assessed as the mean tail moments and as distributions of the tail DNA in the cell. The Comet assay showed significant but reversible increases in the mean tail moments, but not in the distribution of comet tails in the histograms in cells exposed to 1 $\mu g/cm^2$ crocidolite for six hours. At higher concentrations of asbestos fibres all the indices in the Comet assay showed significant and irreversible change. The mean tail moments were highest in the cells with concurrent treatment to TNF-$\alpha$ and crocidolite. The study showed that asbestos fibres cause DNA single strand breaks in human mesothelial cells.

Co-exposure to asbestos and cigarette smoke caused increased risks of lung cancer in asbestos workers. A study (Jung et al. 2000) exposed rats to amosite asbestos, cigarette smoke and the two substances in combination for 1, 2 and 14 days. Numbers of cells showing DNA strand breaks in comparison to control rats were then evaluated in lungs using the TUNEL assay (an assay that detects DNA fragmentation that results from apoptotic signalling cascades) and transmission electron microscopy (TEM). Increases in TUNEL-positive, necrotic epithelial cells occurred after exposure to asbestos alone and in an additive manner after smoke and asbestos in combination. The authors suggest that these results show that DNA strand breakage and necrosis might be important mechanisms of injury by asbestos fibres and cigarette smoke in vivo, to epithelial cells of the respiratory tract.

Asbestos has been shown to induce cell cycle arrest, DNA repair and some abnormalities consistent with DNA damage but not DNA breakage. Levresse et al. (2000) investigated DNA breakage in asbestos-exposed rat pleural mesothelial cells (RPMC). These cells were compared with their transformed counterparts, RPMC-TSV40) (that is p53-inactivated by infection with a retroviral recombinant encoding the Simian virus (SV) to large T antigen) as in these cells, the cell cycle does not arrest and DNA repair is deficient due to ineffective p53-dependent cell cycle control (p53 protein activity stops cell division). RPMC and RPMC-TSV40 were exposed to chrysotile and crocidolite asbestos. The presence of DNA breakage was determined using the Comet assay. It was found that comets were generated by both types of asbestos in RPMC and RPMC-TSV40. Chrysotile induced more abnormalities than did crocidolite. When exposed to chrysotile at similar concentrations, RPMC showed more abnormal comet properties than did RPMC-TSV40. The authors suggest that asbestos causes DNA breakage and that some DNA breakage measured was due to repair mechanisms in the normal RPMC.

Puhakka et al. (2002) investigated the role of glutathione and nitric oxide synthase (NOS) in fibre-induced cells and DNA toxicity using the Comet assay. Two types of cell, transformed cultured human mesothelial (MeT-5A) cells and alveolar epithelial cells (A549) were exposed to crocidolite asbestos fibres (1-10 $\mu g/cm^2$) in the presence of buthionine sultoximine (BSO) or L-arginine-methyl ester (LAME). BSO is an inhibitor $\gamma$-glutamylcysteine synthetase ($\gamma$-GCS) and causes glutathione depletion, whereas LAME is an inhibitor nitric oxide synthase. The results showed that asbestos fibres caused DNA single strand breaks, and the process was significantly enhanced by BSO. A549 cells had a 3.5 fold glutathione content compared to MeT-5A cells, which was consistent with the higher resistance of these cells against oxidants and fibres. Flow cytometry of iNOS showed no change of iNOS by the fibres in either cell type. The authors suggest that glutathione may play an essential role in protecting intact cells against fibre-induced oxidative DNA alterations, and low $\gamma$-GCS reactivity in pleural mesothelium might be associated with the high sensitivity of mesothelial cells to fibre-induced toxicity.

## Role of Reactive Oxygen Species (ROS)

The mechanisms by which fibres induce fibrosis and cancers are largely unknown, but are thought to be modulated by reactive oxygen species (ROS) and altered growth factor pathways. A variety of physiochemical properties govern fibre toxicity and carcinogenicity, including: size and shape, surface chemistry, solubility and biopersistence, and chemical composition (Everitt 1994). ROS are formed indirectly through macrophage and inflammatory cell stimulation and directly on the alveolar surfaces through Fenton reactions catalysed by the iron content of asbestos. ROS have been demonstrated to contribute to asbestos-

induced alveolar cell injury and carcinogenesis through generation of DNA strand breaks, lipid peroxidation and apoptosis (Pociask et al. 2004). Schins (2002) has shown that ROS such as superoxide anions ($O_2^-$) and hydrogen peroxide ($H_2O_2$) originate not only from redox reactions catalysed on the fibre surfaces but also from the incomplete phagocytosis of fibres in various cells. This is an indication that biologically ROS, in particular, hydroxyl radicals (OH) act directly or indirectly can damage neighbouring biomolecules such as DNA. ROS are believed to play a major role in primary genotoxicity of particles, which may derive from their surface properties, the presence of transition metals, intracellular iron mobilisation and lipid peroxidation.

To evaluate the contribution of ROS to the mutagenicity of asbestos, Xu et al. (2002) examined their generation, particularly hydrogen peroxide ($H_2O_2$) and compared the types of mutants induced by crocidolite fibres, with those generated by $H_2O_2$ in human hamster hybrid ($A_1$) cells. It was found that asbestos induces a dose-dependent increase in the level of ROS among fibre-treated AI cells, which is suppressed by concurrent treatment with dimethyl sulfoxide. There was a dose-dependent induction of $H_2O_2$ in crocidolite-treated $A_1$ cells. The amount of $H_2O_2$ induced by asbestos reached a plateau at a dose of 6 μg/cm$^2$. Mutation spectrum analysis showed that types of $CD_{59}$ mutants induced by crocidolite fibres were similar to those induced by equal doses of $H_2O_2$. The authors suggest that these results provide direct evidence that the mutagenicity of asbestos is mediated by ROS in mammalian cells.

Kopnin et al. (2004) suggested that resistance of fibroblasts to asbestos-induced carcinogenesis is likely to be connected with their lower ability to generate reactive oxygen species in response to asbestos exposure and stricter control of proliferation of cells bearing asbestos ROS-induced injuries. They found chrysotile ($Mg_6Si_4O_{10}(OH)_8$) asbestos exposure (5-10μg/cm$^2$) increased intracellular ROS and 8-OHdG content in rat pleural mesothelial cells, but not in lung fibroblasts. Moderate dosages of chrysotile and other agents increasing ROS levels, $H_2O_2$, and ethyl-methanesulfonate (EMS) inhibit cell cycle progression in fibroblasts, but not in mesothelial cells. The arrested fibroblasts underwent apoptosis, while the majority of chrysotile-treated mesothelial cells survived. Chrysotile, $H_2O_2$, and EMS caused p53 up-regulation in both cell types. The authors suggest there is a differential response of fibroblasts and mesothelial cells specifically to asbestos/ROS exposure rather than to all DNA damaging insults.

The mitochondrial respiratory chain is an important source of ROS and RNS (reactive nitrogen species) in cells and therefore Bergamini et al. (2004) investigated the effects of aqueous extracts of asbestos fibres on some mitochondrial activities. Their data showed that crocidolite fibres released substances in solution that might interfere directly with the mitochondrial cytochrome oxidase complex. Calcium ions released from these fibres induced opening of the permeability transition pore of the inner-membrane leading to a possible cytotoxic effect due to the release of apoptotic factors normally located in the mitochondrial inner-membrane space. Crocidolite extracts were found to enhance the mitochondrial production of ROS.

## The Role of Iron

Iron associated with asbestos is thought to play a role in the pathogenic effects of fibres. Removal of iron from asbestos by desferrioxamine B or phytic acid inhibited asbestos-induced decreases in epidermal growth factor receptor (EGFR) phosphorylation. The effects of crocidolite, amosite and chrysotile on EGFR phosphorylation status appeared to be directly related to the amount of iron mobilised from these fibres (Baldys & Aust 2005).

Kamp et al. (1995) tested the hypothesis that asbestos-induced alveolar epithelial cell (AEC) injury in vitro is due to iron-catalysed free radical generation which in turn caused DNA strand breaks. It was found that amosite damages cultured human pulmonary epithelial-like (WI-26) cells and that an iron chelator (phytic acid) ameliorated these effects. A role for iron causing these effects was supported by the observation that ferric chloride-treated phytic acid did not diminish WI-26 cell injury. Production of hydroxyl-like species (.OH) was assessed based on the .OH-dependent formation of formaldehyde (HCHO) in the presence of dimethyl sulfoxide. It was found that asbestos induced dose-dependent DNA strand breaks in WI-26, A549 and rat alveolar type II cells. Phytic acid ameliorated DNA damage in all three cultured AEC. The authors suggest that these results provide support for the hypothesis that iron-catalysed free radicals mediated asbestos-induced pulmonary toxicity.

Wang et al. (2006) tested the hypothesis that the cellular responses to asbestos induces the transport and sequestration of iron through generation of superoxide for ferrireduction and up-regulation of divalent metal transfer-1 (DMT1) for intracellular transport of $Fe^{++}$ and increased production of cellular ferritin where the metal is stored in a catalytically less reactive state. BEAS2B cells with normal and elevated levels of Cu, Zn superoxide dismutase (SOD) expression were used. After exposure of these cells to asbestos, a significant increase in SOD generation with ferrireductive capacity was found. The exposure also increased DMT1 protein and mRNA expression in the cultured BEAS2B cells. The authors suggest that the response of respiratory epithelial cells to asbestos includes oxidant-mediated mechanisms to sequester catalytically active iron associated with the fibre.

Hardy and Aust (1995) completed an experiment with crocidolite and crocidolite pre-treated with desferrioxamine-B (DF crocidolite), with various amounts of bound iron. The pre-treated asbestos fibres were assayed for their abilities to catalyse the formation of DNA single-strand breaks (SSB) in φX 174RFI (markers that facilitate the accurate size determination of double stranded DNA fragments) DNA. The results indicated that native crocidolite with additional bound iron did not significantly change its ability to cause DNA strand breaks in 15 or 30 min. incubations. However, DF crocidolite after the addition of iron had a significantly increased ability to form DNA SSB. It appears that crocidolite might be capable of binding iron from intracellular sources and this additional iron may be as reactive as the intrinsic iron and may increase the reactive lifetime of the fibre.

## Induction of Nitric Oxide Synthase (NOS)

Conflicting evidence exists as to whether nitric oxide (NO) expresses damage/inflammatory or antioxidant/anti-inflammatory properties. Data indicate that in vitro or in vivo exposure to selected environmental or occupational substances such as asbestos, can result in up-regulation of inducible nitric oxide synthase (iNOS) by alveolar macrophages and pulmonary epithelial cells. However, the majority of studies suggest that nitric oxide plays a damaging role in pulmonary injury resulting from exposure to asbestos (Zeidler & Castranova 2004).

Reactive oxygen and nitrogen species have been implicated in the pathogenesis of asbestos fibres-associated pulmonary diseases. By comparing the responses of inducible nitric oxide synthase (iNOS) knockout and wild-type mice, Dorger et al. (2002) examined the consequences of iNOS expression for the development of the inflammatory response and tissue injury on intratracheal instillation of asbestos fibres. Exposure to asbestos fibres resulted in an increased iNOS mRNA and protein expression in the lungs from wild-

type mice. In contrast, iNOS knockout mice showed a pulmonary expression and production of TNF-α as well as a higher influx of neutrophils into the alveolar space than wild-type mice. iNOs knockout animals showed an attenuated oxidant related tissue injury. The authors suggest that the results show that iNOS-derived NO exerts a dichotomous role in acute asbestos-induced lung injury in that iNOS deficiency resulted in an increased inflammatory response but improved oxidant-promoted lung tissue damage.

Nitric oxide radicals (.NO) and peroxynitrite anion ($NO_2^-$) have been implicated in lung inflammation and may be important in pleural injury. A study determined the effects of asbestos and cytokine stimulation on NO and $NO_2$ production by rat pleural mesothelial cells.

> *Rat parietal pleural mesothelial cells were cultured for 2 to 72 hours with or without 50 ng/ml of recombinant interleukin-1β in the presence (1.05-8.4 μg/cm²) or absence of crocidolite or chrysotile asbestos fibres. Mesothelial cell mRNA expression of the inducible form of .NO synthase (iNOS), increased progressively from 2 to 12 hr in IL-1β containing cultures. Nitrite ($NO_2^-$), the stable oxidation product of .NO in mesothelial cell medium was assayed. Both types of asbestos fibres up-regulated the formation of $NO_2^-$ in mesothelial cells co-stimulated with IL-1β in a concentration dependent and time dependent manner. Both types of asbestos also were found to induce iNOS protein expression and the formation of nitrotyrosine and greatly induced the formation of nitrate ($NO_3^-$), a maker of $NO_2^-$ formation, in IL-1β stimulated cells. The authors suggest these findings may have significance for the induction of pleural injury by asbestos fibres* (Choe et al. 1998, p. 226).

To evaluate the contribution of reactive nitrogen species to inflammation by asbestos, Fischer rats were exposed to crocidolite or chrysotile asbestos by Quinlan et al. (1998) to determine whether increases occurred in nitric oxide (NO) metabolites from alveolar macrophages (AMs). The authors did the following experiments.

> *AMs from animals inhaling asbestos showed significant elevations in nitrite/nitrate levels which were ameliorated by NG-monomethyl-1-arginine, an inhibitor of inducible nitric oxide synthase (iNOS). Patterns of NO generation from AMs correlated with neutrophil influx in bronchoalveolar lavage samples after asbestos exposure. To determine the molecular mechanism and specificity of iNOS promoter activation by asbestos; RAW 264.7 cells, a murine macrophage-like cell line, and AMs isolated from control rats were exposed to crocidolite asbestos in vitro. These cells showed increases in steady-state levels of iNOS mRNA in response to asbestos and more dramatic increases in both iNOS m RNA and immunoreactive protein after addition of lipopolysaccharide. The authors suggest that these studies show that NO generation may be important in cell injury and inflammation by asbestos* (Quinlan et al. 1998, p. 778).

## 8-OHdG: a Marker of Oxidative DNA Damage

Oxidative DNA damage was measured in an asbestos-exposed human mesothelial cell line (METSA) by assaying oxidative guanine bases [8-oxo-2-deoxyguanosine (oxo8dG), 8-oxoguanine (oxo8G), and 8-oxoguanosine (oxo8Gua)] excreted into culture medium after DNA repair. At growth inhibiting, but not cytolytic concentration, asbestos caused significant elevation of all bases in the medium over a 48 hour period. Results showed that oxidative RNA and DNA bases are produced in response to asbestos in the cell line used (Chen et al. 1996).

The mutagenicity of crocidolite was investigated in vivo in *lacI* transgenic rats. Test substances were applied so that the fibres could come directly into contact with the mesothelial cell layer of the abdomen. Mutagenicity induced in this system was investigated on the molecular level to analyse the spectrum of mutations induced by crocidolite asbestos. The role of the pre-mutagenic DNA adduct 8-OHdG in this mutagenic process was investigated by measurement of this substance in the genomic DNA of Wistar rats treated with crocidolite. Mutation frequencies in the *lacI* gene were determined in DNA from the abdomen of

*lacI* transgenic rats 4, 12, and 24 wks, after doses of 2 or 5 mg of crocidolite asbestos. In the crocidolite-treated animals, a significant increase in mutation frequency occurred 12 weeks after treatment in the highest dosage group. The most prominent mutation type induced was G to T transversion. This type of mutation is the main descendant of the pre-mutagenic DNA adduct 8-OHdG (Schurkes et al. 2004; Unfried, Schurkes & Abel 2002).

## Role of Apoptosis

Apoptosis is a highly regulated physiological cell death process that is critical for development, defence and the prevention of malignant transformation and inflammation throughout the body, including the lungs. The two major mechanisms regulating apoptosis include the intrinsic pathway mediated by the mitochondria, and the extrinsic pathway induced by death-signalling ligands such as tumor necrosis factor alpha (TNF-$\alpha$) and subsequent caspase-8 activation. Apoptotic stimuli are modulated by the Bcl family of antiapoptotic proteins that prevent apoptosis by inhibiting the change in membrane potential ($\Delta\psi_m$) and subsequent release of mitochomdrial cytochrome c into the cytoplasm (Panduri et al. 2003). Broaddus et al. (1996) investigated whether asbestos induced apoptosis in mesothelial cells. Pleural mesothelial cells (rabbit or human) were exposed to asbestos (crocidolite, amosite or chrysotile) at moderate doses (1-10 $\mu g/cm^2$) over 24 hours and evaluated for oligonucleosomal DNA fragmentation, loss of membrane phospholipid asymmetry, and nuclear condensation. It was found that asbestos fibres induced apoptosis in mesothelial cells for all assays and induction of apoptosis was dose-dependent for all types of asbestos.

To determine whether asbestos causes apoptosis in alveolar epithelial cells (AEC) Aljandali et al. (2001) exposed WI-26, A549 and rat alveolar type II cells to amosite asbestos and assessed apoptosis by the TUNEL assay. It was found that amosite asbestos and hydrogen peroxide each caused apoptosis in AEC. A role for iron catalysed ROS was suggested by the finding that asbestos-induced AEC apoptosis was attenuated by either an iron chelator (phytic acid) or an .OH scavenger (dimethyl thiourea), but not by iron-laden phytic acid. An in vivo experiment with rats showed that 1 week after exposure to amosite asbestos caused a 3-fold increase in the percentage of apoptotic cells in the alveolar region. However, by 4 weeks the number of apoptotic cells was similar to controls. The authors suggest that asbestos induced pulmonary toxicity may be partly caused by apoptosis in the lung epithelium that is mediated by iron-catalysed ROS.

Asbestos causes pulmonary toxicity in part by generating reactive oxygen species that cause DNA damage. Because p53 regulates the DNA damage response in part by inducing intrinsic cell death, Panduri et al. (2006) determined whether p53-dependent transcription activity mediates asbestos-induced alveolar epithelial cells (AEC) mitochondrial dysfunction and apoptosis. They showed that inhibitors of p53-dependent transcriptional activities block asbestos-induced AEC mitochondrial membrane potential change ($\Delta\psi_m$), caspase 9 activation, and apoptosis. They also demonstrated that asbestos activates p53 promoter activity, mRNA levels, protein expression and p53 mitochondrial translocation, and that asbestos augments p53 expression in cells at the bronchoalveolar duct junction of rat lungs and that phytic acid prevents this. The authors suggest that p53-dependent transcription pathways mediate asbestos-induced AEC mitochondria-regulated apoptosis and may have broader implications for our understanding of pulmonary fibrosis and lung cancer.

