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# Occupational hazards and radiation safety in veterinary practice including zoo veterinary practice in Australia

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# Occupational Hazards and Radiation Safety in Veterinary Practice including Zoo Veterinary Practice in Australia

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# USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.

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I certify that this thesis does not, to the best of my knowledge and belief:

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## ABSTRACT

This thesis contains reviews and research on the occupational hazards of zoo veterinary practitioners in Australia. Although occupational hazards have long been recognised in the veterinary profession, little information is available on the number and magnitude of injuries to veterinarians in Australia, the United Kingdom or the United States. Apart from anecdotal accounts and some limited data, most of the available information is on occupational zoonoses, generally well recognized by veterinarians. Other occupational hazards to which veterinarians are exposed have received scant attention.

The veterinary practitioner in a zoo environment has to treat a range of captive wild species which are much more unpredictable and dangerous than domesticated animals. A comprehensive study on occupational hazards sustained by veterinarians in zoological gardens has not been undertaken in Australia. Only one study had been undertaken in the US amongst zoo veterinarians, while comprehensive may not be able to be transposed to zoos in Australia as the species held in Australian zoos differ from those in the US. Personal communication with some senior veterinarians in the zoological gardens in Australia, have elicited further information on the prevalence of occupational hazards sustained by the zoo and wildlife park veterinarians.

The prevalence of physical hazards including radiation, chemical and biological hazards reported by veterinary practitioners and the author's own experience as a veterinary practitioner, chairman of the safety committee, member of the animal ethics committee and manager, research in the zoological gardens in Perth, Western Australia have

demonstrated a need for a comprehensive study on occupational hazards prevalent among zoo veterinarians.

To investigate the occupational hazards including radiological hazards amongst zoo veterinarians in Australia, a self-administered 14-page comprehensive questionnaire comprising 58 questions was mailed to 27 practising zoo veterinarians in Australia. The questionnaire focused on physical injuries, chemical exposures, allergic and irritant reactions, biological exposures, radiological hazards including problems encountered with x-ray machines, use of protective gear and ancillary equipment for radiography, personnel involved in x-ray procedures and in restraining animals, compliance with the Australian National Health and Medical Research Council (NHMRC) Code of Practice (1982), Radiation Safety Regulations (1988) and National Standard for Limiting Occupational Exposure to Ionising Radiation (1995).

The result of the study revealed that 60% of the participants sustained physical injuries such as crushes, bites and scratches inflicted by a range of species with some injuries requiring medical treatment. Also, 50% of the participants suffered from back injuries while 15% reported fractures, kicks, bites necessitating hospitalization. Ninety percent of the participants sustained needlestick injuries ranging from one to 16+ times. Other significant findings include: necropsy injuries, animal allergies, formaldehyde exposure, musculoskeletal injuries and zoonotic infections.

The survey also identified that veterinary practitioners and their staff were exposed to radiation by not complying with the National Health and Medical Research Council (NHMRC) Australian Code of Practice for the Safe Use of Ionising Radiation (1982) which has been framed to minimize exposure to ionising radiation. The majority of the veterinarians in the study group indicated that radiation exposure is a major occupational hazard to the veterinary profession.

Subsequent to the review and research, discussions were held with few senior zoo veterinarians, the Registrar of the Veterinary Surgeons Board and a number of practising senior veterinarians in Australia to collect information on occupational hazards.

Additional information was obtained on occupational injuries sustained by the zoo veterinarians through formal discussions with the Director and the two senior veterinarians in the zoological gardens in Sri Lanka. The discussions with the veterinary practitioners in government and private practice revealed that veterinarians experienced a range of occupational hazards including exposure to rabies. Discussions with the dean and the professor of the animal science department focused on the nature of injuries and preventive strategies. In order to obtain information on occupational hazards in the health care industry, the professor of anatomy of the faculty of medicine and a senior surgeon in Sri Lanka were interviewed.

This study identified that the zoo veterinarians are routinely exposed to a wide range of occupational hazards. The literature review among veterinary practitioners in US, UK, Australia and Canada have also identified numerous occupational hazards sustained by the veterinarians. The discussions held in Sri Lanka with the professionals in veterinary and health care industry showed that occupational injuries have been common amongst them and they do not have appropriate preventive guidelines in place. This thesis has incorporated recommendations in the form of preventive strategies for minimizing occupational hazards among veterinary practitioners both in zoological gardens and veterinary practices in Australia and in the developed and developing countries.

