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## **CHAPTER 4. OCCUPATIONAL HYGIENE IN HEALTHCARE**

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### **Keywords**

Healthcare, dentists, occupational hygiene, disease, chemicals, radiation, lasers, ultrasound, surgical gloves, surgical masks, ethylene oxide, gases, glutaraldehyde, anaesthetic cytotoxic drugs

This chapter focuses on the application of occupational hygiene in healthcare, but has limited coverage of topics that overlap with ergonomics, infectious disease, latex allergy and safety issues which are covered in other chapters.

The anticipation of exposure to physical, chemical and microbiological agents in the workplace, their measurement, evaluation and control are the realm of occupational hygiene. In Australia, as elsewhere, its practitioners are chemist, physicists and engineers, often with postgraduate training in the discipline. Standards of proficiency and professional ethics are controlled by the Australian Institute of Occupational Hygienists ([www.aioh.org.au](http://www.aioh.org.au)) which has over 400 members. Further, in the healthcare setting, specialist scientists and engineers, with a depth of knowledge on radiation issues are employed in hospitals for services associated with diagnostic imaging and therapy and this topic is only briefly reviewed in this chapter. Two professional bodies also cover this speciality<sup>1</sup> and all three bodies confer on ionizing radiation safety accreditation<sup>2</sup>.

### **4.1. INTRODUCTION**

Healthcare workers represent 10% of the workforce (Leichnitz, 2004), including workers in hospitals, clinics, dental clinics, nursing homes, pathology laboratories and radiology. A review of Occupational Health and Safety (OHS) documents on the NOHSC database from Australian federal, state, industry, union and researchers (NOHSC, 2004) shows that most health care specific documents relate to injury, and few relate to occupational disease with the exceptions of infectious disease, cytotoxic drugs and latex allergy. Nevertheless, Charney (1999) indicates that injury and illness rates for healthcare are greater than that for mining.

This problem of under-reporting of occupational disease is recognised in the (Australian) “National Priority Action Plan 3 (2002-2005): Prevent occupational disease more effectively” (NOHSC, 2002) which states that

*“...occupational disease is likely to cause substantially more deaths per year than result from workplace accidents...”* and that *“...occupational diseases usually (but not always) arise from repeated exposures to a hazard over time and, in the case of diseases of long latency, symptoms may take decades to manifest. In addition, there is relatively little*

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<sup>1</sup> ARPS - Australasian Radiation Protection Society [www.arps.org.au](http://www.arps.org.au)

ACPSEM - Australasian College of Physical Scientists and Engineers in Medicine [www.acpsem.org.au](http://www.acpsem.org.au)

<sup>2</sup> Australasian Radiation Protection Accreditation Board [www.arps.org.au/Accreditation.htm](http://www.arps.org.au/Accreditation.htm)

*reliable data available on the incidence and severity of occupational diseases in the Australian workforce. These aspects of occupationally-related disease create some unique problems both in terms of identification of hazards and assessing for the effectiveness of control measures to prevent occupational disease.”*

Some injuries, such as those caused by a needlestick, are well defined and the system encourages reporting of such events. In contrast, there is little encouragement to report suspected exposures for occupational diseases that result from exposures to chemicals and physical agents, particularly low-level chronic exposures to agents that may produce little irritation, are odourless or produce no obvious immediate effects. This under-diagnosis and under-reporting is confounded by latencies of decades inherent in many occupational disease processes, like mesothelioma of the lung. This latency of effects makes it difficult to relate ill health to a particular toxic exposure which may have occurred years before - and perhaps with a different employer.

There are also cultural impediments that may counter improvement in OHS in healthcare. In an editorial in the Medical Journal of Australia on needlestick injuries in Australia, Jagger (2002) noted that

*“...in the United States, where I have observed a culture of self-sacrifice among healthcare professionals that compels them to place self-interest at the bottom of their priority scale. I have also seen administrators make healthcare worker safety a low priority when protective measures for their employees require a financial commitment. Finally, resistance to new prevention policies for healthcare workers is likely to be strongest where there is a lack of surveillance data. This is the ‘no data, no problem’ syndrome.”*

This self sacrifice can be extreme – an early radiologist, Dr Frederick Baetjer (1874-1933) of Johns Hopkins Medical School lost eight fingers, an eye and endured seventy-two operations as a result of exposure to x-rays, but vowed to “...continue his work as long as he lives, fingers or no fingers” (Duffin and Hayter, 2000).

#### **4.2. RISK IDENTIFICATION**

In Australia the Kerr Report estimated that there are over 2000 deaths from occupational disease, but only 200 compensated deaths from occupational injury (Kerr *et al.*, 1966) indicating that occupational disease is a more serious problem than occupational injuries. These estimates were disputed by Christophers and Zammit (1966) and in turn defended by NOHSC<sup>3</sup> (2002). However, it is reasonable to say that whatever resources are allocated for prevention of occupational injury should be more than matched by resources to prevent occupational disease.

To counter the less immediate nature of the manifestation of occupational disease over injury and the under-reporting of toxic exposures, a policy of training and education is needed to better understand the nature of toxic exposures. Another requirement is rapid reporting of toxic exposures and early signs of disease. This early reporting would facilitate control of occupational diseases, manage the legal duty of care and perhaps avoid toxic torts.

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<sup>3</sup> NOHSC - National Occupational Health and Safety Commission [www.nohsc.gov.au](http://www.nohsc.gov.au)

There is a large gap between existing knowledge and actual practice that is tempered by the political profile of OHS. To date, occupational health and safety for healthcare workers has had a limited profile. For example, the 2001 Second Report to the Australian Health Ministers' Conference "Safety in Practice, Making Health Care Safer" (Barraclough, 2001) focuses on patient safety rather than a holistic approach to healthcare, and rates less than one line on healthcare worker OHS in its forty-seven pages.

It is not sufficient to just collect Material Safety Data Sheets and wait for reports of work related illness. Determining conditions that may lead to occupational disease does require considerable professional resources to uncover the sources of toxic exposures in existing establishments and to assist the design of new workplaces.

The benefits of any preventative efforts may not be evident for years. An initial surge of reports of occupational disease and toxic exposures could also be expected after an employer takes additional interest in the area, and workers begin to relate existing health problems to toxic exposures in their workplace.

### **4.3. SPECIFIC RISK MANAGEMENT CHALLENGES**

Details of a number of hazards and risk exposures are provided to illustrate some of the scope of occupational hygiene issues in healthcare. This chapter is not intended to be a comprehensive coverage of the topic, and other reviews give similar views (Brune and Edling, 1989; Hasselhorn *et al.*, 1999; Grantham *et al.*, 2003; Vecchio *et al.*, 2003).

#### **4.3.1 Hospital design**

Some 70% of all work is now performed indoors (Mendell *et al.*, 2002), so issues with air quality are particularly important for healthcare workers, where extended working hours are common. Chapter 7 provides more detail on shiftwork.

One (anonymous) major Australian hospital in a State capital found that staff (and patients) were being affected by toxic emissions from adjoining service buildings and laboratories. The main air intake overlooked this area. It was found that routing the exhausts from the laboratories to the top of the building was not sufficient to disperse the foul air, as the main building had a courtyard. Wind tunnel tests showed that the effect of the courtyard extended well above the building, requiring the engineering of 10 metre high stacks on top of the building to clear the building wake. The cost of the work was over four million dollars but resolved the problem.

A second major hospital in an eastern State capital evolved around a boiler stack. Some buildings were higher than the stack, which emitted gases and particulates from the burning of coal containing high levels of sulphur. The extent of the foul air was seen in the discolouration of the x-rays on the walls of a radiology department on the top floor of one building. The golden colour of the x-rays, like "fool's gold", was due to the formation of silver sulphide and silver sulphate. The stack has long since been demolished and most of the hospital rebuilt, yet toxic exposures to sulphur dioxide and fine particulates would have occurred for many years to both staff and patients.

A new wing of a third hospital was opened with the best possible equipment. The fume cupboards even had Pyrex plumbing and stainless steel ducting. However, the room air conditioner diffusers were poorly placed in the laboratory area and the jet of air from a diffuser displaced foul air from the fume cupboard into the room. Once the error was discovered by a third party, the problem was fixed.

In May 1985 in Staffordshire (England) poor design and maintenance of the cooling towers permitted contaminated air to enter the air supply of the hospital, resulting in a major outbreak of Legionnaires disease. This resulted in the death of 22 patients (CDC, 1985; O'Mahony *et al.*, 1990). Further, nearly one third of the hospital staff developed antibodies to Legionella. Good design and maintenance of the cooling tower and associated buildings could have avoided that outbreak. However, cooling towers are not the main source of infected aerosol, as potable water accounts for most Legionella infections (EPA, 1999; Yu, 2000; Wagenvoort and Sijstermans, 2004). As Legionella is an opportunistic environmental pathogen (EPA, 1999), management of it should not be in terms of outbreaks, but as an endemic problem that must be controlled (Yu, 2000). Further, while good design and maintenance of water systems lessens the possibility of Legionnaires disease, it is necessary to demonstrate the effectiveness of controls with frequent culturing water samples for a range of Legionella species and serotypes.

In another hospital, a radioactive waste store was positioned in the corner of a building. Unsealed liquid radioisotopes used in radiation therapy and nuclear medicine were stored in steel rubbish bins next to a wall to “cool” for weeks until the activity was low enough for disposal via sewer. Unfortunately, there was another tenant on the other side of the wall, and an office worker there received undue exposure to ionising radiations from the radioactive waste. As soon as the error was found, the rubbish bins were moved from the common wall and more effective shielding was introduced for the radioactive waste. This example illustrates that there was insufficient rigor applied to the design and use of the radioactive store and the mindset that responsibility stopped at the boundary of the building was a contributing factor.