## Conclusion

Six leading mechanisms of asbestos toxicity have been discussed. There is considerable evidence for each, but the model that seems to be favoured at the present time is the reactive oxygen species (ROS) model. There is also evidence for the role of iron being involved in the production of free radicals that are known for their destructive effect in biological systems. There is merit for each model and it is likely that the mechanism for asbestos toxicity involves elements of each model. As it is a complex problem there might be other mechanisms involved but not yet discovered.

## References


Aljandali, A., Pollack, H., Yeldandi, A., Li, Y., Weitzman, S.A. & Kamp, D.W. 2001, 'Asbestos causes apoptosis in alveolar epithelial cells: Role of iron-induced free radicals,' *Journal of Laboratory & Clinical Medicine*, vol. 137, pp. 330-9.

Baldys, A. & Aust, A.E. 2005, 'Role of iron in inactivation of epidermal growth factor receptor after asbestos treatment of human lung and pleural target cells,' *American Journal of Respiratory Cell and Molecular Biology*, vol. 32, pp. 436-42.

Bergamini, C., Fato, R., Biagini, G., Pugnaloni, A., Giantomassi, F., Foresti, E. et al. 2004, 'Mitochondrial changes induced by natural and synthetic asbestos fibres: Studies on isolated mitochondria,' *Cell Molecular Biology*, vol. 50, pp. 691-700.

Broaddus, V.C., Yang, L., Scavo, L.M., Ernst, J.D. & Boylan, A.M. 1996, 'Asbestos induces apoptosis of human and rabbit pleural mesothelial cells via reactive oxygen species,' *Journal of Clinical Investigation*, vol. 98, pp. 2050-2059.

Chen, Q., Marsh, J., Ames, B. & Mossman, B. 1996, 'Detection of 8-oxo-2-deoxy guanosine, a marker of oxidative DNA damage, in culture medium from human mesothelial cells exposed to crocidolite asbestos,' *Carcinogenesis*, vol. 17, pp. 2525-7.

Choe, N., Tanaka, S. & Kagan, E. 1998, 'Asbestos fibres and interleukin-1 upregulate the formation of reactivate nitrogen species in rat pleural mesothelial cells, *American Journal of Respiratory Cell and Molecular Biology*, vol. 19, pp. 226-36.

Dopp, E. & Schiffmann, D. 1998, 'Analysis of chromosomal alterations induced by asbestos and ceramic fibres,' *Toxicology Letters*, vols. 96-97, pp. 155-62.

Dorger, M., Allmeling, A.M., Keifmann, R., Schropp, A. & Krombach, F. 2002, 'Dual role of inducible nitric oxide synthase in acute asbestos-induced lung injury,' *Free Radical Biology & Medicine*, vol. 33, pp. 491-501.

Everitt, J.I. 1994, 'Mechanisms of fibre-induced diseases: implications for the safety of synthetic fibres,' *Regulatory Toxicology & Pharmacology*, vol. 14, pp. 57-78.

Hardy, J.A. & Aust, A.E. 1995, 'The effect of iron binding on the ability of crocidolite asbestos to catalyse DNA single strand breaks,' *Carcinogenesis*, vol. 16, pp. 319-325.

Jung, M., Davis, W.P., Taatjes, D.J., Churg, A. & Mossman, B.T. 2000, 'Asbestos and cigarette smoke increased DNA strand breaks and necrosis in bronchiolar epithelial cells in vivo,' *Free Radical Biology & Medicine*, vol. 28, pp. 1295-99.

Kamp, D.W., Israbian, V.A., Preusen, S.E., Zhang, C.X. & Weitzman, S.A. 1995, 'Asbestos causes DNA stand breaks in cultured pulmonary epithelial cells: role of iron-catalysed free radicals,' *American Journal Physiology-Lung Cellular & Molecular Physiology*, vol. 268, pp. 1040-6.

Kopnin, P.B., Krauchenko, I.V., Furalyov, V.A, Pylev, L.N. & Kopnin, B.P. 2004, 'Cell type- specific effects of asbestos on intracellular ROS levels, DNA oxidation and G1 cell cycle checkpoint,' *Oncogene*, vol. 23, pp. 8834-40.

Levresse, V., Renior, A., Levy, F., Broaddus, V.C. & Jaurand, M.C. 2000, 'DNA breakage in asbestos-treated normal and transformed (TSV40) rat pleural mesothelial cells,' *Mutagenesis*, vol. 15, pp. 239-44.

Ollikainen, T., Linnainmaa, K. & Kinnula, V.L. 1999, ' DNA single strand breaks induced by asbestos fibres in human pleural mesothelial cells in vitro,' *Environmental & Molecular Mutagenesis*, vol. 33, pp. 153-60.

Panduri, V, Weitzman, S.A., Chandel, N. & Kamp, D.W. 2003, 'The mitochondria-regulated death pathway mediates asbestos-induced alveolar epithelial cell apoptosis,' *American Journal Respiratory Cell & Molecular Biology*, vol. 28, pp. 241-8.

Panduri, V., Surapureddi, S., Soberanes, S., Weitzman, S.A., Chandel, N. & Kamp, D.W. 2006 'p53 mediates amosite asbestos-induced alveolar epithelial cell mitochondria-regulated apoptosis,' *American Journal of Respiratory Cell & Molecular Biology*, vol. 34, pp. 443-52.

Pociask, D.A., Sime, P.J. & Brady, A.R. 2004, 'Asbestos-derived reactive oxygen species activate TGF-α1,' *Laboratory Investigation*, vol. 84, pp. 1013-23.

Puhakka, A., Ollikainen, T., Soini, Y., Kahlos, K., Sasily, M., Koistinen, P., et al. 2002, 'Modulation of DNA single-strand breaks by intracellular glutathione in human lung cells exposed to asbestos fibres,' *Mutation Research*, vol. 514, pp. 7-17.

Quinlan, T.R., BeruBe, K.A., Hacker, M.P., Taatjes, D.J., Timblin, C.R., Goldgerg, J. et al. 1998, 'Mechanisms of asbestos-induced nitric oxide production by rat alveolar macrophages in inhalation and in vitro models,' *Free Radical Biology & Medicine*, vol. 24, pp. 778-88.

Schins, R.P.F. 2002, 'Mechanisms of genotoxicity of particles and fibres,' *Inhalation Toxicology*, vol. 14, pp. 57-78.

Schurkes, C., Brock, W., Abel, J. & Unfried, K. 2004, 'Induction of 8-hydroxy deoxyguanosine by man made vitreous fibres and crocidolite asbestos administered intraperitoneally in rats,' *Mutation Research/Environmental & Molecular Mechanisms of Mutagenesis*, vol. 553, pp. 59-65.

Unfried, K., Schurkes, C. & Abel, J. 2002, 'Distinct spectrum of mutations induced by crocidolite asbestos: clue for 8-hydroxydeoxyguanosine-dependent mutagenesis in vivo, *Cancer Research*, vol. 62, pp. 99-104.

Wang, X., Wu, Y., Stonehuerner, J.G., Dailey, L.A., Richards, J.D., Jaspers, I. et al. 2006, 'Oxidant generation promotes iron sequestration in BEAS2B cells exposed to asbestos,' *American Journal of Respiratory Cell & Molecular Biology*, vol. 34, pp. 286-92.

Xu, A., Zhou, N., Yu, D.Z. & Hei, T.K. 2002, 'Mechanisms of the genotoxicity of crocidolite asbestos in mammalian cells: implications from mutation patterns induced by reactive oxygen species,' *Environmental Health Perspectives*, vol. 110, pp. 1003-8.

Zeidler, P.C. & Castranova, V. 2004, 'Role of nitric oxide in pathalogical responses of the lung to exposure to environmental/occupational agents,' *Redox Report*, vol. 9, pp. 7-18.

Correspondence to:
He Wang
Discipline of Public Health
University of Adelaide
Level 9, Tower Building
10 Pulteney Street
Adelaide, 5005
AUSTRALIA
Email: hwang2@tulane.edu

**Back to TOC**

# The Zoonotic Potential of Dogs in Aboriginal Communities in Central Australia

**Sharyn Gaskin, Richard Bentham, Nancy Cromar and Howard Fallowfield**

***Department of Environmental Health, Flinders University of South Australia***

*This article reviews the established zoonoses from dogs, and identifies the potential burden of speculative zoonoses of canine origin in Aboriginal communities in Central Australia. A variety of organisms such as bacteria, viruses, and parasites including protozoa, ectoparasites and helminths (worms) have possible zoonotic capability; these organisms are discussed. Observational research was conducted in seven Aboriginal Town Camps of Alice Springs to describe the human and dog interactions and behaviours, and risk factors for transmission. Information was also gathered on the cultural significance of dogs to Aboriginal people in the community under observation. The relationship between Aboriginal people and their dogs appears to be not only one of companionship, but involves other more complex cultural factors. The contribution dogs make to infections and infestations of Aboriginal people in communities throughout Australia remains unclear. Education and dog health programs have an important role in reducing the risk of canine-related human morbidity in Aboriginal communities.*

**Key words:** *Dogs; Zoonosis; Aboriginal Health; Indigenous Australians*

Infectious diseases transmissible between humans and animals are termed zoonoses, or zoonotic diseases. They are caused by bacteria, viruses, fungi, parasites and helminths (Currie 1995). The variety of animal hosts varies greatly, as do modes of transmission from animals to humans. In Australia, animal sources of zoonoses include cattle, sheep, horses, kangaroos, birds, dogs and rodents (Stevenson & Hughes 1988). In particular, Schantz (1991) highlighted more than a decade ago that the potential health risk to humans of enteric parasites harboured by the pet dog is a significant problem. The incidence of zoonoses transmitted from pets to humans depends on a number of factors (Raw 2001):

- The number of animals in and around the home environment
- The human and animal behaviours and extent of interaction
- The route and efficiency of transmission from pets to humans
- Existing measures to prevent transmission.

The impact on public health of zoonotic infections can also be ranked according to the severity of disease. Although it is suggested that none of these are major causes of mortality, they impose a heavy burden in terms of human morbidity (Robertson et al. 2000; Schantz 1991).

The health status of Aborigines and Torres Strait Islander Australians lags behind that of Australians generally (AIHW 2006). Despite much effort over the past two decades, the life expectancy of Aboriginal people remains 17 years behind the non-Aboriginal population of Australia (Condon et al. 2004; Wilson et al. 2007). The health problems of Aborigines vary across Australia, reflecting the different circumstances of communities. There are many remote Aboriginal communities scattered across central and northern Australia. These communities have populations ranging from less than 100 to a few thousand, frequently living in harsh conditions (Currie 1998).

Overcrowding is common and sometimes 10 or more people may share a single house with a poor water supply and inadequate sanitation (Currie 1998). Intestinal and skin infections and infestations remain a major cause of Aboriginal ill-health and of hospitalisation (Currie & Carapetis 2000).

The possible health risk to humans of organisms harboured by the domestic dog is potentially of great importance to Indigenous communities across Australia. In such regions people commonly share their home environment with a variety of animal species that inevitably leads to frequent inter-species exposure to potential zoonoses (Raw 2001; Robertson et al. 2000). The issue in any context where dogs and humans interact is how much infectious disease transmission is the result of zoonoses compared with other environmental sources? The health impact of these interactions in Aboriginal communities across Australia is a point of ongoing discussion. It appears that the implication of close contact between Aboriginal people and their dogs not only involves issues of public health importance, but also the social health and wellbeing of Indigenous communities (Currie 1995; Senior et al. 2006).

The purpose of this paper is to review the 'evidence' for association between the disease burden of domestic dogs and Indigenous health in Central Australia. The literature review looks at the established zoonoses from dogs, and the potential burden of speculative zoonoses of canine origin. This is supplemented with insight from research in Central Australia observing interactions and behaviours of community members and their dogs, and addressing the significance of dogs in aspects of Aboriginal culture.

## Methods

This research consists of two components: a literature review to determine the established zoonoses from dogs, and to identify the potential burden of speculative zoonoses. The results of this review are considered in the light of observations made in the four week field research. The project was a pilot study undertaken at the request of Tangentyere Council (an Aboriginal organisation) in Alice Springs. Tangentyere Council is an Incorporated Body established to manage on behalf of Aboriginal owners of land, Leases in Perpetuity for 18 Housing Associations (known as Town Camps) on the outskirts of Alice Springs.

Field research was conducted in June and July 2001 in Alice Springs, Northern Territory, and comprised direct observation of seven Aboriginal Town Camps within the Alice Springs area. Camps participating in the study were selected by committee members of Tangentyere Council following consultation with community members. Observational data collected included details of human and canine interactions and behaviours within the Town Camps, and visual indicators of the animals' general health. Information was also gathered on the cultural significance of dogs to the community. Ethics approval was provided by the Central Australian Human Research Ethics Committee, Flinders University Social and Behavioural Research Ethics Committee, and Tangentyere Council Ethics Committee in Alice Springs. Field research was conducted with the assistance of Tangentyere Council members and the Centre for Remote Health in Alice Springs.

## Results

### *Field observations*

The population of Aboriginal residents varied significantly between the Town Camps under observation, ranging from 40 to 160 (mean 94). The number of houses occupied by residents of the Town Camps ranged from 7 to 22 (mean 14), meaning approximately 5 to 7 individuals resided in each home within each Camp observed. Observations of the total number of dogs recorded at each camp over the test period showed variation between 5 to 42 dogs (mean 18). For individual Town Camps this represents an average of between

1 and 3 dogs per household, although some households had up to 10 dogs.

Observational data were also collected regarding the interaction and behaviours of both human and canine populations. As mentioned, numerous inhabitants were often observed in a single dwelling. The majority of Camp inhabitants were observed outside their homes during the visits, often sitting on verandas or front yards. In many cases this was due to the extended family network cohabitating. There seemed to be partial domestication of dogs, with many needing to forage for their own food. Partial fencing or boundaries around homes were only observed at one Town Camp. Dogs appeared to have free access around the Camps and in many cases had access indoors. Many of the animals were observed with mange on their coats indicating possible scabies infestation. Close association between dogs and humans in the Aboriginal community was observed. In particular, children were often observed in close proximity to several dogs at one time, frequently engaging in contact with them. Children in particular seemed to have considerable contact with dogs in their extended family network. The observed pet-human interactions in the Aboriginal community show the potential for transmission of canine disease to humans.

### *Review of literature on zoonoses between dogs and humans*

Numerous organisms are recognised in the literature has having zoonotic potential. A summary of these organisms is provided in Table 1, including their transmission routes and ranked evidence of zoonoses from dogs. Each organism is then discussed by group in terms of their zoonotic capability, and potential disease burden to Aboriginal communities in Australia.

### *Ectoparasites*

Scabies, the disease associated with *Sarcoptes scabiei*, is due to the reaction of the host to the mite or its products (Shield 1996). In Aboriginal communities in northern Australia, scabies is endemic in both human and dog populations (Walton et al. 1998). The problem seems to have worsened in recent years, with prevalence in children at times over 50% and in adults up to 25% (Currie & Carapetis 2000). As a result, community based programs have been initiated in order to improve health outcomes. One such program has been developed by the Cooperative Research Centre for Aboriginal Health (CRCAH). The goal of the *Healthy Skin Program* is to reduce the prevalence and impact of scabies and skin sores in Indigenous communities.

In terms of risk factors for infection, it has been suggested that scabies infestation is not related to hygiene, but is strongly associated with overcrowding (Currie & Carapetis 2000). This risk factor is of importance in the community under observation, where many inhabitants were observed in a single dwelling. Research suggests that the role of bedding and clothes (known as fomites) in disease transmission is not as important as close body contact (Currie & Carapetis 2000). Aborigines have a close association with their dogs, as suggested in the current study (see *Totemic Dreaming*), and many animals were observed with the appearance of mange on their coats. As a result of this close contact between people and dogs, the possibility of dogs being a reservoir for human infection has been suggested, and has become the rationale for introducing dog treatment programs in some communities (Tindall 2001).

Past studies around the world have documented incidents of canine scabies spreading to humans (Charlesworth & Johnson 1974; Mitra et al. 1993). Diagnosis in many of these cases was based on classical identification methods (e.g. morphology) of the scabies variant from the affected animals rather than more rigorous identification methods. Recent advances in molecular typing methods for scabies mites have enabled an initial investigation into the differences

***Table 1: Organisms recognised as having zoonotic potential; their transmission route and ranked evidence of zoonoses from dogs***

| Organism | Transmission route | Evidence of zoonosis from dogs |
|---|---|---|
| Ectoparasites: | | |
| *Sarcoptes scabiei* (scabies) | Close contact | Strong historical evidence; emerging evidence for host specificity |
| Helminths: | | |
| *Ancylostoma caninum* (hookworm) | Stool (eggs or larvae) to soil to skin (via infective larvae) | Strong evidence |
| *Toxocara canis* (roundworm) | Stool (eggs or larvae) to soil to accidental ingestion | Strong evidence |
| *Trichuris vulpis* (whipworm) | Stool (eggs or larvae) to soil to accidental ingestion | Weak (presumptive) evidence; no evidence in Australia |
| *Strongyloides stercoralis* (threadworm) | Stool (eggs or larvae) to soil to skin (via infective larvae) | Weak evidence |
| *Dipylidium caninum* | Accidental ingestion (cysterci); fleas and lice intermediate hosts | Weak evidence |
| Protozoan: | | |
| Giardia | Faecal-oral (dog or human) | Weak circumstantial evidence; humans main reservoir. |
| Cryptosporidium | Faecal-oral (dog or human); contaminated water supply | Weak evidence; other sources predominate |
| Bacteria and Viruses: | | |
| Campylobacter | Faecal-oral (dog or human); food, milk or water | Weak evidence; human-to-human thought to predominate |
| Rotavirus | Faecal-oral (dog or human) | No established link; current evidence against it. |

between the canine and human variants (Walton et al. 1999). The findings by Walton et al. (1999) is in contrast to historical evidence and suggests that the vast majority of cases of scabies in the current epidemic in Aboriginal communities show clear genetic separation between mites from humans and those from dogs. Walton et al. (2004) have since extended on previous investigations, with recent data clearly supporting previous work that scabies mites on people are genetically distinct from those on dogs. More epidemiological evidence is required to document accurately the proportion of illness caused by the dog scabies variant residing on human skin, compared with infection due to human-associated scabies variant. Scabies control programs should continue to focus on human-to-human transmission as a source of infection for this organism.