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# TABLE OF CONTENTS: Summary

## TABLE OF CONTENTS: Detailed

## LIST OF TABLES AND FIGURES

# CHAPTER 1

## INTRODUCTION AND DEVELOPMENT OF THESIS STRUCTURE

This thesis describes the occupational injuries and illnesses prevalent among veterinarians including zoo veterinarians in Australia and contains reviews and results of studies on physical, chemical and biological causes of disease, injury and accidents with particular reference to radiological and other occupational hazards.

A literature search of Medical (MEDLINE), Occupational Health and Safety (OSHRAM), Veterinary Public Health (PubMed, E.Medicine), electronic data bases and continual monitoring utilizing the Uncover alerting system using the key words, 'occupational injury', 'occupational disease', 'radiological hazards' linked with the use of the words 'veterinarians' and 'zoo veterinarians' has found relevant articles. Consultations with medical and veterinary professionals who treat domesticated and wild animals, and experts on occupational, radiological and other related hazards were also carried out locally and abroad to assess the extent of disease, injury and accidents in the veterinary profession. Personal communication with people who have undertaken studies on occupational safety among zoo veterinarians elicited further information.

An initial literature review on "Occupational hazards of zoo veterinarians" was documented. A second literature review on "Radiation and related hazards among veterinary practitioners" was developed. A third literature review on "Disease, injury and accidents among veterinary practitioners" was updated.

The outcome of these reviews led to the studies and surveys on occupational exposures to disease, injury and accidents as well as radiological hazards among zoo veterinarians in Australia.

The literature reviews and the findings of the studies along with strategies and recommendations for minimizing occupational hazards in veterinary practices including zoo veterinary practice will be submitted for publication to the "Australian Veterinary Journal" in the interest of the veterinary profession. In this chapter, an outline is provided for reasoning that led to the observations and study. This concludes with the development of thesis structure explaining the underlying logic.

**Reasons for researching occupational hazards**

The establishment and early history of zoos in Australia was modelled very closely on London Zoo and other mid-19$^{th}$ century European zoos. Melbourne Zoo was established in 1862, Adelaide Zoo in 1883, Perth Zoo in 1898 and Toronga Zoo in Sydney in 1916. In addition to the traditional zoos, there are several publicly owned wildlife parks in Australia. These are generally constructed on a larger site and usually feature a particular theme, such as native fauna or animals in open range settings. Some examples are: Healesville Sanctuary in Victoria; Currumbin Sanctuary in Queensland; Territory Wildlife Park in Northern Territory; Monarto Zoological Park in South Australia and Western Plains Zoo in New South Wales (Easton B. personal communication, 2002).

The first full-time veterinarian at an Australian zoo was appointed as late as 1968. Now, all major zoos and wildlife parks have more than one permanent veterinarian on staff working in the animal hospital and keeping staff with veterinary nursing and animal care qualifications and experience (Fletcher T. personal communication, 2002). The veterinary profession is considered to be a relatively high-risk group for adverse work-related exposures compared with any other occupational group. Veterinarians working in zoos and wildlife parks are exposed to a range of wild exotic and native species which are more unpredictable, unreliable and dangerous than domesticated animals.

The veterinary profession encounters physical hazards such as inflicted trauma and exposure to radiation, chemical hazards including exposure to anaesthetics, pesticides, drugs, vaccine, formaldehyde, chemotherapeutic agents, zoonoses and allergic conditions due to interaction with animal patients. Due to the hazardous nature of the profession, associated personnel including veterinary nurses, zookeepers, animal handlers, other zoo staff, work-experience students and visitors are also exposed to occupational hazards. The available information on occupational hazards for zoo veterinary professionals is largely anecdotal and there is very little information available regarding the size of this problem.

Zoological gardens and wildlife parks in all states of Australia hold wild exotic and native species for exhibition and breeding purposes. Veterinarians in the zoological gardens and in most of the wildlife parks of Australia are state government employees. Few wildlife parks are privately owned. In zoological gardens working hours of the veterinarian are long, schedules are often altered and the patients are diverse, but the commitment imparted to each species in the collection remains constant. Treatment and care of unpredictable wild species in zoos is a demanding job and requires dedicated service. In addition, the zoo veterinarian is also responsible for the health and psychological well-being of captive animals, advancement of programmes for preventive medicine, for husbandry and public relations (Huntress S. personal communication, 2001).