#### **4.3.2 Respiratory protection**

There is widespread clinical use of surgical masks to protect patients from infectious droplets from healthcare workers. Surgical masks either deflect or intercept aerosols from the mouth and nose of the wearer. The present vogue is for filtering masks that intercept aerosols (Belkin, 1997), though face shields that deflect exhaled air have some acceptance. However, a Cochrane Review<sup>4</sup> of their use in clean surgery was equivocal (Lipp and Edwards, 2002).

The role reversal from using surgical masks to protect patients to protecting the healthcare worker is seriously flawed. A fabric surgical mask intercepts larger particles of spittle and mucus during loud talking, coughing and sneezing and limits direct contact with the patient producing the infectious aerosol. The airflow during exhalation is in a long plume from the nose and mouth. However, in protecting the wearer, the airflow pattern is quite different. During inhalation, a bubble of air collapses on the face when the person breathes in. This difference is easily understood - it is easy to blow out a candle at arms length but impossible to suck it out, even a centimetre away. Inhaled air flows over the surface of the face and takes

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<sup>4</sup> From [www.cochrane.org](http://www.cochrane.org) “The Cochrane Collaboration is an international non-profit and independent organisation, dedicated to making up-to-date, accurate information about the effects of healthcare readily available worldwide. It produces and disseminates systematic reviews of healthcare interventions and promotes the search for evidence in the form of clinical trials and other studies of interventions. The Cochrane Collaboration was founded in 1993 and named for the British epidemiologist, Archie Cochrane” Cochrane Reviews are systematic reviews on a particular topic.

the route of least resistance, including through imperfections in the face seal. This effect is particularly evident with surgical masks (Wake *et al.*, 1997) as they are not designed to provide an airtight seal to the face. However, surgical masks are still better than paper masks. Paradoxically, improving the quality of the mask filtration can actually increase the exposure (Chen and Willeke, 1992), as better filter materials tend to have a greater flow resistance, increasing the amount of contaminated air flowing through imperfections in the face seal.

The occupational hygiene practice of stopping toxic exposures at their source by masking infectious patients is becoming more popular with tuberculosis (Wake *et al.*, 1997) and SARS (Lim *et al.*, 2004) outbreaks, but present practice is not to mask patients when they are coughing. The use of surgical masks to protect staff from coughing patients by asking patients to wear a mask in an emergency department is a valid use of surgical masks and is well accepted if properly approached (Lenehan, 2004). Signs with “*during this flu season, we ask those with coughs to wear a mask for everyone’s protection*” will help acceptance.

### **4.3.3 Toxic exposures to dental workers**

Dentists, dental technicians and dental nurses are all exposed to a range of health hazards other than infectious diseases through their interaction with patients and the handling of materials.

Dental technicians tend to experience much greater toxic exposures through the more intensive use of dental materials and the shaping and polishing of the materials. There have been reports of silicosis (CDC, 1985; Choudat, 1994; de la Hoz *et al.*, 2004) and other silica-related respiratory conditions (Kim *et al.*, 2002) amongst dental technicians, mainly from the use of sand in casting and polishing operations. Dental technicians are also subject to beryllium diseases from the finishing of beryllium alloys used in dental prostheses (Burgaz *et al.*, 2002; OSHA, 2002; Henneberger *et al.*, 2004) and they can also be exposed to chromium, nickel and cobalt.

Mercury exposure has long been a risk for dentists (Echeverria *et al.*, 1995; ATSDR - Mercury, 1999; Goyer and Clarkson, 2001), but the mixing of mercury amalgam is now performed in sealed capsules in many dental clinics, largely eliminating mercury exposure. However amalgam scrap represents a toxic waste problem (Drummond *et al.*, 2003). Storage in a container permits the build-up of mercury vapour between the times when the container is opened. Storage under photographic fixer has been found to be less effective than storage in special canisters with a dry sorbent (Sutow *et al.*, 2004).

The potential for Legionnaire’s disease in dental workers from contaminated water systems associated with dentistry is low but is ever present (Rowland, 2003; Szymanska, 2004). The bacteria is protected by biofilms and can exist in amoeba (Cooke, 2004). Management of the risk can be by flushing water lines for several minutes each day - and longer after weekends; using a sterile water reservoir or disinfecting the water reservoir with biocides; and micro-filtration of the water before the dental handsets (Szymanska, 2004). Whatever the controls, ultrasonic and rotary dental tools and sprays will always create a fine aerosol which is inhaled and the handpieces themselves can become infected - devices to prevent contaminated water retracting into the dental handpiece when the turbine stops have been found to be largely ineffective (Berlutti *et al.*, 2003).

#### 4.3.4 Exposure to cytotoxic drugs

The potential exposure of healthcare workers - principally pharmacy workers, nursing staff, cleaners, waste handlers and laundry workers - to cytotoxic drugs, has been well documented. Also at risk are those who handle packages of the drugs, other healthcare staff handling contaminated patients (including those with topical drug applications to the skin and eye) in hospitals and at home, and veterinary workers. Long term effects from low level occupational exposure include skin rashes, affects on the foetus and infertility, and possibly cancers including leukaemia (NIOSH, 2004). The NIOSH document is authoritative, but stops short of recommending direct assessment of workplace exposures and the evaluation of the effectiveness of controls.

Exposure to the cytotoxic drug cyclophosphamide occurs through inhalation of aerosols and vapours, and dermal exposure. It has been estimated by urine analysis to cause between 1.4 and 50 cancers per million worker-years for pharmacy technicians and oncology nurses (Connor *et al.*, 1999). A twofold increase in nasal cancers in nurses was attributed to cytotoxic drug exposure (Hasselhorn *et al.*, 1999). Monitoring the urine of workers will increase awareness of exposure and may make workers want to comply with guidelines (DTIR, 1997; HSE, 2003; NIOSH, 2004), but it will not pinpoint the work practices and workplace design elements that contribute to their exposure. Without an empirically based investigative approach, other approaches will be limited.

Fluorescent tracer studies have shown that surface and skin contamination by cytotoxic drugs is widespread (Kromhout *et al.*, 2000), particularly via the skin of patients, urinals and the soles of nurses shoes. The hands, forearms and foreheads of nurses were sporadically contaminated and accounted for most of their exposure, and contamination of hands despite gloves was found after decanting patient's urine (Fransman *et al.*, 2004). Even new drug vials can be contaminated on delivery (Nygren *et al.*, 2002; Mason *et al.*, 2003). Contamination of the outer packaging was not investigated, but if contaminated, could greatly extend the range of potentially exposed people.

Spilled cytotoxic drugs can vaporise, even at room temperature (Connor *et al.*, 2000) and this tendency to vapourise would increase the toxic exposure from spills and contaminated surfaces. Measurements using air samples of cytotoxic drug aerosols would also have produced underestimates of airborne concentrations of cytotoxic drugs and the effectiveness of HEPA<sup>5</sup> air filtration systems would be less than expected, as the vapour would not be trapped (Larson *et al.*, 2003).

An evaluation of the permeability (a molecular process through intact gloves) of latex and nitrile gloves used in chemotherapy assessed three cytotoxic agents with non-aqueous solvent systems. The results showed that most gloves gave poor protection against Etoposide (Singleton and Connor, 1999). As the tests were performed at 23°C rather than skin temperature and the tests did not involve flexure of the gloves, the results would have been somewhat optimistic. In interpreting permeation data with chemicals, one study (Klein *et al.*, 1999) assigned a low permeation rate (1 µg/cm<sup>2</sup>/min) to determine the breakthrough time (or safe working time). However, when a chemical is put in contact with a glove, permeation is instantaneous (Crank,

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<sup>5</sup> HEPA - High Efficiency Particulate Air filter – removes 99.97% of all particles .3 microns or larger from the air.

1975) and with radiotracers (Ursin and Drabaek, 1988) permeation can be measured in seconds on the inside of an intact glove, driven by the chemical concentration gradient across the glove. For a very toxic chemical, a small amount could be significant, particularly if the effects over years are additive. It is never a question of whether permeation has occurred, but whether the amount permeating to the inside of the glove is significant.

Double gloving is widely advocated as a method of increasing protection and has value with micro-organisms (Parkinson, 2003). However double gloving decreases tactility and could increase the toxic exposure if an undetected cut on the outer glove allowed the spread of chemical between the two gloves. The spread could occur by capillary action or active pumping with hand flexure. The amount of chemical permeating through the inner glove is proportional to the exposed area of trapped chemical. Some glove systems are designed to indicate the presence of liquid between the gloves, but these would all have a threshold of detection of fluids. Alice Hamilton, one of the founders of occupational medicine in the US (1925), recognised that the wearing of gloves with even small rips produced a “...poultice of poison”.

#### **4.4. RISK MANAGEMENT OF CHEMICALS IN HEALTHCARE**

One of the first reports of adverse effects of chemicals on healthcare workers was the use of carbolic acid (phenol) sprays by the great surgeon, Lister (Newsom, 2003), who stated “...as regards the spray, I feel ashamed that I should have even recommended it...”. He abandoned its use in 1889 after recognising the hazard. The phenol mist would have affected the workers’ eyes, skin and lungs and entered the body through the skin and lungs to affect the heart and kidneys (Cohen and Rice, 2001).