### *Helminths*

Aboriginal children in Australia frequently suffer from infestation with intestinal parasites (Prociv 2001; Stuart 1990). Prevalence levels in some remote Australian Aboriginal communities compare with those in developing countries (Prociv 2001). Five helminths (4 nematodes and 1 cestode) of dogs in northern and central Australia have recognised zoonotic potential (Shield 1996). For nematodes, these are the dog hookworm, *Ancylostoma caninum*, the dog roundworm, *Toxocara canis*, the dog whipworm, *Trichuris vulpis*, and *Strongyloides stercoralis* in the gastrointestinal tract; for cestodes, *Dipylidium*

*caninum* has the potential to infect humans.

Recent parasitological surveys of dogs have indicated that the prevalence of intestinal helminths has declined over the last 20 years in the developed world (Robertson et al. 2000). This might be a real decrease associated with the ready availability and adoption of safe and effective drugs to eliminate these infections from pets (Robertson et al. 2000). Alternatively, differences in sampling protocols including source and age of animals, prior antihelmintic usage in sampled animals, diagnostic techniques, or environmental conditions between surveys, might account for the decrease in prevalence (Robertson et al. 2000).

Of particular concern with infection with hookworm (*Ancylostoma caninum*) is the fact that single worms have been associated with development of illness (Prociv & Croese 1990; Prociv 2001). Because the hookworm could easily be overlooked in pathological specimens, Robertson et al. (2000) proposed that this condition was likely to be under-diagnosed and might be more widely distributed than is currently appreciated. As with many other zoonoses the faecal-oral route is important in the transmission of this agent to humans. Appropriate hygiene procedures such as hand washing and removal and disposal of faeces will reduce the probability of infection (Currie 1995).

A study in dogs from around Australia found high levels of infection with *Toxocara canis* (roundworm) of up to 45% (Shield 1996). However, the survey involved only small numbers of animals, and thus might not be representative. Bugg et al. (1999) considered that one of the major reasons for the reduction in prevalence of parasites, such as *Toxocara canis* and *Dipylidium caninum*, was a growing awareness by dog owners about these parasites and methods for controlling them.

While it is suggested that control programs have had success with hookworm in Australia, little attention seems to have been paid to *Trichuris* and *Strongyloides* (Shield 1996). Both of these are capable of causing serious morbidity, and strongyloidiasis can persist in an individual for decades (Johnston et al. 2005; Stuart 1990). *Strongyloidiasis* remains common in many Aboriginal communities in Northern Australia with prevalence ranging from 0 to 60% (Johnston et al. 2005). Dogs have been implicated as potential infective reservoirs for *Strongyloides*, although the evidence of dogs as a source of human infection is not convincing (Prociv 2001). Person to person contact in particular with children remains the main mode of transmission. The sustained effects of treatment, particularly noted in children (Prociv 2001) seems to preclude other major sources of infection.

It appears there is a need for increased awareness about the illnesses helminths cause and the potential role of close contact with dogs in their transmission. Although zoonotic infection of humans is believed to be a rare occurrence (other modes of transmission predominate), it is a factor of relative importance in Aboriginal communities and merits further study. The role of host-species specificity in human infection is unknown. Canine strains, while similar to human strains morphologically, might be distinct species, and ongoing molecular research will help clarify the zoonotic capability of these organisms.

### *Protozoan pathogens*

The intestinal flagellated protozoan *Giardia* is ubiquitous and infects large numbers of human and animal hosts worldwide (Isaac-Renton et al. 1993). In Australia, Giardiasis is considered to be the most important parasitic disease in terms of morbidity, in particular as a cause of diarrhoea in children (Thompson 2004). Australian studies have shown that *Giardia* infections have a high prevalence in both humans and dogs, from metropolitan and remote areas (Hopkins et al. 1997; Meloni et al. 1993; Thompson

2004). Dogs may therefore be identified as a potential reservoir for human infection, and should Giardiasis eventually prove to have a zoonotic capability, dogs may provide a significant and ready source of human infection (Hopkins et al. 1997; Monis & Thompson 2003).

As dogs have a very close traditional association with Aboriginal people and have been shown to carry *Giardia* species they may transmit infection by close contact (Meloni et al. 1993). The presence of multiple dogs in a household was identified by Bugg et al. (1999) as increasing the chance of dogs being infected with *Giardia*. Observations regarding the numbers and risk behaviour of dogs, and their interaction with humans in Aboriginal communities have helped to clarify the possibility of zoonotic transfer. Epidemiological evidence suggests that humans are likely to be the main reservoir of human Giardiasis and it is likely that direct person-to-person transmission is more important than zoonotic transmission (Monis & Thompson 2003), however, dogs may carry strains of *Giardia* with the potential to be infective to humans (Hopkins et al. 1997; Thompson 2004).

It remains to be established whether there are distinct host specificities with regards to sub-species of *Giardia* (Thompson 2004) and further epidemiological studies using new genotyping techniques might answer this question. Nevertheless, the potential for dogs to act as reservoirs of human infections is clearly demonstrated, and continues to be of particular significance in Aboriginal communities where close interaction between dogs and humans is observed.

*Cryptosporidium* is another common protozoan and cause of human diarrhoea (Currie 1995). *Cryptosporidium* has also been detected in dogs, which might represent an important reservoir of infection for humans (Bugg et al. 1999). Molecular studies have indicated that *C. parvum* is not a single uniform species but instead composed of at least six genetically distinct genotypes, only two of which appear to be capable of infecting humans (Morgan et al. 2000). Although people of all ages are at risk for exposure to *Cryptosporidium*-infected dogs, younger children are at a higher risk (Fayer 2004). Close human-dog interactions as observed in the current study present the risk of exposure to agents such as *Cryptosporidium*. In addition, the ability of infective oocysts to survive in the environment for extended periods increases the potential of exposure (Fayer 2004). Overall, research suggests *Cryptosporidium* species have possible zoonotic implications in tropical Australia (Currie 1995; Monis & Thompson 2003), and close contact with puppies in particular might increase the risk of exposure (Morgan et al. 2000; Schantz 1991). Further genetic and biological studies are required to determine fully the prevalence, transmission dynamics, and species status of the *Cryptosporidium* 'dog' genotype.

### Bacteria and viruses

*Campylobacter* infection has one of the highest rates of all notifiable diseases in Australia (Tenkate & Stafford 2001). Of these, *Campylobacter jejuni* is recognised as presenting possible zoonoses from dogs, although other animal sources, contaminated food and water, and direct human-to-human spread are thought to be the predominant transmission modes (Cook 1989; Tenkate & Stafford 2001). The true role of *campylobacteria* in human gastroenteritis is probably significantly understated as most routine diagnostic laboratories do not use isolation techniques which would detect the more fastidious and demanding species (Baker et al. 1999). However, recent advances in the molecular characterisation of different *Campylobacter* strains, and the creation of databases containing *Campylobacter* fingerprints, will allow the comparison of strains and give a basis for tracing back the origin (Keller et al. 2007).

*Campylobacter* gastrointestinal infections in Aboriginal children are well documented (Currie 1995; Hanna 1994; Stevenson & Hughes 1988). A recognised risk factor for zoonotic infection in humans is close proximity to dogs, in particular puppies (Hanna 1994; Tenkate & Stafford 2001). In the current study, children had considerable contact with dogs in their extended family network. The close affinity between Aboriginal people and their dogs might help to explain high rates of *Campylobacter* infections in Aboriginal children (Currie 1995; Hanna 1994). A difficulty in attributing human cases to contact with animals is that *Campylobacter* will be present in animal intestine, regardless of their involvement in human disease (Stevenson & Hughes 1988). Regardless of the means by which dogs become carriers, animals carrying *Campylobacter* spp. are certainly a potential source of infection for humans (Baker et al. 1999; Keller et al. 2007). It is appropriate to further document information on *Campylobacter* species as a cause of enteric disease in dogs, and as a possible reservoir for infection in humans.

A group of antigenically related viruses, called rotaviruses, have been demonstrated in the faeces of humans and a wide range of mammalian species (Stevenson & Hughes 1988). In Australia, about half of the 20,000 hospital admissions annually for acute diarrhoea in children under 5 years are due to rotavirus gastroenteritis (Gelbart et al. 2006). The disease burden in Aboriginal communities is particularly marked with rates of hospitalisation for rotavirus in communities in the Northern Territory 3 to 5 times higher than other Australian regions (Gelbart et al. 2006). Rotaviruses are well recognised as being transmitted directly and indirectly from human-to-human, with only a small number of particles required to initiate infection (Desselberger 1999). As a result rotaviruses can spread easily under conditions of overcrowding and poor hygiene (Desselberger 1999). To date there is no established link to zoonotic disease from dogs (Cook et al. 2004; Currie 1995; Nakagomi et al. 1990). A study over a decade ago was successful in identifying rotaviruses of closely related feline and canine origin, but whether animal strains can infect humans has yet to be resolved (Nakagomi et al. 1990), and current evidence seems to suggest it is not likely (Cook et al. 2004; Currie 1995). Regardless of the ambiguity in source of human infections by this pathogen, it appears to be of continuing public health significance in the community under observation in this study. This is particularly so as many people observed lived under conditions of overcrowding and poor hygiene, which aids in the rapid spread of this agent (Desselberger 1999). Further research is required to understand the genetic diversity of human and animal rotavirus genomes, in order to evaluate its significance as a zoonotic agent.

With regard to the control of this and other zoonotic infections, social wellbeing might also be an important issue due to the relationship between Indigenous people and their dogs, as explained below.

### *Totemic dreaming*

To understand fully the dog health and human health in Aboriginal communities, an appreciation of the cultural and historical context is needed. Senior et al. (2006) provide an excellent review of the anthropological literature concerning people's relationships with dogs in Aboriginal communities. The authors explore this relationship within the context of the social determinants of health. It seems the relationship between Aboriginal people and their dogs is partly one of companionship but involves other more complex cultural factors. Some Aboriginals believe that their ancestors might return as animals (in particular as dogs) and so there is reluctance to destroy them even when they are ill (Shield 1996). Traditional Aboriginal

custodians of Alice Springs in the Northern Territory of Australia are Arrernte people. In Arrernte tradition every part of the Alice Springs topography has a name and a totemic association with one of the ancestral beings which in Arrernte culture originally travelled through the area creating features (Brooks 1991). The major totemic association is that of the wild dog. In Arrernte culture, many of the features of the west side of Alice Springs were formed by the activities of the wild dog. For these reasons, these animals remain an integral part of the spiritual life of the Arrernte people.

## Management Programs

Over the last decade there have been numerous programs implemented to improve the health of dogs in Indigenous communities and as a result, to improve the health of the people in those communities (Raw 2001; Tindall 2001). These programs have involved varying combinations of parasite control (in particular scabies), surgical desexing and medical contraception for population control, and other initiatives (Bradbury & Corlette 2006).

Since infections of dogs and humans are often the result of human activity, education must also play a key role in their control. Increased awareness that some diseases might be associated with dogs, and more effective prevention and treatment programs, will help to reduce the prevalence of zoonotic infections and infestations. In a recent conference, an Action Plan for Companion Animal Health Programs was drafted by Animal Management in Rural and Remote Indigenous Communities (AMRRIC) (Aboriginal and Torres Strait Islander Commission 2000). The Plan covered cultural and social concerns, as well as dog and human health, and education and training. Recommendations were made including a move beyond the current 'band-aid' reactive approach towards a more sustainable, proactive and preventative approach. It also highlighted the need for incorporating education and community involvement in dog health programs in Indigenous communities across Australia.

## Conclusion

Factors that influence human infection with zoonotic organisms appears to vary depending on the genus and even species of the organisms involved. Ongoing studies utilising new molecular techniques will help clarify the important issues of host-species specificity and the zoonotic capability of key organisms described in this paper. It is important to consider the continuing occurrence of these diseases in the absence of dogs, and the abundance of literature connecting these diseases with overcrowding, poor hygiene, and other risk factors. Dogs remain an important public health issue in Aboriginal communities of Australia. Ongoing community-focused management and education programs will potentially reduce the prevalence of zoonotic infections and infestations. If this is achieved then dogs will continue to be integral members of healthy Aboriginal households throughout Australia.

### *Acknowledgments*

The authors would like to thank the Centre for Remote Health and the Aboriginal organisation Tangentyere Council, in particular Executive Director William Tilmouth, in Alice Springs for their guidance and support during the field component of this research. We also acknowledge Professor John Wakerman and Dr Inge Kowanko for their helpful comments in reviewing the manuscript.

## References


Australian Institute of Health and Welfare (AIHW) 2006, '*Australia's Health 2006*', AIHW cat. no. AUS 73. AIHW, Canberra.

Aboriginal and Torres Strait Islander Commission 2000, *A Better Dog's Life: Proceedings of a Three-Day Conference on Dog Health Programs in Indigenous Communities*, Darwin, August 2000, Aboriginal and Torres Strait Islander Commission, Darwin.

Baker, J., Barton, M. & Lanser, J. 1999, '*Campylobacter* species in cats and dogs in South Australia', *Australian Veterinary Journal*, vol. 77, pp. 662-6.

Bradbury, L. & Corlette, S. 2006, 'Dog health program in Numbulwar, a remote Aboriginal community in east Arnhem Land', *Australian Veterinary Journal*, vol. 84, pp. 317-20.

Brooks, D. 1991, *The Arrernte Landscape*, Institute for Aboriginal Development, Darwin, Northern Territory.

Bugg, R., Robertson, I., Elliot, A. & Thompson, R. 1999, 'Gastrointestinal parasites of urban dogs in Perth, *Western Australia*', *Veterinary Journal*, vol. 157, pp. 295-301.

Condon, J., Barnes, T., Cunningham, J. & Smith, L. 2004, 'Improvements in Indigenous mortality in the Northern Territory over four decades', *Australian and New Zealand Journal of Public Health*, vol. 28, pp. 445-51.

Cook, G. 1989, 'Canine-associated zoonoses: An unacceptable hazard to human health', *Quarterly Journal of Medicine*, vol. 70, pp. 5-26.

Cook, N., Bridger, J., Kendall, K., Gomara, M., El-Attar, L. & Gray, J. 2004, 'The zoonotic potential of rotavirus', *Journal of Infection*, vol. 48, pp. 289-302.

Currie, B. 1995, 'Dogs and human health in Aboriginal communities: How important are zoonoses?', *Aboriginal and Torres Strait Islander Health Information Bulletin*, vol. 20, pp. 19-29.

Currie, B. 1998, 'Dogs and aboriginal health in Australia', *World Health*, vol. Jul/Aug, pp. 1-3.

Currie, B. & Carapetis, J. 2000, 'Skin infections and infestations in Aboriginal communities in northern Australia', *Australasian Journal of Dermatology*, vol. 41, pp. 139-45.

Desselberger, U. 1999, 'Rotavirus infections: Guidelines for treatment and prevention', *Drugs*, vol. 58, pp. 447-52.

Fayer, R. 2004, '*Cryptosporidium*: A water-borne zoonotic parasite', *Veterinary Parasitology*, vol. 126, pp. 37-56.

Gelbart, B., Hansen-Knarhoi, M., Binns, P. & Krause, V. 2006, 'Rotavirus outbreak in a remote Aboriginal community: The burden of disease', *Journal of Paediatrics and Child Health*, vol. 42, pp. 775-80.

Hanna, J. 1994, '*Campylobacter upsaliensis* bacteraemia in an Aboriginal child', *Medical Journal of Australia*, vol. 160, pp. 655.

Hopkins, R., Meloni, B., Groth, D. & Wetherall, J. 1997, 'Ribosomal RNA sequencing reveals differences between the genotypes of *Giardia* isolates recovered from humans and dogs living in the same locality', *Journal of Parasitology*, vol. 83, pp. 44-51.

Isaac-Renton, J., Cordeiro, C., Sarafis, K. & Shahriari, H. 1993, 'Characterisation of *Giardia duodenalis* isolates from a waterborne outbreak', *Journal of Infectious Diseases*, vol. 167, pp. 431-440.

Johnston, F., Morris, P., Speare, R., McCarthy, J., Currie, B., Ewald, D., Page, W. & Dempsey, K. 2005, 'Strongyloidiasis: A review of the evidence for Australian practitioners', *Australian Journal of Rural Health*, vol. 13, pp. 247-54.

Keller, J., Wieland, B., Wittwer, M., Stephan, R. & Perreten, V. 2007, 'Distribution and genetic variability among *Campylobacter* spp.: Isolates from different animal species and humans in Switzerland', Zoonoses and Public Health, vol. 54, pp. 2-7.

Meloni, B., Thompson, R., Hopkins, R. & Reynoldson, J. 1993, 'The prevalence of Giardia and other intestinal parasites in children, dogs and cats from Aboriginal communities in the Kimberley', *Medical Journal of Australia*, vol. 158, pp. 157-159.

Monis, P. & Thompson, R. 2003, '*Cryptosporidium* and *Giardia-zoonoses*: Fact or fiction?', *Infection, Genetics and Evolution*, vol. 3, pp. 233-44.

Morgan, U., Xiao, L., Monis, P. & Fall, A. 2000, '*Cryptosporidium* spp. in domestic dogs: The "dog" genotype', *Applied and Environmental Microbiology*, vol. 66, pp. 2220-3.

Nakagomi, O., Ohshima, A., Aboudy, Y. & Shif, I. 1990, 'Molecular identification by RNA-RNA hybridisation of a human rotavirus that is closely related to rotaviruses of feline and canine origin', *Journal of Clinical Microbiology*, vol. 28, pp. 1198-203.

Prociv, P. 2001, 'Gastrointestinal worm infections: The prevalence and treatment in Australia', *Australian Family Physician*, vol. 30, pp. 755-61.