So far no studies have been undertaken either on work-related disease, injury or accidents or on radiological hazards amongst zoo veterinary practitioners in Australia. Occupational hazards prevalent among veterinarians in zoological gardens in Australia are not similar to those in the United States (US), the United Kingdom (UK) or Canada as the animal species are mostly unique to each country.

This thesis sets out to discover the physical, chemical and biological hazards sustained in veterinary practices in zoos and wildlife parks in Australia. This study will be compared with the disease and injuries sustained by veterinarians treating domesticated animals. The outcome of this study along with the preventive strategies will be made available to zoo veterinarians and other veterinary professionals in Australia which will enable them to be aware of the occupational hazards in the profession and take appropriate measures to prevent or reduce the risk of occupational disease, injury and accidents.

**Chapter 1** provides an initial introduction and sets out the development of the thesis structure which provides the reasons that led to the review, study, survey and analysis on occupational hazards of zoo veterinarians in Australia.

**Chapter 2** undertakes an initial review of "Physical Hazards in Veterinary Practice." Physical trauma is the greatest cause of physical injury to veterinarians, veterinary nurses, zookeepers and other staff. This chapter provides an overview of the physical hazards to which veterinarians are exposed including traumatic injuries, needle stick and necropsy injuries, musculoskeletal injuries and disorders, equipment injuries and motor vehicle accidents. The pattern of physical hazards have changed recently due to more women taking up veterinary science, previously a male dominated profession. This has changed the pattern of occupational hazards to the veterinary profession as female veterinarians are prone to adverse reproductive outcomes, increased chances of spontaneous abortion and foetal loss when exposed to anaesthetic gases and ionizing radiation.

The majority of veterinarians in Australia are small or mixed animal practitioners while some are large animal practitioners and a very small number in zoo practice. A study carried out in North America by Hill et al., (1998)[1] among zoo veterinarians revealed that majority of zoo veterinarians sustained animal-related injuries during their career. No comprehensive studies have been undertaken in the UK, Canada, or in Australia on physical hazards sustained by the veterinarians in zoo practice. Reports from the American Veterinary Medical Association Group Insurance Trust (AVMAGIT)[2], and an evaluation by the American Veterinary Medical Association Professional Liability Trust[3] (AVMAPLT) and workers' compensation claims over a three-year period showed that the causes of claims were mostly due to physical injuries and zoonotic diseases.

Because of the lack of information available on physical hazards among zoo veterinarians, there was a need to assess the prevalence of exposure to occupational hazards amongst zoo veterinarians in Australia.

**Chapter 3** undertakes a review of the literature on "Chemical Hazards in Veterinary Practice." Even though the veterinary career in a zoo environment can be rewarding, veterinarians are exposed to a number of potential health risks in the course of their employment. This literature review highlights some of the chemical hazards sustained by the veterinarians.

A number of potentially hazardous chemicals including anaesthetics, pesticides, disinfectants, solvents, sterilants and drugs used in veterinary practices have prompted concern. Products such as glutaraldehyde, formaldehyde, ethylene oxide, hexachlorophene and therapeutic agents can cause skin irritations, respiratory ailments, headaches, abortions, infertility and neoplasia. Chemicals such as acetamide, chromium salts, nickel salts and propanol have carcinogenic and/or teratogenic effects on humans. Veterinarians are also exposed to substances such as vaccines, antibiotics and anaesthetics through accidental needle stick injuries. An incident of accidental injection of prostaglandin has resulted in spontaneous abortion in a veterinarian.[4]

Due to insufficient information on work-related disease, injury and accidents in the veterinary profession, a study was undertaken to assess the prevalence of occupational hazards including chemical hazards and to gather sufficient information on exposures amongst veterinarians in a zoo environment.