Smoke from laser surgery may be the modern version of a hazard introduced by an innovation and this is covered in detail in Section 4.5.2.

##### **4.4.1 MSDS’s and other sources of toxicity information**

End users (including healthcare workers) of toxic substances such as chemicals, formulations and drugs tend to rely on either the manufacturer’s information or on Material Safety Data Sheets (MSDS) for information relating to safe use. Two surveys of MSDS for chemicals in Australia using the same evaluation protocol (Wendt, 1989; Winder and Jiamsakul, 1992) found 30% of chemicals did not have a MSDS. Of those that could be sourced, many were inadequate especially with advice regarding safe handling of the chemicals (and particularly so if written in the US). The advice is rarely derived from proper testing of products to select the most appropriate glove or respiratory protection. Even if material specific recommendations are given, gloves of the same type, but made by different manufacturers, will have very different levels of protection due to differences in formulations, manufacturing methods and glove thickness. There can also be significant batch-to-batch variations (Perkins and Pool, 1997). Though there is a vast amount of freely available toxicity data for individual pure chemicals on the Internet, specific information on the safe use of formulations and mixtures of chemicals is often non-existent.

Another major shortcoming of MSDS data is their incompleteness, particularly in under-reporting irritants and sensitisers (Bernstein, 2002). This incompleteness may lead to an under diagnosis of occupational asthmas and contact dermatitis, when

either the exposed person or their physician relies on the MSDS for the potential health effects of a mixture of chemicals.

### ***Inadequate dental product OHS information***

Dentists appear to rely on product data that comes with the materials rather than the Material Safety Data Sheets that exist for some materials. Arguably, many practicing dentists do not have the time or resources to investigate for themselves the safe use of their material.

A desktop review of over 40 materials used by an orthodontist revealed a paucity of health and safety information for the safe use of the materials in the product information sheets. For example, the product information for one light-activated acrylic filler indicated the material included 60% zirconia and silica with a size range 0.01 to 3.5 microns. As zirconia is a mineral, it is possible (Nayebzadeh *et al.*, 2000) that the silica was also crystalline rather than amorphous. When shaped, the dental material would produce an invisible cloud of toxic respirable crystalline silica dust. Freshly fractured crystalline silica is particularly toxic due to the free radicals on the cleaved surfaces (Donaldson and Borm, 1998). There was no warning of the hazard on the product sheet when the product was investigated in October 2004. The product sheet also suggested wearing “*protective gloves*” as it contained methacrylates and to use a “*no touch technique*”. If a “no touch technique” was reliable, then why recommend wearing a glove, particularly when there would be little indication that the glove had become contaminated? The product sheet gave no indication of what type of glove would be most suitable (eg latex, vinyl, nitrile) or how long gloves would give protection.

Of concern, the findings of Lonroth *et al.* (2003) indicate that acrylate monomer would invisibly permeate most gloves in as little as three minutes. Further, latex and vinyl gloves (commonly used by dentists) were amongst the worst choices as they could trap the permeant next to the skin and magnify any allergic reaction. It is also possible that acrylates will cause sub-clinical losses in smell (Gobba, 2003). Acrylic formulations permeated faster than individual components, making glove selection on the basis of permeation of individual components more difficult. Unfortunately, some of the best choice of multi-laminated gloves would have been impractical (4H, North Silver Shield or Ansell Barrier laminated gloves) as this type of glove has very poor tactility. A similar dilemma of protecting from acrylates was also experienced by orthopaedic surgeons in their use of acrylic fillers (Pegum and Medhurst, 1971).

Finally, there was no indication of blue light hazard from photo curing lights used for setting the resins. In recent years LED blue lights have emerged with a greater light output than halogen lights. Blue light is cold, but unlike ultraviolet, it does reach the retina and can cause photoretinitis (Sloney, 2001) and the effects are additive (Widstrom and Edling, 1989). Some 10% of the light is reflected from teeth and up to 30% is reflected from dental strips (Moseley *et al.*, 1987), leading to excessive exposures in an hour. However, more recent research has indicated excessive exposure to the dentist in as little as one minute (Roll *et al.*, 2004). Special eye protection is required to control exposure to this hazard (Sloney, 2001), but this may have to be removed for colour matching dental materials to teeth.

Risk management of problem with incomplete information on a product is very difficult. The problem is not in uncovering the problem, but in estimating or measuring the magnitude of the problem so that appropriate strategies can be used to

control the problem. In the above example with an acrylic filler used in dentistry, there are three separate hazards – silica dust, skin exposure and blue light hazard with very different acute and chronic effects. Implementing a buying system that at least requires the provision of MSDS will partly overcome the problem, but not the quality of the information. Writing to the supplier for further detailed information may be very productive – information was forthcoming on other products, but not for the example above. Reliance on non-reporting of ill-health is very risky, particularly in a largely environment not used to reporting ill-health. Researching the literature will also be unlikely to reveal specific information on a product that has a very specialised market, particularly if chronic effects are sought. Measurements of exposure would be relatively easy with the silica exposure as the methodology is well developed, but still relatively expensive. It is possible that the actual concentrations would be low averaged over an eight hour day. For the acrylate exposure, removing the worst choice of gloves (latex and vinyl) is easy, but estimating – and then evaluating skin exposure, would be a research project. For blue light hazard, measurement may be possible but there is limited expertise in the area. Calibration of a blue light sensor would be difficult and may drift in transport from the factory.

#### **4.4.2 An occupation hygiene perspective on the hierarchy of control**

A “hierarchy of control” should be the basis of all risk management of workplace hazards. Approaches to control should start by making the workplace safe by design – including elimination of the hazard, then consider engineering and administrative controls and as a last resort use personal protection like gloves, ear muffs and dust and vapour masks. In practice, it is not always practicable to remove a hazard, but many managers grossly overestimate the protection give by personal protection and underestimate the resources needed to ensure that gloves and respiration protection are correctly selected, consistently and properly used, maintained and disposed of. The use of personal protective equipment requires a formal program with named and trained people to be responsible.

#### **4.4.3 Air and skin exposure**

Exposure limits for chemicals are usually expressed in terms of an air concentration in  $\text{mg}/\text{m}^3$  or parts per million of air (ppm)<sup>6</sup>. In Australia, the National Occupational Health and Safety Commission (NOHSC) largely adopts the recommendations of a professional body, the American Conference of Governmental Industrial Hygienists (ACGIH). These NOHSC recommendations are usually adopted by State regulators. The ACGIH recommendations are not a divide between safe and unsafe, but a guide for professional occupational hygienists as to what exposure would avoid adverse health effects in most workers exposed every day for a working lifetime and must be read in conjunction with their detailed documentation. However, in legislation, this caveat of less than 100% protection for all is usually overlooked in legislation.

Few chemicals used as therapeutic drugs have occupational exposure limits, though manufacturing facilities tend to have in-house exposure limits. For healthcare workers, little is known about chronic exposures over many years to a multitude of drugs and other chemicals.

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<sup>6</sup> To convert between ppm and  $\text{mg}/\text{m}^3$ : At 25°C 
$$\text{ppm} = \frac{\text{mg} / \text{m}^3 \times 24.45}{\text{gram molecular weight}}$$

For around one third of chemicals, there is a “skin notation”, indicating that skin exposure could also result in some toxic effects. There is limited agreement on what chemicals should have this notation or how it should be used in risk management (Nielsen and Grandjean, 2004). It would be prudent to assume, unless proved otherwise, that skin contact with any chemical could result in local or systemic toxic effects. The skin, as a route of exposure, is likely to become relatively more important, as tightened air exposure standards are met (Fiserova-Bergerova, 1993). There is still no standardised method of risk management of dermal exposure (Poet and McDougal, 2002; Cherrie *et al.*, 2004).

One important source of dermatitis in healthcare relates to the frequent hand washing. This may tend to irritate the skin and leave it more vulnerable to permeation by other chemicals. Buckley *et al.* (2002) found healthcare workers, particularly nurses, food workers and cleaners, were susceptible to occupational allergic contact dermatitis from fragrances and suggested a fragrance-free procurement policy for soaps. An alternative is the use of rubbing alcohol (isopropanol) on unsoiled hands. This is more effective and less irritating than soap and water, and does not need towelling (Jungbauer *et al.*, 2004; Trampuz and Widmer, 2004). There is, however evidence that isopropanol is an animal carcinogen, but none to suggest it is a human carcinogen and no “skin notation” as little permeates the skin (ACGIH, 2004)

An important method of skin protection is the use of gloves. Though the present role of latex surgical gloves is asepsis, they were originally developed in 1890 by the surgeon William Halstead to overcome the sensitivity to a disinfectant of his chief surgical nurse. (Bloodgood actually used latex surgical gloves a year earlier, but Halstead is better remembered, as the surgical nurse Caroline Hampton married him) (Dyck, 2000). Allergies from latex gloves are discussed in Chapter 9.

#### **4.4.4 Common chemicals used in healthcare**

There are hundreds of chemicals used in healthcare and the most exposed include cleaners, kitchen workers and dental technicians and nurses. Those involved with maintenance should not be forgotten and this group would not only add chemicals like epoxies, polyurethanes and hydrofluoric acid to the list, but be potentially exposed to an unknown cocktail of chemicals during maintenance and repair operations. Increasingly, contractors are used for maintenance and little or no training in dealing with hazardous substances would be available.