Prociv, P. & Croese, J. 1990, 'Human eosinophilic enteritis caused by dog hookworm *Ancylostoma caninum*', *The Lancet*, vol. 335, pp. 1299-302.

Raw, L. 2001, 'Human health in relation to pets in urban and Indigenous communities', in *Rural and Remote Environmental Health I*, eds R. Canyon & R. Speare, The Australasian College of Tropical Medicine, Brisbane.

Reid, J. & Trompf, P. 1991, *The Health of Aboriginal Australia*, Harcourt Brace Jovanovic, Sydney.

Robertson, I., Irwin, P., Lymbery, A. & Thompson, R. 2000, 'The role of companion animals in the emergence of parasitic zoonoses', *International Journal of Parasitology*, vol. 30, pp. 1369-77.

Schantz, P. 1991, 'Parasitic zoonoses in perspective', *International Journal of Parasitology*, vol. 21, pp. 161-70.

Senior, K., Chenhall, R., McRae-Williams, E., Daniels, D. & Rogers, K. 2006, 'Dogs and people in Aboriginal communities: Exploring the relationship within the context of the social determinants of health', *Environmental Health*, vol. 6, pp. 39-46.

Shield, J. ed. 1996, *Dog Health in Indigenous Communities*, Queensland Department of Primary Industries, Cairns, Australia.

Stevenson, W. & Hughes, K. 1988, *Synopsis of Zoonosis in Australia*, AGPS, Canberra.

Stuart, J. 1990, 'A review of helminth infestations in Aboriginal children', *Aboriginal Health Information Bulletin*, vol. 13, pp. 33-8.

Tenkate, T. & Stafford, R. 2001, 'Risk factors for campylobacter infection in infants and young children: A matched case-control study', *Epidemiology and Infection*, vol. 127, pp. 399-404.

Thompson, R. 2004, 'The zoonotic significance and molecular epidemiology of *Giardia* and giardiasis', *Veterinary Parasitology*, vol. 126, pp. 15-35.

Tindall, H. 2001, 'Scabies control in a remote Aboriginal community in the Northern Territory, Australia', in *Rural and Remote Environmental Health I*, eds R. Canyon & R. Speare, The Australasian College of Tropical Medicine, Brisbane.

Walton, S., Bonson, A., Choy, L. & Currie, B. 1998, *'Dogs are not a reservoir for human scabies infestations in Northern Australian communities'*, CARPA Newsletter, vol. 28, pp. 4-5.

Walton, S., Choy, L., Bonson, A. & Valle, A. 1999, 'Genetically distinct dog-derived and human-derived Sarcoptes scabiei in scabies-endemic communities in Northern Australia', *American Journal Tropical Medicine and Hygiene*, vol. 61, pp. 542-7.

Walton, S., Dougall, A., Pizzutto, S., Holt, D., Taplin, D., Arlian, L. et al. 2004, 'Genetic epidemiology of *Sarcoptes scabiei* (Acari: Sarcoptidae) in northern Australia', *International Journal for Parasitology*, vol. 34, pp. 839-49.

Wilson, T., Condon, J. & Barnes, T. 2007, 'Northern Territory Indigenous life expectancy improvements, 1967-2004', *Australian and New Zealand Journal of Public Health*, vol. 31, pp. 184-8.

Correspondence to:
Sharyn Gaskin
Department of Environmental Health
School of Medicine
Flinders University of South Australia
GPO Box 2100
Adelaide, 5001
AUSTRALIA
Email: sharyn.gaskin@flinders.edu.au

Back to TOC

# Promoting Comprehensive Sun Protection Policies and Practices in Outdoor Sports: A Qualitative Study of Perceived Priorities and Practicalities

**Sheleigh Lawler[1], Kym Spathonis[1], Liane McDermott[1], Cindy Gallois[2], Elizabeth Eakin[1], Eva Leslie[3] and Neville Owen[1]**

***[1]Cancer Prevention Research Centre, School of Population Health, The University of Queensland, [2]School of Psychology and Faculty of Social and Behavioural Sciences, The University of Queensland & [3]School of Health & Social Development, Deakin University, Geelong***

*Sun protection policies, environments, practices, and attitudes in sporting club contexts might be significant determinants of sun exposure among adult sporting participants. Face-to-face interviews, using standardised, open-ended questions were conducted with 20 club officials from four sports: soccer, hockey, tennis and surf lifesaving. Thematic content analysis identified a number of salient themes. Formal sun protection policies were well-implemented in surf lifesaving, but less so in soccer, hockey and tennis clubs, which often had informal sun protection practices in place. Officials perceived sun protection to be important, which was related to perceived exposure levels, the type of sport, length of time played and the season. Consistent logistical and practical considerations emerged, including limited resources, availability of shade, and lack of control over sporting facilities, uniform regulations and games scheduling. Sun protection efforts often focused on children more than adult players. Reciprocal responsibility was an important theme, where it was perceived that responsibility for sun protection should be equally shared between the club and the member. In this study it was found that reciprocal responsibility, duty of care and sport-specific practical requirements might significantly influence the success of policy, environmental and education initiatives for sun protection in sporting settings.*

**Key words:** *Sun Protection; Physical Activity; Sun Protection Policy; Sport*

Skin cancer is the most common form of cancer in Australia, a country of 21 million people with a strong sporting culture and community sporting infrastructure. In 2002, 256,000 Australians were diagnosed with basal cell carcinomas and 118,000 with squamous cell carcinomas; in 2001, there were 8885 new cases of melanoma diagnosed, with 1074 deaths (Australian Institute of Health and Welfare [AIHW] 2004). With the vast majority of skin cancers being caused by ultraviolet radiation (UVR) exposure, there is considerable scope for prevention through effective sun protection strategies (Armstrong & Kricker 2001). Participation in outdoor sports may increase exposure to the sun and subsequent skin cancer risk. Sport participation is part of Australian culture, with some 27% of the population aged 15 years and older being involved in organised sport (Australian Bureau of Statistics [ABS] 2004). Sporting organisations can play an important role in preventing skin cancer through environmental, policy and education strategies to reduce sun exposure (Dobbinson, Hayman & Livingston 2006; Glanz & Saraiya 2005; National Health and Medical Research Council [NHMRC] 1997).

Government and non-government organisations concerned with cancer prevention are now facing an interesting

conundrum: promoting physical activity has become a key element of cancer prevention policy and programmatic initiatives (Cancer Council Australia 2004; Cerin et al. 2005), however, taking part in outdoor sports and other health-enhancing physical activities is associated with exposure to harmful UVR (Lawler et al. 2007). Sun protective behaviours can interact, positively and negatively, with physical activity and sport participation (Lawler, Sugiyama & Owen 2007). These behaviours mainly include limiting or minimising exposure to the sun during peak UVR periods, wearing protective clothing, using a broad-spectrum sunscreen, wearing sunglasses, and seeking shaded areas when outdoors. However, sun protection arrangements and the relevant behaviours might not always be convenient, comfortable, compatible, or even possible when taking part in outdoor sports.

The implementation of sun protection policies in sporting settings is a key health promotion issue in Australia. One descriptive study investigated sun protection policy adoption and implementation by peak sporting bodies (representing 35 sports) and clubs in the Australian state of Queensland, where skin cancer risk is a particular public health concern, as it has the highest rates of skin cancer in the world (Earl & Tenkate 2006). In that study, over half of the peak sporting bodies had a sun protection policy, but many of the affiliated clubs of those bodies did not. For those peak sporting bodies that had implemented a policy, the level of concordance of the policy with established sun protection guidelines was low. A majority of peak sporting body officials indicated a desire to see more sun protection measures undertaken at a club level, but believed that this would most likely require unrealistic levels of increased funding and greater access to relevant education materials (Earl & Tenkate 2006). This study, however, relied upon peak body representatives reporting on the sun-protective activities of affiliated clubs, and did not obtain direct verification from the clubs themselves. The sporting club context is where relevant sun protection policies, environmental initiatives and education are required, in order to influence the particular sporting culture, and thus participants directly.

This qualitative research was conducted as part of a larger multi-method study that was guided by social cognitive theory and ecological models of health behaviour (McLeroy et al. 1988; Sallis & Owen 2002). Ecological models of health behaviour identify the influence of personal, social and environmental factors, operating at multiple levels, on individual health behaviours (Sallis & Owen 2002). Bandura's (1986) social cognitive theory shares several features with ecological models of health behaviour. The theory specifies that behaviour, environmental factors and a range of personal cognitive factors (such as observational learning and self-efficacy) interact and influence each other.

Standardised, face-to-face interviews were conducted with club officials from four sports (soccer, hockey, tennis and surf lifesaving) to examine sun protection policies, environmental attributes, club practices, and attitudes towards sun protection within the sporting settings of particular clubs.

## Methods

### *Recruitment method*

Club officials were recruited from four major outdoor sports played in Queensland, Australia: field hockey, soccer, tennis and surf lifesaving (lifeguard beach patrol, which is also a competitive surf sport involving beach racing, swimming, surf ski, surf boat, and surfboard events). Selection of these outdoor sports was based on high participation rates by young adults (Sport and Recreation Queensland 2001), relatively equal male to female participation rates, the vigorous intensity nature of the sports and the inclusion of summer and winter sports. This information was gathered and decisions

on the final four outdoor sports were made by the study's investigators. A search of the Electronic Telephone Directory for the South-East area of Queensland yielded a total of 46 eligible clubs, all of which were contacted by telephone. Officials from these clubs were invited to take part in the study.

The study target was to interview five officials from clubs in the four different sports, with the aim of having a maximum purposive variation sample (Driedger et al. 2006). After 46 clubs had been contacted, officials from 22 clubs agreed to participate. Reasons given for non-participation included not being interested, too busy, and not returning the consent form after several reminders.

An information sheet and a consent form were sent to the club officials who agreed to take part, and a follow-up telephone call was made to arrange an interview at a convenient time and location. Each participant received a movie voucher for their involvement in the study. Ethical clearance was obtained from the University of Queensland's Behavioural and Social Sciences Ethical Review Committee.

Interviews with the 20 club officials were conducted between March and August 2006. The other two club officials who consented took part in pilot testing of the interview schedule. The types of positions that were held by respondents in their clubs varied, and included coach, president, secretary, owner and chairperson.

### Interview procedure

Interviews commenced with an explanation of the process of the interview and issues of confidentiality. Participants' consent to proceed with the interview and to have the interview recorded was obtained. One research officer led the interview, while another took written notes. Interviews with the 20 study participants were also audio-taped, and their duration ranged from 11 to 34 minutes (an average of 28 minutes). The interviews were transcribed verbatim and transcripts were used for the analysis.

The interview schedule, which contained standardised, open-ended questions, began by asking general questions about the position the person held within the club, and then progressed to questions relating to sun protection attitudes, policies and practices.

The club officials were asked: if they were aware of any sun protection policy that had been implemented both at the peak sporting body level and within their own club; if club members were educated about existing club policy; whether their club had implemented sun protection practices, and whether or not a formal written club policy existed. The perceived importance of sun protection, skin cancer risk perceptions, and who within the club needed sun protection the most were also addressed. They were asked about club members' roles in relation to sun protection promotion, as well as perceived responsibility for developing and implementing sun protection policies. They were also asked about the practicalities of implementing sun protection policies and practices in their club setting.

### Analysis of interview materials

Thematic content analysis techniques were used (Glesne & Peshkin 1992). The process initially involved two coders independently reading the same four interview transcripts and completing initial open coding to identify patterns and recurrent themes. The research team then met and formulated coding categories with associated definitions. The initial four interview transcripts were then read individually by each coder and coded according to the themes. Assessment of the level of agreement between coders was undertaken, where there was 81% agreement between the two coders. Since there was a high level of agreement established, the remaining 16 transcripts were coded individually by each coder.

The common themes relating to sun protection attitudes, policies and practices are summarised and illustrated in the next

sections. The extracts present the primary information provided by the respondents, edited so as to reduce some of the repetitions and redundancies that characterise normal speech.

## Results

### Existence of formal and informal sun protection policies

Among the five officials interviewed from each sport, there was clear variation in awareness and implementation of sun protection policies (Table 1).

**Table 1: Awareness of sun protection policies in sporting clubs among the five officials interviewed from each sport**

| | Awareness of peak body sun protection policy (n) | Awareness of implementation of club policy (n) |
|---|---|---|
| Soccer | 1 | 1 |
| Hockey | 3 | 0 |
| Tennis | 4 | 0 |
| Surf lifesaving | 5 | 5 |

Formal sun protection policies were less common among hockey, soccer, and tennis clubs, although some reported informal sun protection practices. Officials from surf lifesaving clubs stated that policies developed at the state and national level had been translated into guidelines and practice at the club level, highlighting a 'top-down' approach:

> *It comes down through the branches… the tier structure in the organisation. Years ago they brought in long-sleeve shirts and there was a lot of resentment at first but now it's becoming more acceptable to wear the shirts, but it was policy that they had to wear these long-sleeve shirts. They encouraged people to wear a broad-brimmed hat and put on the sunscreen but it's all coming down the channels through Surf Life Saving Australia* (Surf Lifesaving).

Clubs which did have a written policy had implemented comprehensive sun protection practices, including communication of the policies to members so that there was a high awareness of the importance of skin cancer prevention and sun protection strategies:

> *Any team uniforms that we have, we ensure that we have a long-sleeved, collared shirt that is an appropriate UV protected rating. We include hats within the team uniform, and like a broad-brimmed hat rather than a cap. We have our own range of sunglasses… so they're really good UV rating for eye protection. We have tents on the beach…at each of the competitors' areas so all the competitors have access to shade, in between their events. … we always have sunscreen available for people to access. …we encourage the competitors to keep their hat and shirt on and just take it off before they go to the line* (Surf Lifesaving).

For surf lifesaving, club officials described sun protection as part of the primary purpose of this sport (that is, saving lives), and inherent in their sense of duty of care.

> *It's* [sun protection] *in line with our whole preventative strategy for losing lives through drownings I guess. It's very paramount I guess and it sort of goes hand in hand with the sort of environment that we operate in* (Surf Lifesaving).

Surf lifesaving officials reported rigorous compliance checking within the club and also consistency in the implementation of a broad range of sun protection practices at all levels:

> *We have an internal inspection system, where certain volunteer members of the club go down and part of that inspection is to check for sun protection being utilised, and what sun protection is being offered whether it's been set up properly* (Surf Lifesaving).

On one hand, for the other sports where club officials reported not having any formal written policy, there was a range of levels to which practices had been implemented; some still attempted to address sun protection in a reasonably comprehensive manner:

> *We provide sunscreen for the kids at the start of the season as a means of trying to encourage awareness of the problem and at our coaches and managers' night, we instruct all of our coaches that they have to be aware of the danger of exposure to the sun and do whatever they can within their capacity to influence the kids. We keep coming back to the same problem, there are*

*limits to the physical things that we can do but the use of sunscreen is an obvious one and that's something that we really push* (Soccer).

On the other hand, there were other clubs that took sun protection less seriously and had poorer promotion of sun protection measures:

*Unfortunately, with this sport, they emphasise more on mouthguards and protection of the body before sun protection. There's none available* (Hockey).

Some clubs had other health issues that were considered important, such as heat and safety practices and policies:

*We've got an equipment guide which lists what players should have for the game, such as sunscreen, a hat and water* (Soccer).

### Perceived levels of sun exposure

Officials thought that all their club participants and other members required protection from the sun. Many officials suggested that players, coaches and officials might need a greater level of protection from the sun due to long periods of time spent outdoors.

Surf lifesaving club officials acknowledged that their members might be at an increased risk of skin cancer, because of the long periods of sun exposure during carnivals (lasting 7-8 hours a day), so it was imperative that their members protected their skin. Skin cancer risk was also believed to be exacerbated by beach patrols, which competitors are required to undertake in order to fulfil the duties of being an active club member. These beach patrols are usually for the entire day, making it difficult to avoid being exposed to the sun during peak UVR periods:

*… compared to say a hockey player on a field, you've got the glare off the sand and …the rebound and reflection off the ocean and I know just from spending a day on the beach or spending a day labouring at home, that the wear and tear of just the sun and what it's done. … definitely high risk in our environment compared to other areas* (Surf Lifesaving).

Game duration was a factor that influenced the perception of skin cancer risk. Officials of soccer, hockey and tennis clubs perceived the risk of skin cancer for competitors as lower than those who played other outdoor sports such as cricket and lifesaving, which had longer game durations and consequently higher levels of sun exposure:

*I'm not conscious that it's [sun exposure] a particularly big problem in soccer … with soccer it's only an hour in the sun for juniors and an hour and a half for older players… I imagine it's different in other sports such as cricket where they are outside in the sun for a much longer period of time. Because soccer is an intense, quick physical activity, I'm not sure it's a major problem* (Soccer).

### Perceptions of seasonal variations in sun exposure

Seasons and the time of year that the sport is typically carried out were commonly associated with whether or not skin cancer was perceived to be a risk for sporting competitors. For example, because hockey and soccer are typically referred to as 'winter sports', participants tended to perceive the risk as lower than sports that take place during the hotter summer months. However, some officials acknowledged that UVR levels in Queensland can remain high throughout the year, and suggested that winter sport competitors might be unaware of the risk of skin cancer and might therefore take fewer precautions:

*…I think because hockey is supposed to be a cooler sport and played in the cooler months, people aren't as worried, even though they should be, about sun protection. … it's like all winter sports, people think they don't get sunburnt in winter but they do…* (Hockey).

### Logistical and practical considerations

#### Limited resources

It was common for club officials to report that their clubs had many priorities that competed for limited resources, especially for clubs run entirely by volunteers. A lack of financial resources was perceived to be an issue for clubs, with officials commenting

that providing sun protection resources to members was too expensive. For clubs with very tight budgets, even providing sunscreen was reported to be expensive and in some cases it was reported that coaches provided their own sunscreen for their team members and therefore paid for it 'out of their own pockets':

> *Everything's volunteer-based. There's only so much time and so many people. I mean at the moment I'm doing the Treasurer's job as well. So you know, I just can't do it…We're flat out getting teams on the field every week…* (Hockey).