**Chapter 4** reviews the literature on "Biological Hazards in Veterinary Practice." Veterinarians in zoo practice are exposed to a range of biological hazards such as zoonotic diseases and allergies. Zoonotic diseases include brucellosis, tuberculosis, leptospirosis, salmonellosis, Q fever, cryptococcosis, listeriosis, toxoplasmosis, rabies and psittacosis. Veterinarians are also exposed to allergens from animal hair, dander, urine, saliva and other body fluids as well as to chemicals that can cause irritation or allergic reaction. Frequent exposure to blood proteins and ectoparasites increases the probability of veterinarians developing occupational allergic respiratory diseases. Exposure to vaginal secretions and amniotic fluids and the handling of intestines, pancreases and pig blood have all been known to cause dermatitis. Veterinarians can also accidentally inject themselves with vaccines and animal blood. Several studies among veterinarians have indicated that antibiotics such as spiramycin, tylosin, penethamate, penicillin, neomycin and streptomycin cause dermatitis. It has also been noted iodine and povidone-iodine can cause allergic contact dermatitis.

The literature reviews did not provide sufficient data on harm caused by occupational hazards to zoo and wildlife park veterinarians. However, injuries from occupational hazards sustained by zoo and wildlife park veterinarians in Australia were uncovered largely anecdotally. Due to insufficient information on work-related disease, injury and accidents among veterinarians in a zoo environment, a study was undertaken to assess the prevalence of occupational harm and injuries and to gather sufficient information on exposure to these amongst zoo veterinarians in Australia.

**Chapter 5** outlines a review on "Radiation Safety and Associated Hazards in Veterinary Practice." It seeks to obtain an estimate of the radiological hazards prevalent in the zoo veterinary profession. Literature searches, consultations and discussions with both medical and veterinary professionals, scientists and experts on occupational, radiological and other related hazards were carried out locally and abroad to assess the extent of the prevalence of radiological and other occupational hazards. Previous studies among veterinary practitioners treating domesticated animals in Western Australia suggested that the majority of veterinarians used radiology as a common diagnostic tool. No studies on radiological hazards have been carried out among zoo veterinary practitioners even though, all the veterinarians in the study group used radiology for diagnostic purposes.

**Chapter 6** "Disease, Injury and Accidents among Zoo and Practising Veterinarians" explores many of the questions posed in the literature review and from discussions with senior veterinarians in zoo practices throughout Australia. Further information was obtained from the zoo veterinarians and practising veterinarians in a developing country to compare the nature of work-related hazards prevalent among zoo veterinarians in Australia.

**Chapter 7** "Survey among Zoo Veterinarians in Australia." This chapter ascertains the extent and prevalence of occupational hazards among zoo veterinary practitioners. A comprehensive questionnaire was developed and was pilot tested with a senior veterinarian at Perth zoological gardens and two other veterinarians who had experience in the treatment of domesticated and wild animals in Western Australia. The questionnaire was circulated to all veterinarians in zoological gardens and wildlife parks across Australia. The survey revealed that the majority of veterinarians suffered physical injuries including trauma, musculoskeletal injury and disorders, necropsy injuries, Needlestick injuries and stress due to a range of job responsibilities. The study found that self-treatment was administered by 59% of the participants. Other areas of concern included exposure to anaesthetics, hazardous substances, radiation, insecticides and pesticides. Veterinarians also suffered from zoonotic and allergic conditions.

The comprehensive questionnaire on 'disease, injury and accidents among zoo veterinarians' comprised 15 detailed questions on radiology and related hazards. Information was sought from the zoo veterinary practices in Australia on the type of x-ray machine used, personnel involved in taking x-rays, use of protective gear, compliance with the Australian Code of Practice (1982)[5] and the Radiation Safety Acts in each state such as the Radiation Safety Act (1975)[6] of Western Australia.

The survey found that the majority of female veterinarians taking x-rays were of child-bearing age. One female veterinarian and a female veterinary nurse had taken x-rays while they were pregnant. The result of the survey highlighted the non-use of protective gear including lead gloves, lead aprons, thyroid protection and personal monitor. The study found that zoo veterinarians were being exposed to ionizing radiation in contravention of the Australian Code of Practice (1982)[5] and the Radiation Safety Acts.

The survey also indicated that all the participants in the study group used radiology with one zoo practice taking 20-30 x-rays per week.

The result of the survey highlighted the non-use of protective gear such as lead aprons, gloves, sleeves and even personal monitors by some participants while taking x-rays and during radiological procedures.