##### ***Risk management of ethylene oxide***

Ethylene oxide is still in use as a cold sterilant in Australia, despite it being a probable human carcinogen (NOHSC). The US National Toxicology Program (NTP, 2002) goes further and classifies ethylene oxide as “*known to be a human carcinogen*”. There are also adverse effects on most other organ systems (ACGIH - Ethylene Oxide, 2004). Typical exposures during its use in healthcare are below the NOHSC exposure limit of 1 ppm, but leaks cause exposures 100-1,000 times higher (Donnan, 1986; LaMontagne and Kelsey, 2001). While long term trends of ethylene oxide exposures in healthcare are slowly rising in the US due to regulatory inactivity (LaMontagne *et al.*, 2004), acute exposures are usually undetected by personal monitoring or smell. The odour threshold for recognition of ethylene oxide is around 500 ppm (AIHA, 1989; Hasselhorn *et al.*, 1999), much higher than the 1 ppm occupational exposure limit, so smell cannot be relied upon to warn workers. Short term exposures are of concern, as DNA adduct formation (a precursor of cancer) is

concentration dependent (LaMontagne and Kelsey, 1998), making short exposure to high levels much more toxic than the same exposure over a longer period. Ethylene oxide can form the potent mutagen ethylene chlorohydrin, when in contact with chlorinated polymers like PVC, but in practice the levels are low (NOHSC, 1992).

The ideal control of ethylene oxide is substitution with a less hazardous method of cold sterilization or a safer chemical (NOHSC, 1992), followed by making the process safer by buying automated sterilizing machines and ventilating the area to cope with leaks. The last resort should be the use of respirators. Monitoring using electronic devices clipped near the face of the worker should be considered, particularly during any maintenance operations or where accidental exposures are possible.

The exhaust of sterilizers is vented to the air and it is easy for the toxic discharges from exhaust stacks to be entrained into courtyards, enter air inlets or windows - both upwind and downwind of an exhaust stack. Exhaust stacks heights and locations should be reviewed, particularly near buildings with courtyards, to ensure the discharge is above the “wake” that extends both above and downwind of surrounding buildings (Hughes, 1989). This would require the services of a person experienced in the airflows around buildings.

### ***Risk management of glutaraldehyde***

The two principle uses of glutaraldehyde in healthcare are in cold sterilisation (about 55 tons) and as a photographic hardener for x-rays (about 20 tons) (NOHSC, 1995). Such is the effect of glutaraldehyde and similar chemicals used in healthcare that there are interest groups for those affected<sup>7</sup>.

The Australian exposure limit of 0.1 ppm over 15 minutes for glutaraldehyde was adopted in 1995 (NOHSC, 1995), and is far less stringent than the ACGIH “ceiling” limit of 0.05 ppm (ACGIH - Glutaraldehyde, 2004). To comply with a ceiling limit of 0.05 ppm, average levels need to be about 30% of this level, much lower than the Australian limit. Further, the ACGIH notes (ACGIH - Glutaraldehyde, 2004) three studies that indicate “... *nose, throat, skin and eye irritation: headaches and several other symptoms associated with airborne glutaraldehyde exposure concentrations at or below 0.1 ppm*”, based on 15 minute measurements. Unlike ethylene oxide, a “*suspected human carcinogen*” the ACGIH considers glutaraldehyde as “*not classifiable as a human carcinogen*”.

It is insufficient to comply with the Australian exposure standards to protect workers from health effects. The Australian exposure limits have no short term exposure limit (STEL) so levels can be very high for extended periods, so long as the shift average is below 0.1 ppm. In Queensland, it is suggested that peak exposures of glutaraldehyde be kept below 0.1 ppm (DETIR, 1999). Unlike ethylene oxide, glutaraldehyde has an odour threshold of 0.04 ppm - below any exposure limit (Ballantyne and Jordan, 2001), so most workers would smell concentrations approaching this exposure limit.

Tzacuk and Crea (1993) surveyed 27 South Australian hospitals using both air and skin monitoring and found endoscopy nurses may experience significant glutaraldehyde exposures, particularly by skin contact. NIOSH (2001) notes that latex gloves give inadequate protection and recommends fume hoods for glutaraldehyde

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<sup>7</sup> “Support Network for the Aldehyde and Solvent Affected” formed by a New Zealand radiographer, Marjorie Gordon [www.ncchem.com/snftaas](http://www.ncchem.com/snftaas). The pages are now out of date, but it has useful links.

baths. An in-depth review of glutaraldehyde in healthcare (Ballantyne and Jordan, 2001) recommended an emphasis on engineering controls – particularly ventilation systems that draw the air away from the worker's face. Ceiling level ventilation systems were found to be inappropriate. Where splashes of 2% glutaraldehyde were possible, butyl rubber, nitrile and polyethylene gloves were recommended to avoid allergic contact dermatitis. For more concentrated solutions, only butyl and nitrile gloves provided sufficient protection. In the case of a large spill, a full-face respirator - covering eyes, mouth and nose - (with appropriate organic vapour cartridges) was recommended to ensure that the eyes were also protected. In the case of a splash to the eye, it was recommended that any contact lens should not be removed by untrained personnel as it may be bonded to the cornea by the glutaraldehyde.

The management of glutaraldehyde is very different from ethylene oxide though both are used as sterilant. Glutaraldehyde is highly irritant and risk management involves protecting the lungs, eyes and skin, whilst ethylene oxide is not sensed, but is a carcinogen, so has to be monitored to demonstrate that toxic levels are not inhaled. For both, the effects are concentration dependent and effective engineering controls are required, if a safer substitute cannot be used.

### ***Risk management of anaesthetic gases***

Waste anaesthetic gas in surgical and dental operating theatres and recovery rooms have been associated with ill health from reproductive problems (Pressly, 2000) to a two-fold increase in multiple sclerosis (Flodin *et al.*, 2003)..

The emphasis with aesthetic gases should be on control of release into the workplace. In the operating theatre (surgical or dental) this has become standard practice, but without monitoring of the workplace air, there

A study (Griffiths and Fleming, 1995) was undertaken in Western Australia to examine occupational exposure to waste anaesthetic gases in groups of health care professionals employed within a sample of 10 hospitals, involving 91 employees. A range of occupational exposure levels were identified for professional occupational groups including surgeons, anaesthetists, scrub nurses, theatre nurses and recovery room nurses. A total of 29 (32%) employees were found to exceed recommended occupational exposure standards for enflurane and/or halothane. Factors contributing to occupational exposures were highlighted including inadequate ventilation provisions, anaesthetic delivery equipment leakages and poor work practices. In another study (Peipins *et al.*, 1997), an increase in leukaemia in nurses was attributed to anaesthetic gas and ethylene oxide exposures.

### ***Risk management of asbestos***

Asbestos is a perennial problem in older hospitals, with asbestos found in ceiling insulation, steam pipe lagging, fire doors, and in heater blocks in air conditioning systems. Asbestos cement sheeting and roofing can be a source of exposure if it is mechanically cleaned (eg high pressure water jet), drilled or sanded, but the cement binder reduces the number of respirable fibres. Asbestos exposure tends to occur during maintenance operations. It was once thought that a multiplicative risk existed between asbestos and cigarette smoking, but the effect has been found to be synergistic rather than multiplicative (Liddell, 2001). For a rational approach to control of asbestos exposure, it is sometimes better to keep an asbestos register and leave stripping a building of asbestos until the building needs to be demolished. This particularly applies to roofing, walls and power cables, where the undisturbed

material does not release asbestos fibres and the benefits of removal are small - and the cost can be considerable.

In Australia, the regulatory limit is 0.1 fibres per millilitre of air (0.1 f/ml) except for chrysotile or white asbestos. In Australia, the exposure limit for chrysotile (white) asbestos is higher than for other types of asbestos (Leigh and Driscoll, 2003:207), but all forms are now banned in Australia as from December 3 2003. The ACGIH limit is 0.1 f/ml for all forms of asbestos (ACGIH - Asbestos, 2004) and this disparity may eventually push Australian limits to this level for all form of asbestos. Good guidance on the management and removal of asbestos is available from state authorities and NOHSC ([www.nohsc.gov.au](http://www.nohsc.gov.au)).

#### **4.5. RISK MANAGEMENT OF PHYSICAL AGENTS IN HEALTH CARE**

Physicals agents encountered in healthcare include noise, vibration, x-rays, lasers, unsealed (liquid) radiation sources and radiation therapy units. Examples will be restricted to evolving problem areas or where the management of the problems is either poorly performed or not obvious.

##### **4.5.1 Noise and ultrasound**

Noise exposures to healthcare workers cover a wide range - from continuous loud noises such as in hospital carpentry shops (Mikl, 1998), intermittent noises such as in extracorporeal shockwave lithotripsy (Dawson *et al.*, 1994; Naguib *et al.*, 2002), ultrasound in dental scalers (Walmsley, 1988), to hospital-based helicopters (Pasic and Poulton, 1985). While there are few reports of industrial deafness arising from the clinical exposures, the potential for hearing damage does exist.

##### ***Risk management of noise***

Mikl (1998) reviewed the sources of noise in hospitals and found carpentry, engineering and gardening areas excessively noisy, though laundry, kitchen and cleaning work accounted for many contested hearing loss claims despite those areas not being excessively noisy. Other noisy areas used pneumatic bone saws, ultrasonic cleaners and compressed air, though this work was intermittent.

Where audiometry has been used to direct hearing conservation programs, its effectiveness is limited (Dement *et al.*, 2004) as pure tone audiometry is too insensitive to demonstrate short term changes in hearing (McBride and Calvert, 1994) at the levels generally experienced by healthcare workers. The evaluation of noisy areas requires calibrated sound level meters (preferably with impulse noise capabilities) and personal logging noise dosimeters to record a noise exposure profile for an individual worker. With this noise information and observations of the workplace, rational noise controls can be applied.