Acquiring corporate funding for sun protection products such as sunscreen and uniforms was reported to be difficult, although several lifesaving club officials indicated that their clubs received national corporate sponsorship for sun protective resources such as sunscreen.

### *Availability of shade at sporting parks and venues*

A lack of shade and variation in the quality of shade facilities available at venues was a barrier that was perceived to affect shade use by competitors. Tennis officials identified a lack of tennis facilities in the local community, and where there were facilities, they were reported to have been built 20 to 30 years ago when shade provision was not a priority. For surf lifesaving clubs in particular, it was seen to be difficult to provide adequate shade for competitors and spectators:

> *…there are tents there but it's not possible for everyone to be under a tent but they encourage people when they get a break to get under the tent and, um, drink plenty of water and keep under that shade. But it's not possible to keep everyone under there all the time* (Surf Lifesaving).

### *Logistical barriers to sun protection*

Lack of control over shade facilities at sporting venues was perceived to be a barrier to encouraging sun protection practices among competitors. For example, facilities could be owned by private individuals or companies, and sporting clubs could have limited control over the shade that is provided at such venues:

> *We don't have much control over it because we don't operate the Centre. And there's certainly a perceived lack of shade around the courts and outside the courts… We don't operate [the Centre] and we can't have much say so…it never gets to the top of the priority list …* (Tennis).

### *Clothing restrictions and competition scheduling constraints*

Some club officials reported that there was little that could be done by the club to encourage certain sun protective behaviours in young adult competitors, due to regulations which restrict the nature of clothing worn during competition, and a lack of control over the times that competitions are scheduled. Officials suggested that sunscreen was one of the few modes of sun protection that could be practically encouraged among competitors by the club:

> *…there are limits to the physical things that we can do, but the use of sunscreen is an obvious one and that's something that we really push* (Soccer).

### *Concerns about junior club members*

A salient theme that emerged across the sporting clubs was that the sun protection efforts needed to be focused more on junior competitors within the clubs. This was reflected in the sun protection practices that were implemented in clubs, which often targeted junior members, such as reminding about using sunscreen, the coach or captain carrying sunscreen with them for junior players, and newsletters reminding parents about sun protection for their children.

> *I think that when they're younger, the coaches push more for you know, bring drink bottles, bring sun cream, that sort of thing but once they get to a certain age, for some reason they don't worry about it* (Surf Lifesaving).

It was assessed that senior competitors were more aware of sun protection issues:

> *I know we would focus more on the younger players, rather than the older players. And the reason we would do that is because generally the younger players take the attitude it won't happen to me and the older players should have seen enough publicity and be aware of the risks involved than the younger ones* (Tennis).

### *Reciprocal responsibilities of clubs and participants*

A strong theme emerging from the interviews was that responsibility for sun protection should be shared by both the club and participants. This involved club efforts that encourage and facilitate effective sun protection practices of its members combined with members' acknowledgement of the importance of sun protection and adoption of appropriate means of protection during sporting competition. For example, while the club may provide sunscreen it was the individual's responsibility to use it, especially in the case of adult players.

> *There's a role for the committee but there's a limit to what you can do … It's not like in a school where if you don't have your hat you can't go out and play … With adult fixture players and social players we certainly can't go out there and tell them to get off the court unless they wear a hat when they're adults. They've got to take responsibility for themselves, basically* (Tennis).

Further, clubs felt that they were limited in the extent to which they could enforce their members to use sun protection.

> *It's just we can't hold them over a barrel and make them do it. That's the only thing. So it's their call really at the end of the day* (Surf Lifesaving).

## Discussion

Skin cancer is one of the most preventable cancers, but sport participation might increase exposure to the sun, and thus skin cancer risk (Lawler, Sugiyama & Owen 2007). Interviews with sporting club officials generated salient themes related to the ecological perspectives that guided the study (McLeroy et al. 1988; Sallis & Owen 2002). Individual, social and environmental influences on sun protective behaviour in outdoor sporting clubs were developed. These multiple levels of influence might usefully be considered in the development and implementation of sun protection policies and interventions in sporting environments.

Club officials perceived sun protection as an important issue. There was high awareness of skin cancer risk in Australia, the duration of time spent in the sun in some sports, and seasonal variations in UV exposure. For some officials, sun protection was perceived as more important for junior rather than for senior players. Educational initiatives might be needed to help to dispel myths about exposure particularly for high UVR climates, where regardless of season or the length of time spent competing, sun protection should be utilised all year round (Stanton, Moffatt & Clavarino 2005). In addition, sun protection needs to be perceived as important for adults, as well as for children (Crisp & Swerissen 2003; Dobbinson, Borland & Anderson 1999).

Sun protection was clearly an extremely high priority for surf lifesaving, where there are formal, 'top-down' communications, and compliance and consistency processes around sun protection, highlighted by the high level of sun protection policy implementation. Surf lifesaving clubs are unique in that they are not only sporting clubs, but are closely anchored within their peak body, which is a large corporate organisation with risk management and a duty of care as core responsibilities (Earl & Tenkate 2006). Specifically, surf lifesaving clubs have a sun protection policy that is easily accessible by all, it is handed out to all members each year in their handbook, and is also available on the Internet. Surf lifesaving as a body are committed to ensuring that all members who participate in surf lifesaving activities are both informed

and protected against the harmful effects of the sun's UVR whenever they are outdoors. Specific examples of this risk management policy include requirements for uniforms that are sun safe, with a UVR protection factor (UPF) of 50 or more; instructions to members that when they are on beach patrol that they must use all existing natural shade, and that patrol and club captains must enforce these policies.

For the other sports (hockey, soccer, tennis), there were less clear communication processes around sun protection, and policy implementation was less consistent. However, there were a number of informal practices highlighted (for example, provision of sunscreen and verbal reminders), which were more often targeted at children and younger players. These findings highlight the efforts that such clubs are making towards sun protection, but strong policy support to formalise these practices is needed. For example, there should be clear communication and guidelines for implementing sun protection practices between peak bodies, associations and clubs, in order for policies to advance from development to being well-integrated and part of the relevant sporting culture (Crisp & Swerissen 2003), as was found to be the case for surf lifesaving.

Within each sport, there were specific issues that influenced sun protection (for example, scheduling, clothing restrictions, safety, limited resources). Therefore, behaviour-specific and multi-level policies (McLeroy et al. 1988; Sallis & Owen 2002) are needed that take into account the resources available and the nature of the individual sport (for example, players are unable to wear sunglasses or hard-peaked hats in soccer or hockey for safety reasons). The resource, logistical and practical barriers for sun protection that are unique to each sport must be considered. Recently in Australia, sponsorship funds provided by health promotion foundations have been used as leverage for relevant environmental and policy changes in particular sporting settings (Crisp & Swerissen 2003). Such health-agency sponsorships have had positive effects on environmental, policy and educational measures designed to prevent skin cancer (Dobbinson, Borland & Anderson 1999). Providing support for sporting organisations to gain sponsorship from health agencies for more resources would be an important component of policy implementation.

Sun protection is clearly part of surf lifesaving's culture and the social norms, which have taken many years to develop. In order for other sports to achieve cultural and structural change, a programmatic approach is needed that is tailored to the sport, has clear expectations, a realistic time frame, and strong support, is focused on policy development and implementation, and puts processes in place for monitoring and evaluation (Cancer Council Australia 2004; Dobbinson, Hayman & Livingston 2006; Glanz & Saraiya 2005; National Health and Medical Research Council 1997; Crisp & Swerissen 2003). Accordingly, it will take time for such changes in the social and cultural climates within clubs.

Duty of care and reciprocal responsibility are important in the sporting context and are clearly part of surf lifesaving culture. Duty of care is a strong motivator for implementing health promotion policies (Earl & Tenkate 2006; National Health and Medical Research Council 1997). Reciprocal responsibility, which several of the club officials identified explicitly, emphasises that clubs can encourage and facilitate sun protection practices, and players can also take responsibility for their own sun protection measures. Using a programmatic approach for policy implementation, where duty of care and reciprocal responsibility are integral parts, could lead to greater sun protection initiatives to be integrated into club norms, as is the case with surf lifesaving.

There are a number of limitations to the study. Only one official from each club was

interviewed, so there is a limited range of perceptions relating to sun protection issues for the different sports. The study relied on self-reports about the existence of a formal sun protection policy without an audit of the actual policy (Glanz & Saraiya 2005). The sports selected were only a sample and were not meant to be representative of other sports, so there is a need for further research on other outdoor sports. Further, the positions that officials held in the club differed, thus, those individuals might hold different perspectives from others depending on their role. This mix of roles also reflects some of the barriers faced in conducting research with sporting bodies. For example, participants were often volunteers with limited time. Communication and engagement between clubs and peak bodies, which would have provided insights into communication channels, capacity for policy development and avenues for policy implementation were not investigated. Further studies are needed to elucidate some of the main themes, such as the perceived obligation and role of the club in reciprocal responsibility. Future research is also needed to understand better the interrelationships between these two important health behaviours; physical activity and sun protection. By better understanding these relationships, there is considerable potential for new public health messages to take a combined approach to these two health behaviours.

Sporting environments are settings for sun protection policies and initiatives that can impact on sun protective behaviour among sportspeople and the local community. It is thus essential to address the resource, logistical and practical barriers to sun protection unique to each sport from the onset of policy development. This study highlights what such initiatives want and require specifically, and how these can vary between sports.

## Acknowledgments

This project, Physical activity, sun exposure and the sporting involvements of young Queensland adults: Identifying new opportunities for social and environmental intervention, was supported by a grant from Queensland Health (Grant Number: CP2/HEA027/3186/HIR). We would like to thank Pheobe Keary and the club officials for their contributions to this project.

## References

Armstrong, B.K. & Kricker, A. 2001, 'The epidemiology of UV induced skin cancer, *Journal of Photochemistry and Photobiology B: Biology*, vol. 63, pp. 8-18.

Australian Bureau of Statistics 2004, *Involvement in Organised Sport and Physical Activity, Australia*, Australian Bureau of Statistics, Canberra.

Australian Institute of Health and Welfare Australasian Association of Cancer Registries 2004, *Cancer in Australia 2001*, AIHW, Canberra.

Bandura, A. 1986, *Social Foundations of Thought and Action: A Social Cognitive Theory*, Prentice-Hall, Englewood Cliffs, NJ.

Cancer Council Australia 2004, *National Cancer Prevention Policy 2004-06*. The Cancer Council Australia, Sydney.

Cerin, E., Leslie, E., Bauman, A. & Owen, N. 2005, 'Levels of physical activity for colon cancer prevention compared with generic public health recommendations: Population prevalence and sociodemographic correlates', *Cancer Epidemiology, Biomarkers and Prevention*, vol. 14, pp. 1000-2.

Crisp, B. & Swerissen, H. 2003, 'Critical processes for creating health-promoting sporting environments in Australia', *Health Promotion International*, vol. 18, pp. 145-52.

Dobbinson, S., Borland, R. & Anderson, M. 1999, 'Sponsorship and sun protection practices in lifesavers', *Health Promotion International*, vol. 14, pp. 167-76.

Dobbinson, S., Hayman, J. & Livingston, P. 2006, 'Prevalence of health promotion policies in sports clubs in Victoria, Australia', *Health Promotion International*, vol. 21, pp. 121-9.

Driedger, S.M., Gallois, C., Sanders, C.B. & Santesso, N. 2006, 'Finding common ground in team-based qualitative research using the convergent interviewing method', *Qualitative Health Research*, vol. 16, vol. 1145-57.

Earl, C. & Tenkate, T. 2006, 'Sun protection policies and practices of sporting and recreation organisations and clubs in Queensland', *Environmental Health*, vol. 6, pp. 43-52.

Glanz, K. & Saraiya, M. 2005, 'Using evidence-based community and behavioral interventions to prevent skin cancer: Opportunities and challenges for public health practice', *Preview of Chronic Diseases*, vol. 2, pp. AO3.

Glesne, C. & Peshkin, A. 1992, *Becoming Qualitative Researchers*, Longman, White Plains, NY.

Lawler, S., Spathonis, K., Eakin, E., Gallois, C., Leslie, E. & Owen N. 2007, 'Sun exposure and sun protection behaviours among young adult sport competitors', *Australian and New Journal of Public Health*, vol. 31, pp. 230-4.

Lawler, S., Sugiyama, T. & Owen, N. 2007, 'Sun exposure concern, sun protection behaviors and physical activity among Australian adults', *Cancer Causes and Control*, vol. 18, pp. 1009-14.

McLeroy, K.R., Bibeau, D., Steckler, A. & Glanz, K. 1988, 'An ecological perspective on health promotion programs', *Health Education Quarterly*, vol. 15, pp. 351-77.

National Health and Medical Research Council (NHMRC) 1997, *Health-promoting Sport, Arts and Racing Settings: New Challenges for The Health Sector*, Australian Government Publishing Service, Canberra.

Sallis, J. & Owen, N. 2002, 'Ecological models of health behavior', in *Health Behavior and Health Education*, 3rd edn. eds K. Glanz, B. Rimer, F. Lewis, Jossey-Bass, San Fransisco.

Sport and Recreation Queensland 2001, '*10 most popular activities in Australia by age group*', Exercise, Recreation and Sport Survey, Queensland Government, <http://www.srq.qld.gov.au/ popular_ activities.cfm>, 3 November 2004.

Stanton, W.R., Moffatt, J. & Clavarino, A. 2005, 'Community perceptions of adequate levels and reasons for skin protection', *Behavioural Medicine*, vol. 31, pp. 5-15.

Correspondence to:
Sheleigh Lawler
Cancer Prevention Research Centre
School of Population Health
Level 3, Public Health Building
Herston Road, Herston, Queensland
AUSTRALIA
Email: s.lawler@uq.edu.au

Back to TOC

# Reflections on Experiential Learning in the Bachelor of Public Health

**Paul Jackson, Diane Robertson and Glenda Verrinder**

***School of Public Health, La Trobe University, Bendigo***

*Field placements are an important part of vocational courses offered by universities. They provide an opportunity where theory informs practice and in turn, practice informs theory. This contributes to the overall development of the student, the academic and field mentors, best practice in the field, the relevance of the course, and respect for the roles played in the maturing of the student. Experiential learning is a student-focused approach which engages the learner in action, reflection and transformation (Beard & Wilson 2002). This paper reflects on two field experience units where this approach to learning opportunities for maturation, and the development of critical, pragmatic and systems thinking is planned for by the student, the academic mentor and the field mentor with the primary aim of the student achieving workplace capability.*

**Key words:** *Field Experience; Experiential Learning; Environmental Health Learning; Public Health Learning; Capability; Maturity*

Field placements are integral to many vocational courses offered by universities. Ideally, field placements are designed to facilitate the personal and professional development of students. Placements should not be merely living through a set of experiences.

Field placements provide the academic mentor, the field mentor and the student with a mechanism whereby a feedback loop can be established, where theory informs practice and in turn, practice informs theory. This feedback loop contributes to the overall development of the student. The 'spin-off' is that it also contributes to the development of the academic and field mentors, best practice in the field, the relevance of the course, and respect for the roles played in the maturing of the student.

The philosophy that can guide the development of the learning encounter to facilitate personal and professional development is experiential learning:

> *The Experiential Learning model pursues a framework for examining and strengthening the critical linkages among education, work and personal development. It offers a system of competencies for describing job demands and corresponding educational objectives and emphasizes the critical linkages that can be developed between the classroom and the 'real world' with experiential learning methods. It pictures the workplace as a learning environment that can enhance and supplement formal education and can foster personal development opportunities. And it stresses the role of formal education in lifelong learning and the development of individuals to their full potential as citizens, family members, and human beings* (Kolb 1984, p. 4).

Theoretically, experiential learning is a student-focused approach which engages the learner in action, reflection and transformation (Beard & Wilson 2002). The process involves the whole person through thought, feelings and action. Its strength is that it provides an underpinning philosophy that acts as a thread joining many of the learning theories together in an integrated whole (Beard & Wilson 2002). It can be incorporated into primary, secondary and tertiary studies and forms the basis of many adult learning programs. However, 'Experience may underpin all learning but it does not always result in learning' (Beard & Wilson 2002, p. 17). Students need to reflect on what happened, how it happened and

why. There are three primary outcomes to aim for in planning and implementing a field experience placement: developing capability and maturity; developing critical and pragmatic thinking; and developing systems thinking (Ashworth & Saxton 1992).

The role of public health practice and education is being re-examined world-wide in light of events such as bioterrorism, as well as increased public awareness of issues such as immunisation, chronic infections, SARS, bird flu, lifestyle disease and anthrax. Some reports suggest that the public health workforce is under-prepared to meet emerging threats and challenges (Bartee et al. 2003). Providing environmental and public health undergraduates with appropriate workplace skills is seen as vital to this profession's future. There is a burgeoning number of ways in which public health practitioners are being trained and this is occurring in a variety of institutional settings (Beaglehole & Dal Poz 2003). Nevertheless, there are recognised limitations to public health training, particularly around experiential learning. These limitations include 'the emphasis on institution-based teaching and didactic training and the lack of field experience', and 'the lack of experienced field-based senior public health practitioners as role models and the absence of apprenticeship experience' (Beaglehole & Dal Poz 2003, p. 4).

## Terminologies: A Rose by any other Name?

Within the paradigms of university education, experiential learning comes under a range of terminologies and titles such as: Field Experience, Field Placement, Practicum, Work Experience, Industry Based Learning, Clinical Placement, Work Placements and Cadetships. However, no matter what the terminology, there are a number of common objectives shared by most experiential learning programs, including:

- Providing students with knowledge of the varied approaches used in human-services programs;
- Helping students extend self-awareness and achieve a sense of professional identity;
- Broadening students' sociocultural understanding of the individual, the family, the community, and relevant social systems;
- Assisting students in recognizing and respecting cultural diversity and offering ways to use this understanding in practice;
- Helping students expand their awareness of professional role relationships within their organisation as well as the agency's role with the community (Corey & Corey 1998, p. 35).

There is also a variety of placement models, some quite formal and with rigid procedures, others less so, by which universities are able to put their students into agencies. These include through teaching hospitals, centralised allocations, regional arrangements, one-on-one approach, and 'old-boy' networks.