**Chapter 8** makes a "Discussion and Conclusion" which draws together the findings of the previous chapters and presents a picture of the disease and injury to the zoo veterinarians with particular emphasis on radiation safety in zoo veterinary practice. The literature review initially carried out could not provide sufficient information on work-related hazards. The survey on disease, injury and accidents undertaken among all zoo veterinary practitioners across Australia assessed the nature of injuries sustained by zoo veterinarians in their practice. The results of this study revealed that physical, chemical and biological hazards and work-related stress and trauma are prevalent among zoo veterinary practitioners. The study also found that zoo veterinarians are exposed to ionizing radiation due to non-compliance of the Australian National Health and Medical Research Council (NHMRC) Code of Practice for the Safe Use of Ionising Radiation (1982)[5] and the radiation safety acts. Earlier studies among veterinary practitioners in Western Australia has reported that veterinarians have not adhered to NHMRC Code of Practice and the Radiation Safety Act (1975)[6]

The survey had two objectives; firstly to obtain an estimate on the potential risk areas on physical, chemical, biological, radiological and related hazards among zoo veterinarians and secondly, to suggest preventive measures on occupational health and safety issues. The NHMRC Code of Practice (1982)[5] also should be strengthened and legislation enacted to ensure that there is no exposure to ionizing radiation.

**Chapter 9** provides "Strategies and Recommendation for Minimizing Hazards in zoo and other veterinary practices." There have been no studies undertaken to collect detailed information on occupational hazards among zoo veterinarians in the US, the UK, Canada and Australia with the objective of recommending strategies for minimizing occupational hazards including radiological hazards. This study has provided preventive measures to minimize occupational hazards and will be of particular value to zoo veterinarians and other veterinary practitioners.

## Development of thesis structure

| Knowledge | Questions | Response |
|---|---|---|
| 1. Zoo and wildlife medicine is one of the most challenging forms of veterinary medicine. Veterinarians in zoo practice have sustained numerous animal-related disease, injury and accidents. | What are the causes of disease, injury and accidents sustained by zoo and wildlife park veterinarians? | Review of current knowledge. Discussions with senior zoo and practising veterinarians as well as with experts in veterinary medicine. **Chapters 2,3 & 4. –** Physical, chemical and biological hazards |
| 2. Information on occupational hazards of zoo and wildlife park veterinarians is largely anecdotal. There is no data available on occupational hazards for zoo veterinarians in Australia. | What are the occupational hazards including radiological hazards for zoo and wildlife park veterinarians? | Data collection through a comprehensive questionnaire from zoo veterinarians. Personal communication with experts in radiology from Australia and abroad. **Chapters 5 & 6 -** Radiological hazards; Disease & Injury among zoo veterinarians. |
| 3 Animals in captivity in zoos and wildlife parks are unpredictable and dangerous. Veterinarians experience a range of physical (including radiological), chemical and biological hazards. | What are the actual diseases and injuries to which zoo and wildlife park veterinarians are exposed? | Results of the survey, interviews and discussions. **Chapter 7 –** Survey among zoo veterinarians. |
| 4. Veterinarians treating domesticated livestock, pets and companion animals do not confront similar type of occupational hazards experienced by veterinarians in zoos and wildlife parks. The zoo veterinarians sustain severe animal-related injuries while treating unreliable wild animal species in captivity in closed quarters and confinement facilities. So far, no studies have been undertaken on occupational hazards prevalent among zoo veterinarians in Australia. | Do veterinarians in zoo and wildlife park industry confront similar types of occupational hazards compared to their colleagues treating livestock, pets and companion animals? | Previous studies among practising veterinarians in the field and the current study among zoo veterinarians. **Chapter 8 –** Discussion and conclusion |
| 5. Veterinarians in wildlife and domesticated animal practice do not have adequate preventive strategies for minimizing occupational hazards. | What are the strategies and recommendations to minimize occupational hazards for veterinarians working in zoos and wildlife parks? | Recommended strategies for practical application for minimizing occupational hazards. **Chapter 9 –** Strategies and recommendations. |

# CHAPTER 2

# REVIEW OF PHYSICAL HAZARDS IN VETERINARY PRACTICE

## Introduction

Australia is dependent on its primary industries of agriculture and animal husbandry where veterinarians and their staff play a vital role in promoting animal production and health activities of livestock, pets and wildlife. A substantial number of veterinarians are employed in state department of agriculture in animal production areas and through the Australian Quarantine and Inspection Service. Currently, there are about 8300 veterinary professionals practising in Australia of whom, more than 60% are in private practice treating and caring for companion animals, agricultural animals and racing animals including greyhounds and horses (Keef A. personal communication, 2001). Traditionally, veterinarians have been involved primarily in the treatment of animals, but today, the veterinarian's role has diversified to include prevention and eradication of diseases, treatment of animal injuries and diseases including emerging new diseases, animal breeding, food hygiene, prescribing medications and advising clients on feeding, breeding, enrichment and behaviour of animals. They also work in laboratories, research, pharmaceutical and chemical industries (Spalding T. personal communication, 2002).