A purchasing policy requiring low noise power levels for hand tools and machines is the best method of control. Requiring and enforcing the use of ear muffs and ear plugs is an expensive and inappropriate long-term control strategy.

##### ***Risk management of ultrasound***

Ultrasound in healthcare is used both therapeutically (disintegration of kidney stones, heating of tissue, descaling teeth) and diagnostically (ultrasonic imaging, Doppler blood flow measurements). In general, therapeutic applications use higher energies and the damage to tissues can be both thermal and mechanical. Physiotherapists, dentists and those using ultrasonic cleaners are the most exposed.

The biological effects of ultrasound have been extensively studied over many decades (Nyborg, 2000; 2001) and the mechanisms behind tissue damage are well understood. The effects include heating from ultrasound absorption and scattering, micro bubble cavitation and acoustic streaming. When micro bubbles collapse, they can produce local temperatures of thousands of degrees which produce chemically-reactive free radicals. The collapsing bubbles can also produce microscopic fluid jets that rupture structures such as cell walls. The effect appears to be less with short pulses (Persson, 1989) but sub harmonics from the collapsing bubbles can produce headaches, nausea and vertigo (Persson, 1989) to the operator.

Kenkel *et al.* (2000) surveyed the use of ultrasound assisted liposuction and found the airborne exposures to the ears of the surgeons acceptable, but against an older 90 dBA noise standard. However in extracorporeal shock wave lithotripsy, Naguib *et al.* (2002) performed an elaborate study on 54 lithotripter staff. Though there was no discernable temporary deafness by pure tone audiometry in the staff, nearly half reported tinnitus that lasted several days. Measurements of otoacoustic emissions – a non-invasive but sensitive method for measuring cellular changes in the inner ear, revealed reversible changes to the sensory hair cells in the inner ear. The potential for hearing loss exists for sensitive individuals.

For healthcare workers using ultrasonic tools and cleaners, exposure to ultrasound can occur to the fingers and airborne to the ear. Direct bone conduction damage to the hair cells in the inner ear would be unlikely. The ultrasound itself is well attenuated by air above about 200 kHz. Trenter (2003) reviewed the use of dental ultrasonic scalers and found prolonged use may cause circulatory and sensory problems in fingers, produce infectious aerosols and cause temporary deafness in dentists. A recent review for the UK Health and Safety Executive of workers with ultrasound (Lawton, 2001) found that there is still a need for research to better define the risks for users of ultrasonic tools.

Therapy frequencies for ultrasound are usually above 800 kHz. Ultrasound exposure standards for airborne ultrasound to 100 kHz have been published (ACGIH - Ultrasound, 2004)<sup>8</sup> to help avoid industrial deafness from sub harmonics below 20 kHz and other effects like nausea above 20 kHz. These recommendations were seen to be inadequate by Lawton (2001) and young female workers have been found to be more sensitive to ultrasound above 75 dBA below 20 kHz (Lawton, 2001)<sup>9</sup>, somewhat less than the 85dBA widely accepted for audible sound. The levels can be measured with a sound level meter with an octave band analyser, but the evaluation of measurements is complex.

To control ultrasound exposure it is necessary to limit power levels and exposure times, avoid direct contact with ultrasound sources with the fingers and if necessary, wear hearing protection, particularly with ultrasonic cleaners.

#### **4.5.2 Radiation**

The management of ionising and non-ionising radiation in healthcare is largely performed by people with knowledge of medical health physics. Health physics broke from industrial hygiene with the dawn of nuclear power and became its own

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<sup>8</sup> Available for electronic purchase from [www.acgih.org](http://www.acgih.org)

<sup>9</sup> Freely available from [www.hse.gov.uk](http://www.hse.gov.uk)

speciality as medical physics (Lippman, 1995), though an interest in the adverse health effects of radiation had followed the discovery of X-rays by Roentgen in 1896 (Vetter, 2004).

### ***Risk management of ionising radiation***

Much of risk management of ionising radiation (particularly x-rays) for health care workers surrounds avoidance of risk to the foetus with pregnant healthcare workers. This particularly applies to the female dominated professions of nursing and radiography. The present dose limit to pregnant workers is 1 mSv (milli Sievert) a year (ARPANSA, 2004), the same as for members of the public. A radiation dose of 1 mSv is close to normal background levels.

The problem with ionising radiation is that it is invisible and cannot be sensed. If a TLD<sup>10</sup> or film badge is worn to measure radiation exposure, then an unacceptable dose will only be apparent at the end of a wearing cycle, usually 3 months. A dose of 50  $\mu$ Sv (1000  $\mu$ Sv = 1 mSv, millisievert) is now detectable for a wearing cycle of three months, but newer electronic dosimeters (cost ~\$A900) read to 1  $\mu$ Sv and can instantaneously warn an at-risk worker of elevated radiation exposure. It is prudent to provide all potentially pregnant radiation workers with electronic dosimeters, particularly when this is a very small part of the cost of a large piece of diagnostic or therapeutic equipment. Early models of electronic dosimeter were sensitive to large magnetic fields (such as from MRI<sup>11</sup> machines and perhaps mobile phones) and gave jumbled results. Newer models are more reliable.

The eyes are relatively sensitive to radiation cataracts (Cember, 1988) but considerable additional radiation protection can be given with ceiling mounted eye screens and protective spectacles made from lead glass, particularly in high radiation areas like cardiac catheter laboratories. It is reasonable for an employer to pay the difference between normal and lead glass spectacles for radiation workers when these are requested.

One of the most significant changes in radiation practices in healthcare is the move towards digital radiography. Here, film cassettes are being replaced by laser-read cassettes or direct digital imaging. Despite the potential to reduce radiation dose to patients and staff, radiation doses have increased significantly. The ICRP<sup>12</sup> (Valentin, 2004) noted a number of reasons for this. The quality of digital images increases with exposure, unlike conventional x-ray film. A desire by radiographers for quality images drives increased x-ray exposure times and currents as over-exposed images can be corrected by a computer, but under-exposed images may have to be repeated. Other factors include the ease of requesting digital images and of getting results. It is necessary to implement radiation minimisation policies involving medical physicists and radiology staff to overcome these problems and optimise image quality but minimise radiation doses. A side benefit of digital radiography is the reduction in the use and effects of photographic chemicals, including glutaraldehyde.

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<sup>10</sup> TLD Thermo Luminescent Dosimeter – a radiation sensitive material that releases a glow of light on heating, proportional to the amount of radiation it receives.

<sup>11</sup> MRI - Magnetic Resonance Imaging

<sup>12</sup> ICRP International Commission on Radiation Protection [www.icrp.org](http://www.icrp.org)

The problem will tend to be worse in country hospitals where the transition to digital radiography is less likely to be supported by radiation safety professionals. To minimise this problem it is necessary to provide additional and ongoing training to practitioners in more isolated hospitals and clinics.

With an aging population and hospital beds becoming a scarce resource, it is likely that the technology available in hospitals will become increasingly available in nursing homes and home care. Portable x-ray sets are likely to become more popular - particularly if the digital image can be instantly assessed in a central radiology department using high-speed wireless networking. There is potential for significant increases in radiation to health care workers and the public in nursing homes and near portable x-ray sets.

There will be continuing pressure to adopt sophisticated imaging such as virtual colonoscopies using x-ray computed tomography (Mendelson and Forbes, 2002), particularly for scans in the absence of any symptoms. Some Australian States oppose asymptomatic scans, partly due to the unnecessary radiation dose to patients and staff.

Unsealed sources can produce significant doses, particularly to the fingers in nuclear medicine and pathology staff. The change from solvent based liquid scintillation fluids to water based fluids has permitted disposal directly to sewer once the radioactivity has declined. There has also been a move towards isotopes with shorter half-lives - the radioactivity will decay to 1% of the original activity in seven half-lives.

### ***Risk management of lasers***

Lasers have enjoyed widespread use in healthcare, from bar scanners and digital radiography cassette readers to laser surgery (Taravella *et al.*, 2001) and dermatology (Acland and Barlow, 2000). Risk management of lasers requires not only a basic understanding of the risks posed by lasers to the eye, but other toxic effects caused by laser smoke (Plappert *et al.*, 1999).

Unlike normal light sources which produce an inverted image on the retina, lasers focus to a point and can cause local tissue to boil if the heat is not dissipated quickly enough. Classification of lasers is on the basis of risk to the retina of the eye, particularly the fovea (Sliney *et al.*, 2002), which accounts for central vision. Noticeable damage to the retina is rare but devastating.

**Table 1 Laser classifications**

<b><i>Class</i></b>	<b><i>Reason</i></b>
1	Intrinsically safe (CD players, supermarket checkouts)
2	Some care (survey lasers). Only hazardous if you stare into them. Some laser pointers are class 2
3A	Not protected by blink reflex (1/4 second), visible light. Entertainment lasers. Specular (mirror) reflectors potentially a problem but diffuse reflectors are not a problem. Hazardous.
3B	Non visible, so eye does not blink, medium power. Hazardous
4	High powered. Surgery, cutting. Any surface can reflect enough light to be harmful.

If the eye cannot see a laser because it is in the infra red region, then the blink reflex is not initiated. Higher powered lasers (class 4) for cutting tissue or removal of tattoos can damage the eye, even if reflected from a matt surface.