This paper reflects on two field experience units within the Bachelor of Public Health at La Trobe University, Bendigo, in which opportunities for maturation, and the development of critical, pragmatic and systems thinking are planned for by the student, the academic mentor and the field mentor. The primary objective is for the student to achieve workplace capability. We concur with Smith and associates (2001) who suggest that there is clear evidence that familiarity with the place of work is a beneficial impact on future vocational practice. There is also evidence that placements play a key role in training in health related fields, developing not only skills and knowledge but also enabling undergraduates

to feel confident in their ability to enter the workforce (Edwards et al. 2004; Lee & French 1997; Wotton & Gonda 1999).

## Experiential Learning

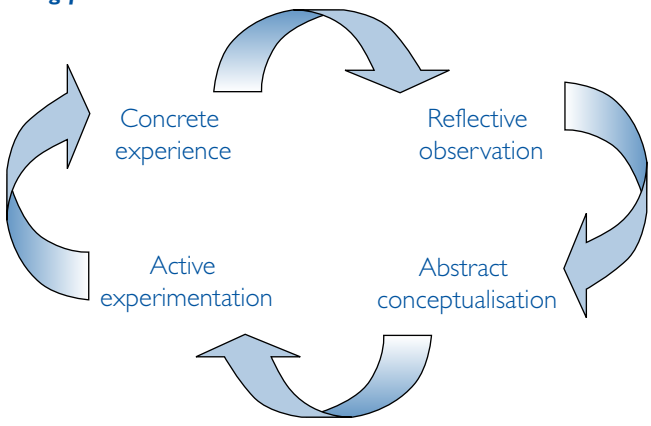
Experiential learning is based on the assumption that people learn differently. There have been a number of influential experiential learning theorists who each present the learning process as stages in a feedback loop. For example, Kolb's Learning Cycle includes i. concrete experience - learning from feelings related to a specific experience; ii. reflective observation - learning by watching and listening; iii. abstract conceptualization - learning by thinking; and iv. active experimentation - learning by doing (in Miller et al. 2005).

There have been criticisms of experiential learning models. For example, Jarvis (1987) criticised Kolb's learning cycle as simplistic and disagreed with the premise of sequential learning. He also criticised the model for its lack of attention to reflection and different learning approaches (in Miller et al. 2005). Other criticisms include a lack of attention to the social elements of learning which have particular relevance to field experience (Baumgartner in Miller 2005). Beard and Wilson (2002) present three criticisms of experiential learning, first, the lack of direction attributed to experiential learning; second, the perceived subjectivity of experiential learning; and finally, the limitations of the learning cycles.

In our experience, the problem of a potential lack of direction is perhaps the easiest to overcome and is accomplished through adherence to the guidance of the course and unit aims and objectives. Personal learning objectives are developed within this context. The issue of subjectivity and objectivity is strongly debated; however, the way people experience phenomena and learn is both a personal and social construction. Again, unit objectives and personal learning objectives assist in addressing some objective and subjective elements of field experience. Further, we are of the view that models are developed, refined and reviewed in order to clarify phenomena. They are often oversimplified for easy understanding and need to be reflected upon within a particular context. One size does not fit all but Kolb's model although simple, provides guidance for integrating experiential learning in student learning opportunities.

Brown et al. (1997) adapted Kolb and associates' (1974) learning process and constructed a spiral learning process which overcomes some of the criticisms levelled above, in particular, the criticism about sequential learning. In Brown's view it is hypothesised that learners may enter the spiral at different points and learning is a continuous spiral (Brown et al. 2005, pp. 21-28).

***Figure 1: Spiral learning process***




*Source: Kolb 1984*

## The Bachelor of Public Health: A Case Study

Field placements play a central role in La Trobe University's Bachelor of Public Health (BPH). The BPH commenced in 1995 and in 2000 it was divided into two streams: Health Promotion and Environmental Health. The course is an innovative and flexible three year, full-time undergraduate program and can have a fourth year honours program. It is designed to equip students for a variety of careers in public and environmental health. Students undertake a common first year before making their stream choice at the end of that year. Students can also undertake a Bachelor of Public Health (Health Promotion)/Bachelor of Nursing double degree. Students in each stream study, in depth, the social and environmental factors that influence health.

The two streams have many common elements but are designed to send the students on different career paths. Nevertheless, students in both streams undertake exactly the same compulsory experiential learning components, viz: Field Experience A and Field Experience B. Field Experience A is undertaken in the 2nd semester of first year and Field experience B during the 2nd semester of the final year.

The integrity of the principles of capability and maturity; critical and pragmatic thinking; and systems thinking (Ashworth & Sexton 1992) are supported in the course by a set of objectives which help the student to link theory to practice, identify with a professional role, develop professional attributes, gain knowledge of a professional organisation, and develop personal maturity.

Field Experience A provides an introduction to field placement. Students gain an understanding of the role that agencies and health workers play in protecting and promoting health and how theoretical frameworks guide environmental and public health practice. Field Experience A acquaints students with a number of environmental and public health practitioners in a variety of settings. At the completion of first year, students decide which health stream to pursue: environmental health or health promotion. The opportunity to hear from a range of public and environmental health practitioners helps them to choose. Importantly, this unit introduces students to the concept of reflective learning. One of the requirements of this unit is that students identify their personal learning objectives and record these and their reflections on the learning experience in a journal. This encourages students to take responsibility for their own learning and helps them develop their critical and pragmatic thinking. Most Field Experience A activities are undertaken under academic supervision but the unit includes a number of self-directed components.

In Field Experience A the students are given the opportunity to:

- Develop personal learning objectives for each field experience/visit;
- Visit public and environmental health related areas and agencies and identify environmental, social and organisational factors that affect health;
- Maintain a journal of recorded experiences and information gained that is relevant to the visit/experience;
- Create visual and graphic material to provide an oral presentation about one of the field visits;
- Provide a report on field experiences/visits that demonstrates how theory is applied to practice and how organisations develop and change;
- Incorporate into their reporting international, national and state priorities regarding environmental and public health.

- Compare public health practices and strategies to societal expectations and reflect on these.

Students have the opportunity to listen to a number of health promotion and environmental health practitioners. In 2006 students visited several workplaces including a food processing plant, a gold mine to examine EPA issues, Coliban Water, a recycling facility to look at employment conditions and EPA concerns, and salinity testing of the sites around Bendigo. Students also had the chance to look at issues surrounding a Country AIDS network, men-in-sheds, community gardens, and the practice of health promotion at the state level. As well, students were required to undertake a stay at an immunisation clinic, audit a playground for safety, suggest uses for recycled water and examine nutritious choices at a take-away restaurant. All of the visits and activities are recorded by the students in a journal.

Self-reflection is an important part of experiential learning and professional competence. Diaries and journals are commonly used to help develop an understanding of oneself, both personally and professionally. A reflective journal allows students to articulate the 'ideas, perceptions, hunches, practice wisdom, joys, hardships, frustrations and failings and successes' they experience (Cleak & Wilson 2004, p. 77). By maintaining a reflective journal the students are able to record and examine their experiences. This provides an opportunity for students to examine their assumptions, values and beliefs. Importantly, they begin to recognise that reflective writing enhances reflective practice. Part of their maturation also enables them to appreciate that 'unexamined practice is a practice hardly worth doing' (Cleak & Wilson 2004, p. 77). The importance of maintaining a professional journal for reflective practice is a core part of both Field Experience A and Field Experience B. It provides i. a conscious engagement with the learning cycle of concrete experience - learning from feelings related to a specific experience; ii. reflective observation - learning by watching and listening; iii. an abstract conceptualisation - learning by thinking; and iv. active experimentation, is best achieved through this method. As part of the requirements for Field Experience B the professional journal is to be viewed as an important data base to inform the written report of their placement project. The emphasis on reflective learning established in the first year of the course is thus reinforced and enhanced by use of their journal, the formal sessions with their academic and placement supervisors, and in the university class sessions.

In Field Experience B students complete 160 hours of field placement - 2 days per week for 10 weeks. This unit enables us to put into practice our resolve to meet the students' individual learning needs. The process has been refined over the past 10 years through student evaluations, feedback from the field, and critical reflection. Students are asked where they would like to do their field placement and what they would like to achieve from it. Negotiations then take place between the field mentor, the student and the academic mentor, to assess the suitability of the field placement agency, the project opportunities and the student's learning needs and abilities. A detailed manual that outlines the specific learning/teaching roles of the student, the field mentor and the academic mentor has been developed and refined in response to evaluation. Group and individual pre-practicum sessions are conducted prior to the students going into the field. Further sessions with the whole class are held twice within the semester to discuss the links the students are making between theory and practice. Again, ongoing reflection has led to this practice. Each student is required to report by email each week. The academic mentor also visits the student at their agency once or twice during the placement. Many students gain employment in the agencies

where they complete their field experience.

Field Experience B enables the student to:

- Integrate theory and practice in public and environmental health;
- Play a specific and defined role in a particular area of service delivery within a specified time frame;
- Examine public health practice and strategies employed by health organisations and health providers;
- Apply interpersonal skills where necessary (negotiation, team work, motivation, conflict resolution, decision-making and problem solving skills); and
- Compare and contrast the role of health workers in health related agencies with particular reference to preparation of the health worker for practice in public health, and the scope of the health worker.

In 2006, students participated in a variety of health promotion and environmental health placements, including the following.

Health promotion placements:

- Encouraging physical activity in the elderly;
- Healthy nutrition program in a primary school;
- Health and sexuality issues for Aboriginal youth;
- Hospital nursing staff attitudes to and understanding of health promotion;
- Health needs of working women and available times to access services;
- Men's health awareness and information;
- Forum for school teachers to promote healthy nutrition in their schools - developing materials that teachers could use;
- Asthma care for the elderly;
- Encourage the playing of tennis in low-income families who might not otherwise have this opportunity;
- Develop sexual education materials for local secondary schools ;
- Community attitudes to mining;
- Development of a new sunscreen program in children.

Environmental health placements:

- Fish speciation in seafood outlets;
- Fish speciation in food shops;
- Survey of attitudes to immunisation
- Management of health plans for DHS;
- Septic tank management and education for owners;
- Development of council web site; and
- Developing and implementing guidelines for new businesses in the council

## Experiential Learning Objective 1: Capability and Maturity

As noted earlier, the first of the three primary outcomes to aim for in planning and implementing the placement is developing capability and maturity. The word maturity is variously understood. In this article we have adopted the meaning which the

educationalist Knowles (1970) developed and Ashworth and Saxton (1992) discussed in relation to field experience (Table 1).

Students develop and become more seasoned because there are processes in place to foster maturation. Importantly, students need to be fully involved in designing the scope of the placement. Students need to be given the opportunity to take responsibility, and see that they have some autonomy, and that they must cope, co-operate, demonstrate creativity and competence; that is, become capable (Ashworth & Saxton 1992). They contact their field mentor, draft a proposal that meets both of their needs and present this proposal to the academic mentor. Finalising of the proposal is a consultative and interactive process among the three individuals.

***Table 1: Meanings of maturation***

| From | Towards |
|---|---|
| Dependence | Autonomy |
| Passivity | Activity |
| Unitivity | Taking other people's view into account |
| Ignorance | Broad awareness |
| Small abilities | Extended capacities |
| Few responsibilities | Many responsibilities |
| Narrow interests | Broad interests |
| Selfishness | Considering the general good |
| Self-rejection | Self-acceptance |
| Amorphous self-identity | Clarity of self in work role |
| Focus on particulars | Focus on principles |
| Superficial concerns | Non-petty stance |
| Imitative | Original |
| Need for certainty | Tolerance of ambiguity |
| Impulsiveness | Rationality |

*Source: Knowles 1970 in Ashworth and Saxton 1992, p. 9*

## Experiential Learning Objective 2: Developing Critical and Pragmatic Thinking 'There is nothing so practical as a good theory' (Lewin 1951)

The second of the three primary outcomes for field experience is developing critical and pragmatic thinking. All stakeholders need to be given the opportunity to explore the theory-practice-theory link. The notions of theory and practice are often polarised; however, in our view they are part of a reflective cycle of learning that becomes part of the critical, pragmatic and systems thinking development of the student. This reflection and maturation incorporates all aspects of the field experience and involves recognising phenomena in the field and using theoretical constructs to reflect on these phenomena. It may also mean recognising the limitation of a theory in this context.

It is tempting to think of these as separate ways of thinking but in fact they are part of the same analysis. A job has to be done. The student is aware that there are robust theoretical ways of doing the job. There are also practical constraints, for example, limitations on time and money, or organisations that are not learning organisations and so incapable of incorporating new ways of doing a job. Ideally, both the critical and pragmatic analyses of how the job is to be done can be satisfied; however, the most important thing is that the student is able to reflect on the outcome.

In Field Experience A students are asked to reflect on their observations using the theoretical constructs such as the World Health Organization's *Healthy Cities* principles and the Ottawa *Charter for Health Promotion*. Students identify their personal learning objectives before visiting, listening to and observing public and environmental health practitioners. The students observe, record and reflect on their experiences with these practitioners and whether their learning objectives were met. This reflection is achieved by examining each experience and applying one or more of these theoretical frameworks.

In Field Experience B students participate in the public health workforce and contribute to the organisation in a meaningful way. They are no longer merely observers who record and reflect on their experiences. The observations and reflections that students make in this part of the course continue to be informed by theoretical constructs but

they are also informed by the act of 'doing'. From the ability to observe the relationship between theory and practice students are now able to play an active role as public health practitioners. Through reflection on their practice, and that of the host organisation, students are actively involved in linking theory to practice and developing critical and pragmatic thinking.

## Experiential Learning Objective 3: Developing Systems Thinking

The third primary outcome of field experience is to develop and demonstrate the importance of systems thinking. At the simplest level the students need to see the organisation as a whole, operating in a complex web of interrelationships with the outside world. Students are required to demonstrate a clear understanding of the organisation in which they are completing their field placement. When visited by their academic mentor they are required to identify the mission, vision, objectives and funding of the organisation. In addition they are expected to understand the roles of staff members within the organisation. In many cases students are able to experience first-hand, the connections between related organisations as our students often meet fellow students at regional meetings, conferences and other forums while on placement. In some cases the students are involved in projects with more than one organisation. Contact with each other at meetings demonstrates that the various organisations are working as a whole system.

Field experience placement skills help in other units and also in workplace and life skills. The systems thinking comes to fruition when the students look at the workplace components such as organisational structure and dynamics, networking, and the large array of people involved in most activities; their theoretical skills can be transferred into a variety of settings. Students are now working on 50 different work projects in 30 different workplaces, such as social engagement of the elderly from different ethnic groups to fish speciation in fish and chip shops.

## Conclusion

New insights or learning do not automatically emerge from experience. As we have discussed, one size does not fit all and further, the length of the field placement is rendered irrelevant if the program is not integral to the whole course and is not planned to enable the student to reflect on experiences. If appropriately planned, field experience of up to one year, either as a sandwich year or at the end of a course, provides ideal opportunities for maturation, and the development of critical, pragmatic and systems thinking, and thus capability.

### References


Ashworth, P. & Saxton, J. 1992, *Managing Work Experience*, Routledge, London.

Bartee, R., Winnail, S., Olsen, S., Diaz, C. & Blevins, J. 2003, 'Assessing competencies of the public health workforce in a frontier state', *Journal of Community Health*, vol. 28, no. 6, p. 459.

Beaglehole, R. & Dal Poz, M. 2003, 'Public health workforce: Challenges and policy issues', *Human Resources for Health*, vol. 1, p. 4.

Beard, C. & Wilson, J. 2002, *The Power of Experiential Learning. A Handbook for Trainers and Educators*, Kogan Page, London.

Brown, V. ed. 1997, *Managing for local sustainability: Policy, problem-solving, practice and place*, National Office of Local Government, Canberra.

Brown, V., Grootjans, J., Ritchie, J., Townsend, M. & Verrinder, G. eds. 2005, *Sustainability and Health: Supporting Global Ecological Integrity in Public Health*, Earthscan, London.

Cleak, H. & Wilson, J. 2004, *Making the Most of Field Placement*, Thomson, Southbank.

Corey, M. & Corey, G. 1998, *Becoming a Helper,* Brooks Cole, Pacific Grove.
Edwards, H., Smith, S., Courtney, M., Finlayson, K. & Chapman, H. 2004, 'The impact of clinical placement location on nursing students' competence and preparedness for practice', *Nurse Education Today*, vol. 244, pp. 248-55.
James, E., Talbot, L. & Kent, M. 2006, 'How an evidence-driven audit cycle model can be used to assist quality assurance in environmental health education', *Environmental Health*, vol. 63, pp. 55-61.
Jarvis, P. 1987, *Adult Learning in the Social Context*, Croom Helm, London.
Knowles, Malcolm S. 1970, *The Modern Practice of Adult Education: Andragogy versus Pedagogy*, Association Press, New York.
Kolb, D. 1984, *Experiential Learning: Experience as the Source of Learning and Development*, Prentice Hall, New Jersey.
Kolb, D., Rubin, I. & McIntyre, J. 1974, *Organizational Psychology: An Experiential Approach,* Prentice Hall, New Jersey.
Lee, C.H. & French P. 1997, 'Education in the practicum: A study of the ward learning climate in Hong Kong', *Journal of Advanced Nursing*, vol. 26, pp. 455-62.
Lewin, K. 1951, *Field Theory in Social Science: Selected Theoretical Papers*, ed. D. Cartwright, Harper & Row, New York.
Miller, J., Kovacs, P., Wright, L., Corcoran, J. & Rosenblum, A. 2005, 'Field education: Student and field instructor perceptions of the learning process', Special Section: Field education in social work, *Journal of Social Work Education*, vol. 411, pp. 131-46.
Smith, S., Edwards, H., Courtney, M. & Finlayson, K. 2001, 'Factors influencing student nurses in their choice of a rural clinical placement site', *Rural and Remote Health*, vol.1, p. 89, <http://rrh.deakin.edu.au>.
Wotton, K. & Gonda, J. 1999, Redesigning clinical experience for undergraduate nursing students: An innovative model, paper presented to the HERDSA Annual International Conference, Melbourne, 12-15 July 1999.