Specialization is becoming an increasing demand and veterinarians specialize in surgery, medicine, ophthalmology, dentistry, radiology, acupuncture, chiropractic and artificial breeding. Veterinarians employed by the Commonwealth of Australia, supervise quality assurance programs for handling of stock and processing of meat for export markets. In addition, veterinarians have to supervise live animals for exports and imports and prevent diseases gaining entry into Australia. State government veterinarians control and eradicate animal diseases in food producing species such as cattle, sheep, pigs and poultry as well as attend to food safety by monitoring residues, contaminants and food quality. Comparatively a small number of veterinarians work in zoological gardens and wildlife parks caring for and treating wild animals in captivity and ensuring suitable habitats are maintained (Monaghan C. personal communication, 2001).

Veterinary practitioners are exposed to many hazardous situations at their work place. Even though, veterinarians working in zoological gardens experience work-related injuries which are a major problem, little is known of the specific risk factors associated with their profession. A number of veterinarians and their staff have contracted occupational zoonoses, experienced trauma, physical and chemical hazards as a result of their work.

The veterinary profession is well represented by women and they play a very significant role in the nation's animal production and health activities. Thirty years ago women formed less than 5% of the veterinary profession because of the belief that handling and treating animals are difficult tasks. Today, the current intakes into four veterinary schools in Australia are predominantly females. The profile of the veterinary profession is changing with the increase in number of females taking up to this profession which had been previously male dominated (Keef A. personal communication, 2000).

Veterinarians have to apply their expertise in a range of fields when they commence work as practitioners. During the period of graduation, they are unable to gain required experience in the care, diagnosis, treatment and delivery of the diversified species in zoos. Veterinarians need to develop their skills in certain areas in which they were unable gain experience during the period of graduation.

Studies among veterinary practitioners the UK and the US reported that the majority of veterinarians play a major role in the healthcare of companion animals such as dogs, cats and birds (Spalding T. personal communication, 2000). Some veterinarians specialize in the treatment of cattle, horses, sheep and swine and in rural areas veterinarians treat large and small animals including companion animals. Veterinarians use their skills to protect humans against diseases transmitted by animals and contribute to public health on human and animal health problems. Veterinarians also undertake educational activities, quarantine work, animal production, pregnancy diagnosis, meat inspection, anti mortem and post mortem examinations, milk production, issue of breeding materials and deal with issues associated with residues from insecticides, herbicides and antibiotics.

Veterinary professionals in Australia are regarded as a high risk group for exposure and harm from occupational hazards. Most of the available information is on occupational zoonoses, generally well-recognised by veterinarians. Other occupational diseases to which veterinarians are exposed have received scant attention and reports are mostly anecdotal.[7] Recent studies amongst veterinarians in Western Australia and North America have provided reliable information on the number and magnitude of injuries and disease in veterinarians in Western Australia, and in North America.[1-3,8]

Veterinarians working in a zoo environment are exposed to numerous occupational hazards while treating a range of wild animal species. Zoo veterinarians encounter unique hazards in their daily practice in an environment which has been fostered to accommodate large scale public attendance for education on conservation and recreation. The observation, restraint, diagnosis and treatment of animals including surgical procedures are mostly performed in the close quarters, cages or confinement facilities by zoo veterinarians as certain species cannot be transported to a veterinary hospitals or clinics outside the facility. This contrasts sharply with the medical profession where diagnosis and treatment are performed not only by medical practitioners but also by other medical or health care personnel including audiologists, chiropractors, dentists, optometrists, physiotherapists, podiatrists, radiographers, anaesthetists and speech pathologists. In the zoological gardens, the noise levels and exposure to poor air quality in an enclosed environment can also have harmful effects on the veterinarian. Most veterinarians work 50 or more hours a week, about a fifth working 40 hours, and those in private practice sometimes working during nights and weekends (Culliver M. personal communication, 2002).