There over 80 accounts of medical laser injury on the Rockwell Industries database <http://www.rli.com> ranging from minor burns to patient death.: Barat (2003) documented to the eye of a doctor occurred when laser goggles for a laser of a different wavelength were worn and the goggles did not stop the beam.

In laser surgery, placement of the inlet of a smoke evacuator more than 2 cm from the source was found to reduce its capture by 50% (Plappert *et al.*, 1999). Surgical masks will give little respiratory protection, as discussed in Section 4.3.2, despite recommendations to the contrary (Taravella *et al.*, 2001). Vapours from laser surgery (Stocker *et al.*, 1998) will not be stopped by respiratory protection designed to arrest particulates. Stocker *et al.* (1998) also found that the volatile components in laser smoke, though less in volume, were more potent health hazards. Infections from viable aerosols produced when a laser strikes infected tissue are also a potential hazard in the operating theatre, particularly from the human papillomavirus in warts (Gloster and Roenigk, 1995).

To properly manage the risks from lasers, it is necessary for an institution to not only appoint a laser safety officer to address the optical hazards, but to evaluate the secondary hazards caused by laser smoke.

#### **4.6. CONCLUSION**

The focus of this chapter has been to raise an awareness of occupational hygiene issues in healthcare rather than provide a prescriptive list of solutions. Many of the issues are complex, requiring specialist professional investigation and advice, particularly at the design stage. Risk management based on simple solutions like providing gloves and respiratory protection has its limits and a focus on elimination of the hazard and engineering design is more desirable.

Many of the hazards will be hidden and a policy that encourages the reporting of toxic exposures with an associated appropriate response will reveal significant issues early and counter the culture of self-sacrifice. A successful risk management policy would be accompanied by an ongoing education program (Vecchio *et al.*, 2003) and visible efforts to reduce hazards. Monitoring of the work environment should not be viewed as just legal compliance monitoring, but as part of an active and effective policy to protect the health of workers.

There are cost effective solutions available for most problems.

#### **4.7. REFERENCES**

ACGIH. *Documentation of Threshold Limit Values and Biological Exposure Indices* [7th Edition. American Conference of Governmental Industrial Hygienists,; 2004 [cited 2004 November 2004]; Available from: URL:www.acgih.org

ACGIH - Asbestos. *Asbestos*. In: American Conference of Governmental Industrial Hygienists, editor. *Documentation of Threshold Limit Values and Biological Exposure Indices*. 7th Edition ed. Cincinnati: ACGIH; 2004.

ACGIH - Ethylene Oxide. *Ethylene Oxide*. In: American Conference of Governmental Industrial Hygienists, editor. Documentation of Threshold Limit Values and Biological Exposure Indices. 7th Edition ed. Cincinnati: ACGIH; 2004.

ACGIH - Gluteraldehyde. *Gluteraldehyde*. In: American Conference of Governmental Industrial Hygienists, editor. Documentation of Threshold Limit Values and Biological Exposure Indices. 7th Edition ed. Cincinnati: ACGIH; 2004.

ACGIH - Ultrasound. *Ultrasound*. In: American Conference of Governmental Industrial Hygienists, editor. Documentation of Threshold Limit Values and Biological Exposure Indices. 7th Edition ed. Cincinnati: ACGIH; 2004.

Acland KM, Barlow RJ. *Lasers for the dermatologist*. Br J Dermatol 2000;143(2):244-55.

AIHA. *Odor Thresholds for Chemicals with Established Occupational Health Standards*. Fairfax, VA: American Industrial Hygiene Association; 1989.

ARPANSA. *National Directory for Radiation Protection (NDRP)* [2004; Available from: URL:<http://www.arpansa.gov.au/pubs/rps/rps6.pdf>

ATSDR - Mercury. *Toxicological Profile for Mercury* [U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry,; 1999; Available from: URL:<http://www.atsdr.cdc.gov/toxprofiles/tp46-c1.pdf>

Ballantyne B, Jordan SL. *Toxicological, medical and industrial hygiene aspects of glutaraldehyde with particular reference to its biocidal use in cold sterilization procedures*. J Appl Toxicol 2001;21(2):131-51.

Barat K. *Laser Accidents: Occurance and Response*. Operational Radiation Safety 2003;84(suppl 2):s93-5.

Barracough B. *Second Report to the Australian Health Ministers' Conference. Safety in Practice, Making Health Care Safer*. The Australian Council for Safety and Quality in Health Care; 2001 July 2001.

Belkin NL. *The evolution of the surgical mask: Filtering efficiency versus effectiveness*. Infection Control and Hospital Epidemiology 1997;18(1):49-57.

Berluti F, Testarelli L, Vaia F, Luca MD, Dolci G. *Efficacy of anti-retraction devices in preventing bacterial contamination of dental unit water lines*. Journal of Dentistry 2003;31(2):105-10.

Bernstein JA. *Material safety data sheets: are they reliable in identifying human hazards?* J Allergy Clin Immunol 2002;110(1):35-8.

Brune D, Edling C. *Occupational hazards in the health professions*. Boca Raton, Fla.: CRC Press; 1989.

Buckley DA, Rycroft RJG, White IR, McFadden JP. *Fragrance as an occupational allergen*. Occup Med (Lond) 2002;52(1):13-6.

Burgaz S, Demircigil GC, Yilmazer M, Ertas N, Kemaloglu Y, Burgaz Y. *Assessment of cytogenetic damage in lymphocytes and in exfoliated nasal cells of dental laboratory technicians exposed to chromium, cobalt, and nickel*. Mutation Research/Genetic Toxicology and Environmental Mutagenesis 2002;521(1-2):47-56.

CDC. *Legionellosis -- Staffordshire, England, and Wayne County, Michigan* [Centres for Disease Control and Prevention; 1985 [cited 34 23]; Available from: URL:<http://www.cdc.gov/mmwr/preview/mmwrhtml/00000558.htm>

Cember H. *Introduction to Health Physics*. New York: Maxwell McMillan; 1988.

Charney W. *An Epidemic of Health Care Worker Injury*. In: Charney W, Fragala G, editors. *The epidemic of health care worker injury : an epidemiology*. Boca Raton, Fla.: CRC Press; 1999. p. 1-10.

Chen CC, Willeke K. *Characteristics of Face Seal Leakage in Filtering Facepieces*. *American Industrial Hygiene Association Journal* 1992;53(9):533-9.

Cherrie JW, Semple S, Brouwer D. *Gloves and Dermal Exposure to Chemicals: Proposals for Evaluating Workplace Effectiveness*. *Ann Occup Hyg* 2004;48(7):607-15.

Choudat D. *Occupational lung diseases among dental technicians*. *Tubercle and Lung Disease* 1994;75(2):99-104.

Christophers AJ, Zammit MR. *A Critique of the Kerr Report: The Best Estimate of the Magnitude of Health Effects of Occupational Exposure to Chemicals in Australia*. In: 15th Annual Conference of the Australian Institute of Occupational Hygienists, 1966 1-4 December 1996; Perth.

Cohen DE, Rice RH. *Chapter 19 Toxic Responses of the Skin*. In: Klaassen CD, editor. *Casarett & Doull's Toxicology The Basic Science of Poisons*. 6th ed. New York: McGraw-Hill; 2001. p. 653-71.

Connor TH, Anderson RW, Sessink PJ, Broadfield L, Power LA. *Surface contamination with antineoplastic agents in six cancer treatment centers in Canada and the United States*. *Am J Health Syst Pharm* 1999;56(14):1427-32.

Connor TH, Shults M, Fraser MP. *Determination of the vaporization of solutions of mutagenic antineoplastic agents at 23 and 37 degrees C using a desiccator technique*. *Mutat Res* 2000;470(1):85-92.

Cooke RPD. *Hazards of water*. *Journal of Hospital Infection* 2004;57(4):290-3.

Crank J. *The Mathematics of Diffusion*. second ed. Oxford: Clarendon Press; 1975.

Dawson C, Chilcott-Jones A, Corry DA, Cohen NP, Williams HO, Nockler IB, Whitfield HN. *Does lithotripsy cause hearing loss?* *Br J Urol* 1994;73(2):129-35.

de la Hoz RE, Rosenman K, Borczuk A. *Silicosis in dental supply factory workers*. *Respiratory Medicine* 2004;98(8):791-4.

Dement JM, Pompeii LA, Ostbye T, Epling C, Lipscomb HJ, James T, Jacobs MJ, Jackson G, Thomann W. *An integrated comprehensive occupational surveillance system for health care workers*. *Am J Ind Med* 2004;45(6):528-38.

DETIR. *Hazardous Substances Case Study No 8 Glutaraldehyde* [Queensland Government; 1999 [cited 2004 November 2004]; Available from: URL:<http://www.whs.qld.gov.au/casestudy/case008v3.pdf>

Donaldson K, Borm PJA. *The Quartz Hazard: A Variable Entity*. *The Annals of Occupational Hygiene* 1998;42(5):287-94.

Donnan M. *Ethylene Oxide – TLV and Exposure in Victorian Hospitals*. In: Proceedings of the 5th Annual Conference of the Australian Institute of Occupational Hygienists, 1986 November 30 - December 3 1986; Ballarat: p. 12-9.

Drummond JL, Cailas MD, Croke K. *Mercury generation potential from dental waste amalgam*. Journal of Dentistry 2003;31(7):493-501.

DTIR. *Guide for Handling Cytotoxic (Anti neoplastic) Drugs and Related Waste*. Brisbane: Queensland Government; 1997 November 1997.

Duffin J, Hayter CRR. *Baring the Sole: The Rise and Fall of the Shoe-Fitting Fluoroscope*. Isis 2000;91(2):260-82.