Correspondence to:
Paul Jackson
School of Public Health
La Trobe University
Bendigo, 3550
AUSTRALIA
Email: paul.jackson@latrobe.edu.au

Back to TOC

# The Role of Stakeholders in HIA: A Landfill Site and Housing Development in Mundijong, Western Australia

**Marie Little[1], Jaya Earnest[1], Jeffery Spickett[2] & Dianne Katscherian[3]**

***[1]Centre for International Health, Curtin University of Technology, [2]WHO Collaborating Centre in Environmental Health Impact Assessment, School of Public Health, Curtin University of Technology, [3]Environmental Health Directorate, Department of Health, Western Australia & Murdoch University***

*The use of Health Impact Assessment (HIA) as a tool to identify and manage issues relating to health has not been widely adopted in Western Australia. Health Impact Assessment methodology was applied to two concurrent developments in the Shire of Serpentine Jarrahdale, Western Australia. Potential health impacts of the expansion of a sanitary landfill adjacent to a proposed housing development were identified following a literature review and stakeholder interviews. Recommendations to assess the risk to the community in the housing estate through quantitative analysis, and risk management strategies were provided to the Shire. The ability of an existing stakeholder group for the landfill, the South Cardup Landfill Stakeholder Consultative Group, to resolve concerns of the community relating to environmental and social issues were also evaluated. Recommendations to improve collaborative decision making were provided to the Stakeholder Group using the Framework for Democratic Science. The outcomes of the HIA informed the Shire of potential health impacts to assist decision making during the development application process and the design of a local District Structure Plan.*

**Key words:** *Health Impact Assessment; Sanitary Landfill, Housing Estate, Stakeholders*

## Health Impact Assessment

A Health Impact Assessment (HIA) is "the process of estimating the potential impact of a chemical, biological, physical or social agent on a specific human population system under a specific set of conditions and for a certain timeframe" (enHealth 2001 p. v). The Western Australia State Sustainability Strategy, *Hope for the Future*, recommends that HIAs are adopted by health authorities to support sustainable development (Government of Western Australia 2003), however, implementation of HIA by local government has not been widely adopted.

The Shire of Serpentine Jarrahdale (SJ Shire) Environmental Health Services team recognised an opportunity to incorporate a HIA for two concurrent developments, the expansion of an existing landfill facility, and a proposed housing development adjacent to the landfill in Mundijong Western Australia. The health impacts identified would then be available to inform decision making for conditions for approval and to guide the development of a District Structure Plan for the suburb (SJ Shire 2006a). This study identified potential health impacts of the developments through a literature review and stakeholder interviews (University of New South Wales 2006). As the focus of this study was stakeholder involvement, quantitative assessment of factors such as air quality and noise modelling was not undertaken.

The aims of the study were to:

- Identify the potential health impacts of concern to the stakeholder group;

- Evaluate the ability of the stakeholder group to resolve concerns of the community regarding social and environmental issues; and,

- Recommend strategies to enhance stakeholder involvement and hence promote participatory decision making.

## The Landfill Site and Housing Development

The landfill expansion was approved by the WA Minister for the Environment in 2006 despite Council opposition (SJ Shire 2006b). The approval was subject to a number of conditions that included a review of the existing stakeholder group for the landfill site (South Cardup Landfill Stakeholder Consultative Group). South Cardup Landfill is a privately owned landfill that is currently operating with a Class II license; the proprietors sought to expand two existing cells into one super-cell that extends the life of the landfill for a further seven years (Environmental Protection Authority 2006). The landfill accepts clean fill, type 1 and 2 inert wastes, putrescible waste and type 1 and 2 special waste (Western Australia Department of Environment 2004). This waste includes municipal waste, asbestos, animal manure and carcasses, office waste and demolition waste (Western Australia Department of Environment 2005). The Urban Pacific site is an area of approximately 504 hectares located in the 'Whitby' locality in Serpentine Jarrahdale and will potentially house up to 8000 new inhabitants as close as 850 metres to the landfill (Office of the Appeals Convenor, Environmental Protection Act 1986 2006).

## Stakeholder Consultative Group

The South Cardup Landfill Stakeholder Consultative Group was formed in late 2004 with the objective of meeting monthly to discuss community concerns relating to the landfill. The initial group included an SJ Shire officer and council member, representatives from the Department of Environment, Western Australian Landfill Services (WALS), a representative for the Contaminated Sites Alliance and the local ratepayers association (Stass Environmental 2004). The Minister for the Environment approved the expansion of the landfill, and gave the following recommendations to the stakeholder group:

1. A review of the current structure and terms of reference for the Stakeholder Consultation Group;

2. Appointment of an independent chairperson for the Stakeholder Consultation Group in consultation with stakeholders;

3. Identification of relevant stakeholders;

4. An outline of opportunities to discuss the management plans, monitoring programmes and studies with stakeholders;

5. Reporting on environmental performance; and,

6. A review of current methods of communication with stakeholders and the community (Minister for the Environment 2006, p. 3).

These issues were evaluated along with the group's ability to resolve issues of environmental and social concern.

## Methods

A health impact assessment of the South Cardup Landfill expansion and the Urban Pacific Housing development in Mundijong was undertaken by the first author in early 2007. Health Impact Assessment methodology described by the enHealth Guidelines (2001) was the framework that

underpinned the assessment. A preliminary screening assessment indicated that the projects were of an appropriate scale and interest to conduct a HIA. Scoping of the projects was conducted using the following steps:

1. A literature review that generated a comprehensive list of positive and negative health impacts of similar projects in Australia and abroad;

2. Profiling of the projects that included an analysis of population trends for the suburb, given the population at risk would largely consist of the future residents of the housing estate;

3. Semi-structured interviews with stakeholders based on focus questions that compared concerns of group members with best practise principles described in the literature. Six telephonic interviews were conducted with members of the South Cardup Landfill Stakeholder Group (Abramson & Abramson 1999).

4. The overall evaluation of the stakeholder group was based on these interview results, literature review, and analysis of the minutes of the meetings between stakeholder members;

5. Finally, recommendations to improve collaborative decision making were proposed and were based around the Framework for Democratic Science (Charnely 2000).

Quantitative data are unavailable for this study as the proponents' had not yet undertaken analysis such as water sampling or odour modelling as part of the Shire's development application conditions for approval. This type of quantitative assessment was outside the scope of this study due to time and financial constraints (Donelly, Dalal-Clayton & Hughes 1998).

## Results

### Screening

The Screening Tools identified in the enHealth HIA Guidelines (2001) indicated that a HIA would be suitable for both developments. A literature review examined possible factors that would lead to positive or negative health impacts, and a health impact matrix was developed that identified the factor, health impact, population at risk and probability of occurrence (enHealth 2001).

### Scoping

The landfill expansion has several environmental factors which might influence health that include air quality (biogases, volatile organic compounds [VOCs], odours, litter and dust), along with noise, fire, vermin and emission of leachate. Social factors that might influence health include declining property values, access to employment, impact on vulnerable groups, the visual impact of the landfill, and management of complaints regarding the landfill by the proprietor and government agencies (Health Canada 2005). Negative health impacts experienced by communities adjacent to landfill can include neurological and respiratory conditions, with decreases in self reported symptoms correlating with distance from the landfill (Wright 2003).

The housing development has a number of environmental and social factors that will influence health which include noise, airborne waste, fire risk, physical activity of inhabitants, vector breeding sites, retention of native landscape and water bodies (Western Australian Planning Commission 2000). Social factors that influence health include suburb density and housing affordability, community facilities, street lighting, transport, access to facilities, economic and employment opportunities, and local development and community networks (Community and Disability Services 2004).

### *Profiling*

Trend data indicate that the biggest increases in the population of SJ Shire will be in the elderly and the 0-4 age groups (Stoneham and Associates 2005). These groups are vulnerable to environmental health risks due to compromised or underdeveloped immune status (enHealth 2002). A qualitative assessment of health behaviour factors would have contributed to the study, however, as the population does not yet reside at the housing estate this was not undertaken (Institute of Public Health Scotland 2001).

## Risk Assessment and Management

Risk assessment and management requires quantitative assessment of factors such as noise, odour and gas (Department of Health 2006) to guide appropriate decision making. Health impacts identified in this study were used to inform SJ Shire during the development application process. SJ Shire requested noise, odour and gas assessments from the landfill proprietor along with other conditions. The matter was reviewed through a State Administrative Tribunal (SAT) following a failure to negotiate with the proponent. The expansion of the landfill was approved through this process, and improvements to the environmental monitoring conditions and standards include gas and odour modelling from all potential sources of the landfill on a regular basis during its operation (Government of Western Australia 2007).

## Stakeholder Evaluation

Some stakeholders have presented concerns in meetings that subsequent analysis by the proponent has lacked scientific rigour in determining actual risk (not carried out to the relevant standard), such issues should be addressed to improve the risk communication process (quality and comparability of data). Issues of environmental concern presented by the stakeholder members include whether contamination has occurred to groundwater, surface water and air, and what type of remedial action will be taken (Stass Environmental 2005). Bore monitoring results that are carried out to determine potential leachate contamination of groundwater have lengthy delays in reporting results to stakeholders which has limited their ability to evaluate this information. This has occurred on occasions where resampling of bore sites is required. One stakeholder believed this was an opportunity for anomalous results to be rectified. Before results were reported back to the group.

The detection of elevated levels of arsenic in a bore water sampling site, along with methane and benzene, toluene, ethylbenzene and xylene (BTEX), have concerned some stakeholders as these are signatures of leachate and might be indicative of leachate contamination of groundwater (Stass Environmental 2005). Some stakeholders believe that the Department of Environment and Conservation (DEC) should have greater input at the stakeholder meetings with regard to these results. In order to improve the interpretation of the data an independent person from the process (approved by both parties) could present information, along with the consultants, to improve the issues of trust and credibility of the data (National Environment Protection Council 1999).

Some stakeholders believe that the risk is not being properly managed and that the source of increased levels of some metal compounds and other contaminants reported in the groundwater sampled is consistent with leachate signatures and is not naturally occurring as suggested by the consultants. Further, the issue of air contamination (including methane and VOCs) has not been assessed by regulatory authorities by any quantitative assessment methods. The proponent has provided a facilitator for the group and has had environmental monitoring conducted by independent consultants. Some of the stakeholders have trust issues with this

as the proponent is paying these parties to present information and coordinate the flow of information. Further, if the bore quality sample results are supplied to the stakeholders close to the meeting dates it is difficult to fully "understand the science and its implications" (United States (US) Environment Protection Agency (EPA) 2001, p. 9).

The terms of reference have changed for the stakeholder group, from a question asking basis by stakeholders, to increased interest in the environmental monitoring standards, reporting, regulation and remedial action. Self review by the stakeholders in the group on a regular basis will allow them to make the function of the group relevant to the community concerns over time (enHealth 2002). Some stakeholders do not want the expansion of the existing facility to go ahead; however, they do acknowledge that the stakeholder group might not be the appropriate forum to achieve this outcome (United States Environmental Protection Agency 2001).

## Discussion

Where state and local government agencies approve development, a Health Impact Assessment in the early approval process would increase stakeholder consultation and address their concerns through scientific investigation and appropriate risk management. It is acknowledged that this process is more time consuming and expensive than traditional environmental decision making, however, benefits include increased acceptance of the development by the local community, more collaboration between government departments, opportunities to enhance health, the ability to ensure that all relevant issues are assessed (Hughes 1998). This process might also identify issues that might arise at a later stage and hence cause major problems requiring expensive processes to address the problems. If the identified problems are addressed at an early stage there might be minor expenses. Any requests by the Shire to the proponent for data or analysis not required by state government might end up in a State Administrative Tribunal for legal practitioners of the Shire and proponent to debate. This is not the transparent and democratic approach that a HIA supports (enHealth 2001).

An issue arising from this development includes the lack of timely reporting of environmental monitoring, and technical advice regarding this monitoring by a trusted agency. Over time the DEC was not seen as impartial by some stakeholders who believed they should have had increased input in the meetings with regard to bore water sampling methodology and analysis and potential action or remediation. Some stakeholders held similar views regarding the impartiality of the facilitator and the environmental consultants who carried out the monitoring. The stakeholder group has changed from consultative discourse to a participatory role in the management of the landfill. Failing to address the ongoing concerns of some stakeholders has increased the perception of risk to the community and distrust with government agencies and the proponent.

### *Limitations of the study*

The identification of potential health impacts from the literature requires triangulation through quantitative assessment (Presidential/Congressional Commission on Risk Assessment and Risk Management 1997). As this assessment is the responsibility of the proponent, and might be subject to negotiation where legislation or standards might not apply, it might be difficult to confirm the risk to the community (enHealth 2001). Further, there can be difficulties confirming the dose-response relationships to individuals in the community where multiple sources of exposure or contamination might lead to the health impacts (enHealth 2002). The precautionary approach of HIA takes these issues into consideration to prevent harm

and enhance health within the community (Health Canada 2005).

The interviews with stakeholder members has limitations when members chose not to participate, therefore, the full range of responses is not able to be considered in the research. The information might reflect a small part of the stakeholder group concerns, and might not represent other views held within the community that are equally valid. Comparing the interview data with the minutes of the meetings, however, provides triangulation of these data, with the data collected in the literature review.

## Proposed Recommendations

The use of HIA by proponents of large developments should consider stakeholder concerns and it is also a vehicle to incorporate the regulatory requirements of local and state government during the scoping process (enHealth 2001). HIAs provide an opportunity to improve health and manage potential risks, thereby promoting the acceptability of the development. Greater cohesion between the DEC and Department of Health might have increased environmental assessment and reporting to include air, surface and groundwater analysis that have now become a source of concern among stakeholders. Interagency collaboration within SJ Shire could provide environment, social and health impact assessment data for a HIA that can be incorporated into planning, building and health approval conditions as a means of addressing stakeholder concerns. Given that these State and Local Government agencies will be dealing with the long term consequences of development decisions their input and experience is highly important.

The stakeholder group should respond to new concerns from group members or the community using the Framework for Democratic Science (Charnley 2000). This would indicate a real commitment to the stakeholder process and either resolve issues, or formally acknowledge that some issues are beyond the scope of the stakeholder group (US EPA 2001). The bore monitoring results could be co-presented to the group by a suitably qualified and independent agency, as some stakeholders indicated mistrust of information provided by consultants that included highly technical language (Hughes 1998). Funding could be made available at the early stages of the development for this purpose, so that stakeholders could agree to the appointment of such an agency.

Following quantitative assessment of the potential off-site impacts of the landfill, negative health impacts could be mitigated by developing risk management strategies that are action based following stakeholder concerns. Based on previous experience this could include dust emission, gas and leachate emissions from the landfill (Redfearn & Roberts 2002). A risk communication summary should also be developed to inform the community and the media (enHealth 2001). Long term strategies such as waste minimisation and recycling would reduce the overall impact of the landfill (Department of Health 2006).

Engaging social service agencies in the process might increase the use of age friendly housing design including highly walkable street design and pedestrian friendly facilities, such as adequate public toilets (Community and Disability Services 2004), legible signage, street lighting, wide footpaths, seating and shaded areas and safe road crossings. These would encourage all sectors of the community to exercise (Australian Local Government Association 2005). Access to important facilities, such as retail, public transport, meeting places, medical and education centres, also needs to be readily available to pedestrians (Institute of Public Health Scotland 2001), particularly for older members of the community as car use declines with age (Community and Disability Services 2004). Limiting wood heating devices in residences will preserve

indoor air quality and protect respiratory function. Where odour modelling conducted by the landfill proponent indicates potentially offensive characteristics (Department of Environmental Protection 2002), the release of the land for the housing estate could be staged to prevent proximity to the landfill until the landfill site closes.

Planning and environment agencies might have particular interest in the retention of natural bushland in the housing development, which supports a 'sense of place' and encourages recreation as well as providing some noise attenuation from transport factors (Western Australian Planning Commission 2000). Further, noise modelling carried out at the housing development would assist the design of the estate to orient noise sensitive premises such as schools and parkland away from noise sources such as major roads and trains (World Health Organization 1999). Analysis and management of water bodies would prevent accidental consumption or dermal contact by the public of potentially hazardous water (Redfearn & Roberts 2002), and reduce vector breeding (Western Australian Planning Commission 2000). A dust management plan would assist dust control during site works and construction activities to improve air quality. The precautionary approach of HIA would suggest that groundwater extraction should be prevented in the housing development if elevated levels of arsenic have been identified in bore water sampling sites in landfills (enHealth 2001). HIA and stakeholder involvement needs to be action based to ensure that the process is participatory and equitable.

## Conclusion

The study found several environmental and social determinants of health that might have a negative or positive effect on the community. Many of the environmental determinants require quantitative assessments to determine actual risk. These determinants require careful monitoring and management to prevent short term and long term harm to community wellbeing and sustainability in the region (Presidential/Congressional Commission on Risk Assessment and Risk Management 1997). The stakeholder's concerns that had not been adequately addressed by the proponent reinforced the perceived risks to the environment and health from the landfill and decreased trust in regulatory authorities and the landfill operators (National Environment Protection Council 1999). This study might be the first where Health Impact Assessment has been considered from a local government perspective in Western Australia.

### Acknowledgments

The authors wish to thank the Principal Environmental Health Officer for the Shire of Serpentine Jarrahdale, Tony Turner, and the South Cardup Landfill Stakeholder Consultative Group for their valuable contributions to this project.

### References

Abramson, J.H. & Abramson, Z.H. 1999, 'Interviews and self-administered questionnaires', *Survey Methods in Community Medicine: Epidemiological Research, Programme Evaluation, Clinical Trials*, 5th edn, Churchill Livingstone, Edinburgh.

Australian Local Government Association 2005, *Age-friendly built environments*, <http://www.alga.asn.au/policy/healthAgeing/ageing/resources/publications/Agefriendly_built_environment_paper.pdf/> 26 February 2007.

Charnley, G. 2000, *Enhancing the Role of Science in Stakeholder-Based Risk Management Decision-Making*, <http://www.riskworld.com/Nreports/2000/Charnley/NR00GC05.htm#section5.1> 7 February 2007.

City of Melville 2007, City of Melville: *SEIFA Index of Disadvantage*, <http://www.id.com.au/melville/commprofile/default.asp?id=253&gid=10&pg=240&bhcp=1> 9 March 2007.