Numerous studies have investigated the occupational hazards sustained by veterinary practitioners treating large, mixed and small animals, companion animals, swine and equine. No studies have been carried out in Australia among veterinarians treating captive animals which are much more unpredictable and dangerous than domesticated animals and as such no information is available on the occupational injuries and illnesses sustained by zoo veterinary practitioners in Australia. These animals inflict a range of injuries on veterinary practitioners including puncture wounds, bites, scratches, fractures, musculoskeletal injuries, infectious wounds and trauma from kicks, hits, punches, being stepped on or fallen upon. They can also inflict injuries to veterinarians which can be fatal.

The National Occupational Safety and Health Commission (NOSHC) which collates workers' compensation records of occupational injuries excludes the state of Victoria and the Australian Capital Territory. Also, it does not provide sufficient detailed breakdown of occupation to identify veterinarians who, at present, are reported with other professionals. The insurer for the Australian Veterinary Association (AVA) is precluded from workers' compensation insurance in New South Wales and the available national insurance records do not provide a complete picture of occupational disease and injury among veterinarians. This is due to under-reporting and to the large number of companies involved in insuring veterinarians and their staff. Zoo veterinarians are covered by the Australian state government employees insurance award and there are no accessible records on the occupational hazards of zoo veterinarians.

Occupational disease statistics exist in several countries including the US, the UK, Canada and Australia. Coverage differs greatly on the notification system, as the legal concept of occupational disease, and on workers' compensation of different occupational groups. Some independent professional entrepreneurs including veterinarians are not covered by compensation systems. All statistics tend to underestimate the true incidence of occupational disease and injury sustained by the veterinarians.

## Trauma

Due to the stressful nature of veterinary practice, veterinarians often have to deal with a number of life threatening and dangerous occupational injuries and illnesses sometimes complicated by a range of physical trauma.

Veterinarians may encounter large and uncooperative patients in their daily practice and potential for injury is always present.[9] It is evident from the studies by Landercasper et al.,(1988)[9] and Hill et al., (1998)[1] that the incidence of occupational injuries to the veterinarian is very significant. The veterinarian has to work often with difficult-to-restrain wild animals in captivity as well as with domesticated animals having reactions due to fear or pain. Because of the unpredictable behaviour, injuries sustained can often be accidental when a large animal tramples or attacks a veterinarian.

There is an increasing public awareness of human infectious diseases such as human immunodeficiency virus (HIV) and hepatitis. This subject has resulted in an interest in both medical and lay press about the potential injury these diseases can cause to medical practitioners when they treat infectious diseases of this nature. However, work-related accidents are uncommon among medical professionals. In contrast, the amount of zoonotic diseases and trauma sustained by veterinary surgeons is very high and there is very little information available regarding the size of this problem. Due to the unpredictable behaviour of both domesticated and wild animals in captivity, and the adverse working conditions in zoo veterinary practices, injuries are common. As a result, there is significant work day loss to veterinary surgeons and possible long term morbidity and even mortality.

A study carried out among zoo veterinarians in the US[1] revealed that 61.5% of zoo veterinarians reported at least one major animal-related injury during their career of which, 17.8% had been hospitalized. A survey of North Carolina veterinarians showed that 68% of participants received a major animal-related injury and 8% were hospitalized.[10] Similarly another study[9] reported a 65% incidence of a major animal-related injury during veterinary careers. In contrast, 12.5% of swine veterinarians sustained a major swine related injury with 2% requiring hospitalization.[11]

A study among veterinary practitioners in West Australia[8] reported physical injuries sustained by small, large and mixed animal practitioners, with large-animal practitioners experiencing a greater rate of injuries than small-animal practitioners. These results are similar to overseas studies.[9,10,12]

A review of Labor Statistics in the US[13] for the five year period 1992-1997 revealed that working with animals causes occupational hazards sometimes with deadly results. However, occupational hazards cannot be categorised exclusively for veterinarians; veterinary practitioners share some of the same risks as many other animal handlers. The study reported that there were 75,000 animal-related non-fatal injuries amongst animal handlers. On an average, there were 63 fatal injuries and 12,500 non-fatal injuries and illnesses involving animals each year. Among the animals that caused fatalities, cattle rank the most dangerous followed by equine, dogs and cats. Of the 13,800 non-fatal injuries and illnesses involving days off from work were caused by dogs and almost three-quarters were caused by animal attacks. Overexertion from lifting heavy animals and objects accounted for all remaining cases. Non-fatal occupational injuries sustained from cat bites and scratches amounted to 4600.[13]