Dyck RJ. *Historical Development of Latex Allergy*. AORN Journal 2000;71(7).

Echeverria D, Heyer NJ, Martin MD, Naleway CA, Woods JS, Bittner J, Alvah C. *Behavioral effects of low-level exposure to Hgo among dentists*. Neurotoxicology and Teratology 1995;17(2):161-8.

EPA. *Legionella: Human Health Criteria Document EPA-822-R-99-001* [United States Environmental Protection Agency, Office of Science and Technology, Office of Water; 1999; Available from:

URL:<http://www.epa.gov/waterscience/humanhealth/microbial/legionella.pdf>

Fiserova-Bergerova V. *Relevance of occupational skin exposure*. Ann Occup Hyg 1993;37(6):673-85.

Flodin U, Landtblom AM, Axelson O. *Multiple sclerosis in nurse anaesthetists*. Occupational and Environmental Medicine 2003;60(1):66.

Fransman W, Vermeulen R, Kromhout H. *Occupational Dermal Exposure to Cyclophosphamide in Dutch Hospitals: A Pilot Study*. Ann Occup Hyg 2004.

Gloster J, Hugh M., Roenigk RK. *Risk of acquiring human papillomavirus from the plume produced by the carbon dioxide laser in the treatment of warts*. Journal of the American Academy of Dermatology 1995;32(3):436-41.

Gobba F. *Occupational Exposure to Chemicals and Sensory Organs: A Neglected Research Field*. NeuroToxicology 2003;24(4-5):675-91.

Goyer RA, Clarkson TW. *Toxic Effects of Metals*. In: Klassen CD, editor. Casarett & Doull's Toxicology. The Basic Science of Poisons. 6th ed. New York: McGraw Hill; 2001. p. 811-67.

Grantham D, Wright J, Golding G, Lee G, Wallace B, King G. *The need for occupational hygiene in the health care industry*. Journal of Occupational Health and Safety, Australia and New Zealand 2003;19(1):87-96.

Griffiths S, Fleming D. *Occupational Exposure to Anaesthetic Gases in Operating Theatre and Recovery Room Personnel. A West Australian Study*. In: The Asian Pacific Conference on Occupational Health and Safety. Towards Health and Safety at Work, 1995 September 1995; Brisbane: p. 50-3.

Hamilton A. *Industrial Poisons in the United States*. New York: The Macmillan Company; 1925.

Hasselhorn H-M, Toomingas A, Lagerström M, Arbetslivsinstitutet (Sweden)., International Commission on Occupational Health. *Occupational health for health*

*care workers : a practical guide*. 1st ed. Amsterdam ; New York ; Oxford: Elsevier; 1999.

Henneberger PK, Goe SK, Miller WE, Doney B, Groce DW. *Industries in the United States with Airborne Beryllium Exposure and Estimates of the Number of Current Workers Potentially Exposed*. JOEH 2004;1(10):648-59.

HSE. *HSE Information Sheet MISC615. Safe Handling of Cytotoxic Drugs* [Health and Safety Executive; 2003; Available from: URL:www.hse.gov.uk/pubns/misc615.pdf

Hughes D. *Discharging to Atmosphere from Laboratory-Scale Processes*. Leeds: HHSC Scientific Consultants; 1989. (HHSS handbook No 4).

Jagger JC. *Are Australia's healthcare workers stuck with inadequate needle protection?* Med J Aust 2002;177(8):407-8.

Jungbauer FHW, van der Harst JJ, Groothoff JW, Coenraads PJ. *Skin protection in nursing work: promoting the use of gloves and hand alcohol*. Contact Dermatitis 2004;51(3):135-40.

Kenkel JM, Johns DF, Rohrich RJ, Adams WP, Jr., Roeser RJ. *Hearing and ultrasound-assisted liposuction: the effect on surgeon and patient*. Plast Reconstr Surg 2000;106(1):150-3; discussion 4.

Kerr C, Morrell S, Salkeld G, Corbett S, Taylor R, Webster F. *Best Estimate of the Magnitude of Health Effects of Occupational Exposure to Hazardous Substances*. Canberra: Australian Government Publishing Service; 1966 April 1996.

Kim TS, Kim HA, Heo Y, Park Y, Park CY, Roh YM. *Level of silica in the respirable dust inhaled by dental technicians with demonstration of respirable symptoms*. Ind Health 2002;40(3):260-5.

Klein M, Rau S, Samev N, Carstens G. *Protection Offered by Selected Medical Gloves Made of Either Latex or a Synthetic Elastomer Against Exposure to Nine Cytotoxic Agents*. European Hospital Pharmacy 1999;5(4):152-8.

Kromhout H, Hoek F, Uitterhoeve R, Huijbers R, Overmars RF, Anzion R, Vermeulen R. *Postulating a dermal pathway for exposure to anti-neoplastic drugs among hospital workers.: Applying a conceptual model to the results of three workplace surveys*. The Annals of Occupational Hygiene 2000;44(7):551-60.

LaMontagne AD, Kelsey KT. *OSHA's renewed mandate for regulatory flexibility review: in support of the 1984 ethylene oxide standard*. Am J Ind Med 1998;34(2):95-104.

LaMontagne AD, Kelsey KT. *Evaluating OSHA's ethylene oxide standard: Exposure determinants in Massachusetts hospitals*. American Journal of Public Health 2001;91(3):412.

LaMontagne AD, Oakes JM, Turley RNL. *Long-Term Ethylene Oxide Exposure Trends in US Hospitals: Relationship With OSHA Regulatory and Enforcement Actions*. American Journal of Public Health 2004;94(9):1614.

Larson RR, Khazaeli MB, Dillon HK. *A new monitoring method using solid sorbent media for evaluation of airborne cyclophosphamide and other antineoplastic agents*. Appl Occup Environ Hyg 2003;18(2):120-31.

- Lawton BW. *Contract Research Report 343/2001 Damage to Human Hearing by Airborne Sound of Very High Frequency or Ultrasonic Frequency* [Health and Safety Executive; 2001; Available from:  
URL:[http://www.hse.gov.uk/research/crr\\_pdf/2001/crr01343.pdf](http://www.hse.gov.uk/research/crr_pdf/2001/crr01343.pdf)
- Leichnitz K. *2004 William P. Yant Award Lecture Occupational Hygiene in Nursing Homes*. JOEH 2004;1(11):D129 - D32.
- Leigh J, Driscoll T. *Malignant mesothelioma in Australia, 1945-2002*. Int J Occup Environ Health 2003;9(3):206-17.
- Lenahan GP. *Universal Respiratory Etiquette: A Modest Proposal*. Journal of Emergency Nursing 2004;30(1):3.
- Liddell FDK. *The interaction of asbestos and smoking in lung cancer*. The Annals of Occupational Hygiene 2001;45(5):341-56.
- Lim WS, Anderson SR, Read RC, on behalf of the SARS guidelines committee of the British Thoracic Society tBISatHPA. *Hospital management of adults with severe acute respiratory syndrome (SARS) if SARS re-emerges--updated 10 February 2004*. Journal of Infection 2004;49(1):1-7.
- Lipp A, Edwards P. *Disposable surgical face masks for preventing surgical wound infection in clean surgery*. Cochrane Database Syst Rev 2002(1):CD002929.
- Lippman M. *Broadening the Limits of Occupational Hygiene*. In: 14th Annual Conference of the Australian Institute of Occupational Hygienists, 1995 December 9-13 1995; Adelaide: p. 262.
- Lonnroth E-C, Wellendorf H, Ruyter E. *Permeability of different types of medical protective gloves to acrylic monomers*. Eur J Oral Sci 2003;111(5):440-6.
- Mason HJ, Morton J, Garfitt SJ, Iqbal S, Jones K. *Cytotoxic Drug Contamination on the Outside of Vials Delivered to a Hospital Pharmacy*. Ann Occup Hyg 2003;47(8):681-5.
- McBride D, Calvert I. *Audiometry in industry*. Ann Occup Hyg 1994;38(2):219-30.
- Mendell MJ, Fisk WJ, Kreiss K, Levin H, Alexander D, Cain WS, Girman JR, Hines CJ, Jensen PA, Milton DK, Rexroat LP, Wallingford KM. *Improving the health of workers in indoor environments: priority research needs for a national occupational research agenda*. Am J Public Health 2002;92(9):1430-40.
- Mendelson RM, Forbes GM. *Computed tomography colonography (virtual colonoscopy): Review*. Australas Radiol 2002;46(1):1-12.
- Mikl K. *Quiet Please Its a Hospital*. In: Proceedings of the 17th Annual Conference of the Australian Institute of Occupational Hygienists, 1998 December 5-9 1998; Canberra: p. 215-26.
- Moseley H, Strang R, MacDonald I. *Evaluation of the risk associated with the use of blue light polymerizing sources*. Journal of Dentistry 1987;15(1):12-5.
- Naguib M, Badr-El D, Madian Y, Iskander N. *Identification of the auditory hazards of extracorporeal shock wave lithotripsy*. Journal of Laryngology & Otology 2002;116(1):1.