Community and Disability Services 2004, *Age-friendly built environments*, <http://www.health.gov.au/internet/wcms/publishing.nsf/Content/2C1B48A0B980486ACA25708A00138A8D/$File/afbe.pdf> 21 December 2006.

Department of Environment and Conservation 2007, Media Statement: 2 February 2007, *Composting operation to recommence with conditions*, <http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/MEDIA_REPOSITORY/TAB108318/TAB116513/SMRC%20REVOCATION%20010207.PDF/> 18 July 2007.

Department of Environmental Protection 2002, *Odour Methodology Guideline*, Department of Environmental Protection, Perth, Western Australia.

Department of Health Western Australia 2006, *Submission to the Productivity Commission Public inquiry into Waste Generation and Resource Efficiency: Impacts of Waste Generation and Resources Efficiency on the Community*, <http://www.pc.gov.au/inquiry/waste/subs/sub063.pdf/> 15 December 2006.

enHealth 2001, *Health Impact Assessment Guidelines*, Commonwealth of Australia, Canberra.

enHealth 2002, *Environmental Health Risk Assessment: Guidelines for Assessing Human Risk from Environmental Hazards*, Commonwealth of Australia, Canberra.

Environmental Protection Authority 2006, *Landfill Footprint Modification: South Cardup Landfill, West Australian Landfill Services Pty Ltd,* Report and Recommendations of the Environmental Protection Authority, Bulletin 1218, April 2006.

Donnelly, A., Dalal-Clayton, B. & Hughes, R. 1998, *A Directory of Impact Assessment Guidelines*, 2nd edn, International Institute for Environment and Development, Russell Press, Nottingham

Government of Western Australia 2003, *Hope for the Future: The Western Australia State Sustainability Strategy*, Department of Premier and Cabinet, Perth.

Government of Western Australia 2007, Western Australian Landfill Services Pty Ltd v Shire of Serpentine Jarrahdale, MATTER No. DR/89 of 2007, State Administrative Tribunal, Perth.

Health Canada 2005, *Canadian Handbook on Health Impact Assessment: Volume 2,*

*Health Impacts by Industry Sector, Table 7.2 Sanitary Landfilling*, <http://www.hc-sc.gc.ca/ewh-semt/pubs/eval/handbook-guide/vol_4/table-tableau-7_e.html#Table-7-2b> 24 February 2007.

Hughes, R. 1998, *Environmental Impact Assessment and Stakeholder Involvement*, International Institute for Environment and Development, Environmental Planning Issues, No. 11, 1998.

Institute of Public Health Scotland 2001, *Heath Impact Assessment: A Guide for Local Authorities*, <http://www.phel.gov.uk/hiadocs/263_scottish_hia_guide_for_local_authorities.pdf> 6 December 2006.

Mindell, J. & Joffe, M. 2003, 'Health impact assessment in relation to other forms of impact assessment', *Journal of Public Health Medicine*, 1 June, vol. 25, no. 2, pp. 107-13.

Minister for the Environment 2006, Appeal Decision Summary: Appeal Numbers 126-208 of 2006, Appeals Convenor Environmental Protection Act, Perth.

National Environment Protection Council 1999, Schedule B (8) Guideline on

Community Consultation and Risk Communication, <www.ephc.gov.au/pdf/cs/cs_08_community_consult.pdf/ > 9 March 2007.

Office of the Appeals Convenor Environmental Protection Act 1986, 2006, *Landfill Footprint Modification South Cardup Landfill*, <http://203.20.251.100/appeals/documents/126-208-06%20Appeal%20Convenors%20Report2.pdf/> 9 March 2007.

Presidential/Congressional Commission on Risk Assessment and Risk Management 1997, *Framework for Environmental Health Risk Management*, Final Report, Volume 2, US Government Printing Office.

Razom, O. & Gerhardus, A. 1999, 'Methodological triangulation in public health Research: Advancement or mirage?, *Tropical Medicine and International Health*, vol. 4, no. 4, pp. 243-4.

Redfearn, A. & Roberts, D. 2002, *Health Effects and Landfill Sites*, Issues in Environmental Science and Technology, No. 18, Environmental and Health Impacts of Solid Waste Management Activities, The Royal Society of Chemistry, <http://www.rsc.org/images/IS018004_tcm18-27410.pdf> 18 December 2006.

SJ Shire 2006a, Mundijong/Whitby District Structure Plan, Information Sheet 2, Strategic Planning.

SJ Shire 2006b, Council News, September 2006, South Cardup Landfill Expansion Site Approved Despite Council Opposition. <http://www.sjshire.wa.gov.au/site/news/september2006.html> 6 March 2007

Scott-Samuel, A., Birley, A. & Ardern, K. 2001, *The Merseyside Guidelines for Health Impact Assessment*, 2nd edn, <http://www.ihia.org.uk/document/merseyguide3.pdf 5 February 2007> 5 February 2007.

Stass Environmental 2004, South Cardup Landfill Stakeholder Consultative Group Meeting, Minutes, Meeting No. 1. Kalamunda, Australia.

Stass Environmental 2005-2006, South Cardup Landfill Stakeholder Consultative Group Meeting, Minutes (12-17, 19). Kalamunda, Australia.

Stoneham and Associates 2005, *Preliminary Draft: Serpentine Jarrahdale Shire Population Health Profile*, East Fremantle, Western Australia.

University of New South Wales 2006, *HIA Connect: Building Capacity to Undertake Health Impact Assessment: Step 3 - Identification and Assessment of Potential Health Impacts*, <http://www.hiaconnect.edu.au/stage_3_assessment_of_potential_health_impacts.htm> 5 February 2007.

US EPA 2001, *Improved Science-Based Environmental Stakeholder Decision Making*, A Commentary by the EPA Science Advisory Board, <http://www.epa.gov/sab/pdf/eccm01006.pdf/> 18 February 2002.

Waste Management WA 2002, *Proposal to Change Plant Processes and Waste Acceptance Criteria at the Brookdale Liquid Waste Treatment Facility: Response to Public Submissions, 11 January 2002*, <www.epa.wa.gov.au/docs/1000_B1039.pdf/> 18 July 2007.

Western Australian Department of Environment 2004, *Landfill Waste Classifications and Waste Definitions 1996 (as amended)*, <http://portal.environment.wa.gov.au/pls/portal/docs/PAGE/DOE_ADMIN/GUIDELINE_REPOSITORY/LANDFILL_WASTE_CLASSIFICN_V3_2004.PDF> 6 March 2006.

Western Australian Department of Environment 2005, *Licence: Licence Number 7390/7*, <http://www.epa.wa.gov.au/docs/SouthCardup/SouthCardup_App2.pdf> 6 March 2007.

Western Australian Planning Commission 2000, *Bush Forever: Volume 1, Policies, Principles and Processes*, Appendix 3, Site Implementation Guidelines Practice Notes, Perth, Western Australia.

Wright, J. 2003, *Parkwood Health Impact Assessment 2003 North Sheffield PCT*, <http://www.sheffield.nhs.uk/healthdata/resources/nspctlandfillreportsumm.pdf/> 15 December 2006.

World Health Organization 1999, Guidelines for Community Noise, <http://www.who.int/docstore/peh/noise/guidelines2.html> 19 December 2006.

Correspondence to:
Marie Little
Centre for International Health
Curtin University of Technology
GPO Box U1987
Perth, Western Australia, 6845
AUSTRALIA
Email: marielittle@westnet.com.au

Back to TOC

# The November 2006 AIEH Conference

**Fidelis Jaravani**

***Health Protection, Hunter New England Area Health Service, NSW***

The Australian Institute of Environmental Health's Annual Conference, which was held in Sydney in 2006, provided exposure to best practice knowledge, tools and techniques, leadership strategies, sound advice, and shared wisdom. The Conference provided an ideal forum for environmental health practitioners to discuss common issues and gain assistance in planning their environmental health practice. Participants had the opportunity to observe and learn additional intangible environmental health skills that inspire confidence, promote action-oriented efforts and generate innovative approaches. The diversity of attendees provided a platform for generating ideas and new contacts to facilitate continued exchange of experiences beyond the conference. There was enormous value in making connections with like-minded professionals and sharing experiences which can provide vital data for best environmental health practice.

The Conference covered a broad spectrum of topics. The presenters were enthusiastic and some of the presentations blended professionalism with lively activism. Keynote presentations kept the conference theme in focus.

Conference highlights included the technical tour of a contaminated site. The tour enabled participants to realise how complex and costly decontamination can be, given the pressures of urban development. Another highlight was the gala dinner, which provided the opportunity to meet and converse with established environmental health practitioners and experts from diverse backgrounds.

Given the unique opportunity provided by the Conference, the following observations might assist organisers to further enhance future conferences:

- Organisers should invite high profile, well-known and widely respected keynote speakers with technical expertise who can champion the Conference theme and attract media attention.

- Organisers should invite the media and provide policy briefing papers to the media that align with the strategic advocacy goals of the Conference. Each Conference should have an identified advocacy agenda. Media coverage would help to promote future Conferences and the profession itself, especially if key note addresses discuss politically topical issues of the day.

- The Conference theme should focus on emerging priorities for environmental health, such as emerging and re-emerging diseases, climate change and global warming, and equity in health.

- There should be a greater focus on scientific presentations backed by research; policy and legislative discussions to exhibit how the profession is dealing with emerging professional challenges; and sessions that focus on how the profession is enhancing partnerships and how the practitioners are linking the science and practice of environmental health.

- 'Advertorials' consumed much presentation time. Advertorials should be limited to exhibition stands, unless they relate to new inventions or techniques that demand peer review.

- Presentation abstracts should be published online.

The next International Federation of Environmental Health Congress should serve as a point of convergence of international agendas and programs that must reach action oriented resolutions, effectively responding to the new challenges that have arisen since the last Conference. It should endeavor to match organisations seeking information with those that have useful lessons to guide the profession. The organising and scientific review committees should include a multidisciplinary membership from government, academia, and industry from both Australia and overseas. The Congress should be used to present the AIEH as an inspirational player in the environmental health global village, with a Conference able to attract and accommodate the widest range of international environmental health stakeholders embracing environmental science, environmental engineering, health protection, and public health.

***Acknowledgments***

I would like to acknowledge Craig Dalton and David Durrheim for reviewing early drafts of this report.

Correspondence to:
Fidelis Jaravani
Health Protection
Hunter New England Area Health Service
New South Wales
AUSTRALIA
Email: Fidelis.Jaravani@hnehealth.nsw.gov.au

Back to TOC

Feedback and comments on conferences and workshops is most welcome. The suggestions made in this report have been noted and have been reflected in the International Federation of Environmental Health (IFEH) Congress program which can be accessed at http://www.aieh.org.au. The theme of the congress is

***Environmental Health, a Sustainable Future – 20 years on … .***

Ed.

# Principles of Occupational Health and Hygiene

**Cherilyn Tillman (Ed.)**

*Allen & Unwin, Crows Nest, NSW, 2007, 478 pp, ISBN 1 74175 058 X, RRP $79.95*

There are a large number of general occupational hygiene texts available, but few have an Australian/Asia-Pacific focus. This text has been authored by members of the Australian Institute of Occupational Hygienists (AIOH) and represents the most important project ever undertaken by the AIOH.

The aim of the text is to provide a broad range of health and safety professionals with a book that covers current occupational hygiene, with a focus on Australian conditions through referring to Australian Standards and specific issues seen in Australian workplaces. An interesting aspect of the development of this text is that it is based on a widely used and highly respected book by David Grantham in 1992 titled, *Occupational Hygiene: Guidebook for the WHSO*. Grantham handed copyright of his text to the AIOH for it to be revised and updated. With such a strong base to work from, much can be expected from the new text.

The content of the 14 chapters of the text follows a logical structure, with the first four chapters providing an introduction to some basic occupational hygiene concepts. Chapter 1 describes what occupational hygiene is, its role and the challenges faced within hazardous work environments. Chapter 2 then provides a nice overview of occupational health, toxicology and epidemiology. Chapter 3 goes on to discuss the fundamental concept of the exposure standard, and Chapter 4 provides an introduction to the general methods or approaches available to control occupational hazards. The remaining chapters then provide comprehensive discussions of the following key occupational hazards and issues: aerosols, metals, gases and vapours, biological hazards and biological monitoring, indoor air quality, noise and vibration, ionising and non-ionising radiation, and other physical agents. The text concludes with a short chapter on current sources of occupational hygiene information.

With each chapter written by an expert in the field, the content is comprehensive but pitched at a level appropriate for general health and safety professionals. Some multi-authored texts are not very consistent across chapters, but this text is extremely well edited for consistency and clarity. The text is also very well illustrated through the extensive use of tables, graphs, diagrams and photos.

From an environmental health practitioner's perspective, there is generally little professional interaction with occupational hygienists, despite the many common elements we share regarding the roles and issues to be addressed. One aspect of occupational hygiene that often goes under-appreciated by environmental health practitioners is the critical role it can play in the exposure assessment stage of the environmental health risk assessment process. Despite the exposure assessment techniques discussed in the text having a

focus on workplace exposures, many are equally applicable to broader environmental exposures. As such, it is important for environmental health practitioners to have a sound appreciation of exposure assessment approaches so that they can effectively undertake environmental health risk assessment.

Overall, this text is well written and extremely relevant to Australian conditions. The level of detail included is both comprehensive and contemporary, but provides the novice and more experienced practitioner alike with a very useful introduction to the complex discipline of occupational hygiene. I would highly recommend this text to environmental health practitioners who are interested in gaining a better understanding of exposure assessment techniques and their role in environmental health risk assessment.

*Thomas Tenkate*
*School of Public Health, Queensland University of Technology*
*Email: t.tenkate@qut.edu.au*

**Back to TOC**

Environmental Health

The Journal of the Australian Institute of Environmental Health

# Environmental Health Subscription Form

## Annual Subscription Rates: four electronic issues per year *(These rates are subject to change)*

**Within Australia (includes GST)**

| | | |
|---|---|---|
| Individual rate | AUD $180.00 | ☐ |
| Student rate | AUD $100.00 | ☐ |
| Institutional rate | AUD $300.00 | ☐ |
| IP Access rate* | AUD $500.00 | ☐ |

**Overseas (GST does not apply)**

| | | |
|---|---|---|
| Individual rate | AUD $ 160.00 | ☐ |
| Institutional rate | AUD $ 270.00 | ☐ |
| IP Access rate* | AUD $ 480.00 | ☐ |

**Please include your IP Address below*

*IP Address (IP Access rate only):* _____

## Subscriber Contact Details

Name: _____

Institution: _____

Address: _____

_____ Postcode: _____

Telephone: _____ Email: _____

## Payment Details

☐ *Please find a cheque enclosed made payable to AIEH* ***Or***

☐ *Please charge my Credit Card:* ☐ Bankcard ☐ Mastercard ☐ Visa

Card Number: ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Expiry Date: ☐☐ / ☐☐

Cardholder's Name: _____ Signature: _____

## Journal Contact Details

***Please send completed forms/payment to:***

Bernadet Ferraro (National Finance Officer)
Australian Institute of Environmental Health
PO Box 378, Diamond Creek
Victoria 3089 AUSTRALIA
**P**: (03) 9438 5960
**F**: (03) 9438 5955

***For all other enquiries:***

Jim Smith (Editor)
Jaclyn Huntley (Editorial Assistant)
PO Box 225, Kew
Victoria 3101 AUSTRALIA
**P**: (03) 9855 2444
**F**: (03) 9855 2442

**Environmental Health**

The Journal of the Australian Institute of Environmental Health

# Guidelines for Contributors

## *Manuscripts*

Manuscripts should be submitted to Jim Smith, Editor, Environmental Health, PO Box 225, Kew, Victoria, 3101, Australia.

Material will be considered for publication on the understanding that it is original and unpublished work and has not been submitted for publication elsewhere. Authors are responsible for all statements made in the material. Papers accepted for publication become the copyright of the Journal but release for publication elsewhere can be applied for on the understanding that acknowledgment is made to the Journal.

## *Preparation of Manuscripts*

Manuscripts should in general conform to the style outlined in the Australian Government Publishing Service 1994 Style Manual for Authors, Editors and Printers, 5th edn, AGPS, Canberra. Spelling should conform to the Macquarie Dictionary.

## *Submission of Manuscripts*

Articles should not normally exceed 5000 words. Reflections on practice, reports, views and discussion, policy analysis and other material should not normally exceed 3000 words. Authors should forward the manuscript electronically to the editor. A covering letter should identify the author to receive correspondence, including mail and email addresses, telephone and facsimile numbers. Upon acceptance of the manuscript, authors will be requested to submit the document. Manuscripts should generally conform to the following sequence: title page; abstract; text; acknowledgments; endnotes; references; tables and figures, contact details including affiliations and full postal addresses for ALL authors, and telephone, facsimile and email address for contact author.

## *Title Page*

The title page should include the manuscript title, names, institutional affiliations, and academic qualifications of authors (please give complete details including addresses).

## *Abstract*

All articles should include an abstract. The abstract should summarise the paper in 200 words or less. Abstracts can be reprinted in other publications and data bases so that it is important to include the main purpose, content, and conclusions of the article. Up to six key words should be included.

## *Text*

Articles should not normally exceed 5000 words. As the Journal is multidisciplinary, the presentation of material should conform to the standard format according to the particular discipline. Other entries in the Journal, reviews, case reports, editorials, discussion, should not normally exceed 3000 words and are likely to require a different format. Please consult with the editor for guidance.

## *Tables and Figures*

Submit three hard copies of tables and figures as black and white prints preferably 80 x 80 mm but no larger than 180 X 250 mm. Environmental Health will be happy to produce tables and figures if data and type of table or figure required (i.e., bar chart, line graphs) are supplied. If tables or figures are to be reproduced please supply full details of source. Titles and captions of tables and figures should be placed on the actual table or figure. Figures may be from original artwork, photographs, graphs or charts.

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

Each table and figure must be produced on a separate page, double spaced, numbered consecutively, and given a title. Each table and figure must be cited in the text and its position indicated.

## *Acknowledgments*

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

## *Endnotes*

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

## *References*

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