- Nayebzadeh A, Stangel I, Dufresne A. *Risk of respiratory exposure of dental personnel to amalgam alternatives*. *The Science of The Total Environment* 2000;247(1):33-9.
- Newsom SWB. *Pioneers in infection control--Joseph Lister*. *Journal of Hospital Infection* 2003;55(4):246-53.
- Nielsen JB, Grandjean P. *Criteria for skin notation in different countries*. *Am J Ind Med* 2004;45(3):275-80.
- NIOSH. *Glutaraldehyde - Occupational Hazards in Hospitals DHHS (NIOSH) Publication No. 2001-115*. Cincinnati: National Institute for Occupational Safety and Health; 2001.
- NIOSH. *NIOSH Alert - Preventing Occupational Exposures to Antineoplastic and other Hazardous Drugs in Healthcare Settings. DHHS (NIOSH) Publication No. 2004-165*. National Institute for Occupational Safety and Health; 2004 September 2004.
- NOHSC. *Guidance Note for the Safe Use of Ethylene Oxide in Sterilisation/Fumigation Processes [NOHSC:3016(1992)]*. Sydney: National Occupational Health and Safety Commission; 1992 1992.
- NOHSC. *National Code of Practice for the Safe Use of Ethylene Oxide in Sterilisation/Fumigation Processes [NOHSC:2008(1992)]*. Sydney: National Occupational Health and Safety Commission; 1992 1992.
- NOHSC. *Exposure Standards - Glutaraldehyde* [National Occupational Health and Safety Commission; 1995 [cited 2004 November 2004]; Available from: URL:<http://www.nohsc.gov.au/OHSInformation/Databases/ExposureStandards/az/Glutaraldehyde.htm>
- NOHSC. *National OHS Strategy 2002-2012* [National Occupational Health and Safety Commission; 2002 [cited 2004 September 2004]; Available from: URL:<http://www.nohsc.gov.au/nationalstrategy/>
- NOHSC. *National Priority Action Plan 3 (2002-2005): Prevent occupational disease more effectively* [National Occupational Health and Safety Commission; 2002 [cited 2004 September 2004]; Available from: URL:<http://www.nohsc.gov.au/nationalstrategy/Papers/NPAP3.pdf>
- NOHSC. *The Australian Occupational Health and Safety Index - points to Practical Guidance Material and Safety Alerts available on Australian OHS Authorities websites* [National Occupational Health and Safety Commission; 2004 [cited 2004 September 2004]; Available from: URL:<http://natindex.nohsc.gov.au>
- NOHSC. *Exposure Standards - Ethylene oxide* [National Occupational Health and Safety Commission; 2004 [cited 2004 November 2004]; Available from: URL:[http://www.nohsc.gov.au/OHSInformation/Databases/ExposureStandards/az/Ethylene\\_oxide.htm](http://www.nohsc.gov.au/OHSInformation/Databases/ExposureStandards/az/Ethylene_oxide.htm)
- NTP. *Report on Carcinogens, Tenth Edition* [U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program; 2002; Available from: URL:<http://ehp.niehs.nih.gov/roc/toc10.html>
- Nyborg WL. *Biological effects of ultrasound: development of safety guidelines. Part I: personal histories*. *Ultrasound in Medicine & Biology* 2000;26(6):911-64.

- Nyborg WL. *Biological effects of ultrasound: Development of safety guidelines. Part II: General review.* *Ultrasound in Medicine & Biology* 2001;27(3):301-33.
- Nygren O, Gustavsson B, Strom L, Friberg A. *Cisplatin Contamination Observed on the Outside of Drug Vials.* *Ann Occup Hyg* 2002;46(6):555-7.
- O'Mahony MC, Stanwell-Smith RE, Tillett HE, Harper D, Hutchison JG, Farrell ID, Hutchinson DN, Lee JV, Dennis PJ, Duggal HV. *The Stafford outbreak of Legionnaires' disease.* *Epidemiol Infect* 1990;104(3):361-80.
- OSHA. *Hazard Information Bulletin. Preventing Adverse Health Effects from Exposure to Beryllium in Dental Laboratories:* Centres for Disease Control; 2002.
- Parkinson TJ. *Double gloving to reduce surgical cross-infection (Cochrane Review).* *Journal of the American College of Surgeons* 2003;196(4):617-8.
- Pasic TB, Poulton TJ. *The hospital-based helicopter. A threat to hearing?* *Arch Otolaryngol* 1985;111(8):507-8.
- Pegum JS, Medhurst FA. *Contact Dermatitis from Penetration of Rubber Gloves by Acrylic Monomer.* *BMJ* 1971;2:141-3.
- Peipins LA, Burnett C, Alterman T, Lalich N. *Mortality patterns among female nurses: A 27-state study, 1984 through 1990.* *American Journal of Public Health* 1997;87(9):1539.
- Perkins JL, Pool B. *Batch Lot Variability in Permeation Through Nitrile Gloves.* *AIHAJ* 1997;58(7):474-9.
- Persson BRR. *Radiation Hazards.* In: Brune D, Edling C, editors. *Occupational hazards in the health professions.* Boca Raton, Fla.: CRC Press; 1989. p. 163-236.
- Plappert UG, Stocker B, Helbig R, Fliedner TM, Seidel HJ. *Laser pyrolysis products - genotoxic, clastogenic and mutagenic effects of the particulate aerosol fractions.* *Mutation Research/Genetic Toxicology and Environmental Mutagenesis* 1999;441(1):29-41.
- Poet TS, McDougal JN. *Skin absorption and human risk assessment.* *Chemico-Biological Interactions* 2002;140(1):19-34.
- Pressly V. *Waste anaesthetic gases.* *British Journal of Perioperative Nursing* 2000;10(6):299.
- Roll EMB, Jacobsen N, Hensten-Pettersen A. *Health hazards associated with curing light in the dental clinic.* *Clinical Oral Investigations* 2004;8(3):113-7.
- Rowland BM. *Bacterial contamination of dental unit waterlines: What is your dentist spraying into your mouth?* *Clinical Microbiology Newsletter* 2003;25(10):73-7.
- Singleton LC, Connor TH. *An evaluation of the permeability of chemotherapy gloves to three cancer chemotherapy drugs.* *Oncol Nurs Forum* 1999;26(9):1491-6.
- Sliney DH. *Photoprotection of the eye - UV radiation and sunglasses.* *Journal of Photochemistry and Photobiology B: Biology* 2001;64(2-3):166-75.
- Sliney DH, Mellerio J, Gabel VP, Schulmeister K. *What is the meaning of threshold in laser injury experiments? Implications for human exposure limits.* *Health Phys* 2002;82(3):335-47.

- Stocker B, Meier T, Fliedner TM, Plappert U. *Laser pyrolysis products: sampling procedures, cytotoxic and genotoxic effects*. Mutation Research/Genetic Toxicology and Environmental Mutagenesis 1998;412(2):145-54.
- Sutow EJ, Hall GC, MacLean CA. *Effectiveness of wet and dry mercury vapour suppressant systems in a faculty of dentistry clinic*. J Oral Rehabil 2004;31(8):822-6.
- Szymanska J. *Risk of exposure to Legionella in dental practice*. Ann Agric Environ Med 2004;11(1):9-12.
- Taravella MJ, Viega J, Luiszer F, Drexler J, Blackburn P, Hovland P, Repine JE. *Respirable particles in the excimer laser plume*. J Cataract Refract Surg 2001;27(4):604-7.
- Trampuz A, Widmer AF. *Hand hygiene: a frequently missed lifesaving opportunity during patient care*. Mayo Clin Proc 2004;79(1):109-16.
- Trenter SC, Walmsley AD. *Ultrasonic dental scaler: associated hazards*. J Clin Periodontol 2003;30(2):95-101.
- Tzaczuk MN, Crea J. *Glutaraldehyde Exposure of Endoscopy Nurses*. In: Proceedings of the 12th Annual Conference of the Australian Institute of Occupational Hygienists, 1993 December 5-8 1993; Terrigal, NSW: p. 111-3.
- Ursin C, Drabaek I. *Carbon-14 Tracers in Permeation Studies: Feasibility Demonstration*. In: Performance of Protective Clothing, 1988; Philadelphia: p. 266-94.
- Valentin J. *Guest Editorial, Preface, Main Points, Glossary and Chapter 1*. Annals of the ICRP 2004;34(1):1-20.
- Vecchio D, Sasco AJ, Cann CI. *Occupational risk in health care and research*. Am J Ind Med 2003;43(4):369-97.
- Vetter RJ. *Medical health physics: a review*. Health Phys 2004;86(5):445-56.
- Wagenvoort JHT, Sijstermans MLH. *From legionnaire to guerrilla combatant: suppression of Legionella pneumophila in a hospital cold water supply*. Journal of Hospital Infection 2004;In Press, Corrected Proof.
- Wake D, Bowry AC, Crook B, Brown RC. *Performance of respirator filters and surgical masks against bacterial aerosols*. Journal of Aerosol Science 1997;28(7):1311-29.
- Walmsley AD. *Potential hazards of the dental ultrasonic descaler*. Ultrasound in Medicine & Biology 1988;14(1):15-20.
- Wendt NW. *Material Safety Data Sheets: The Life Blood of Chemicals' Control or Just another Burden to Bear?* In: Proceedings of the Australian Institute of Occupational Hygienists Annual Conference, 1989: p. 175-9.
- Widstrom J, Edling C. *Antineoplastic Agents*. In: Brune D, Edling C, editors. Occupational hazards in the health professions. Boca Raton, Fla.: CRC Press; 1989. p. 131-9.
- Winder C, Jiamsakul W. *The Quality of Material Safety Data Sheets (MSDS) in Australia*. In: Proceedings of the Australian Institute of Occupational Hygienists' Annual Conference, 1992 December, 1992; Melbourne: p. 89-94.

Yu VL. *Nosocomial legionellosis*. Current Opinion in Infectious Diseases 2000;13(4):385-8.