**Insurance Claims**

Figures were obtained from the Western Australian Department of Occupational Health, Safety and Welfare and the Workers' Compensation Rehabilitation Commission for claims made by employed veterinarians and veterinary staff from 1991 to 1996. Of the total number of claims, 36% were from animal bites, 8% from being hit by an animal, 9% from being hit by falling or moving objects, 8% from falls, 15% from muscular stress, 28% from sprains and strains and 9% from contusions and crushes. There were 5% claims due to vehicle accidents. Women made more animal-related injury claims than do men (Table 1). The study among veterinary practitioners in Western Australia showed that majority of veterinary employees are females working as veterinary nurses and receptionists.[8]

A published work from the US was based on the response to a questionnaire sent to members of the American Veterinary Medical Association (AVMA) working in Minnesota and Wisconsin. In this study, veterinary surgeons had sustained major animal-related injuries which required medical treatment, including sutures, antibiotics or operative procedures. The authors attempted to correlate the nature of the injury and the severity, as shown by days off work, with the type of practices and the specific injury. The practitioners in this cohort were predominantly male (80%) and 47%

were mainly large animal practitioners. Cattle and horses caused 61.7% of the accidents with many sustaining several injuries. All parts of the body were injured with 52.6% of hand injuries. Fifty-six surgical procedures were undertaken for 56.3% of the injuries and 3.6% reduced fractures or dislocations.[9]

**Table 1. Number of workers' compensation claims made by women and men in veterinary practice from 1991 to 1996 in Western Australia**

| | Number of claims (%) | | |
|---|---|---|---|
| Period | Women | Men | Total |
| 1991-1992 | 27(84) | 5(16) | 32 |
| 1992-1993 | 35(87.5) | 5(12.5) | 40 |
| 1993-1994 | 27(87) | 4(13) | 31 |
| 1994-1995 | 38(90.5) | 4(9.5) | 42 |

Figures supplied by White C. Chief Statistician, Worksafe WA 1997

These figures only cover employed veterinarians and staff because most veterinarians are insured with private insurance companies and records of their injuries are not available.

## Analysis of injuries and insurance claims in the US

Thigpen and Dorn (1973)[2] analysed the records of the AVMA Group Insurance Trust from 1967 to 1969 and showed that, of the 773 reported injuries sustained by male veterinarians, most were the result of handling large animals. Veterinarians were bitten, kicked, trampled or fallen upon by their patients and the major injuries sustained were strains, dislocations, bruising, contusions and fractures. More veterinarians were injured in the afternoon than in the morning, which may reflect lack of concentration as a cause in some cases.

A more recent evaluation of over 2000 workers' compensation claims over a three-year period for the AVMA Professional Liability Group Insurance Trust shows that the major causes stated for claims by veterinarians in the US are animal bites, animal handling, slips, trips and falls, and zoonotic diseases. These resulted in an estimated US $4 million in compensation.[3]

Whereas nearly half the claims in the AVMA analyses were associated with animal bites resulting primarily in lacerations, bruising and puncture wounds, they only accounted for a small percentage of claims dollars because these injuries can be treated relatively and inexpensively.

A review of insurance claims by veterinarians for themselves or staff of the American Animal Hospital Association (AAHA) from 1987 to 1994 (Henriksen E. personal communication, 1998) shows similar patterns for small animal practitioners. Animal bites accounted for 55% – 65% of the number of claims, yet formed a much smaller percentage of total claims dollars. The 1993 to 1994 summary of claims for AAHA Members shown in Table 2 supports this.

Gabel (2000)[14] in a case-controlled study of veterinarians in Minnesota identified the extent of work-related injuries among veterinarians and the pertinent risk factors. She observed increased rates of injuries in those people who currently smoke (10% versus 3%), have exposure to large animals (60% versus 48%), are females (46 versus 32%) and who have allergies (29% versus 17%).

**Table 2 Workers' compensation losses for American animal hospital association insured veterinarians: a summary of claims by cause of injury for 1993 to 1994**

| Loss description | % total claims (for 2000 claims) | % total cost |
|---|---|---|
| Animal/insect bite | 59% (1180) | 46% |
| Absorption or inhalation of toxin | 5% (100) | 6% |
| Lifting objects | 5% (100) | 12% |
| Stepping on objects | 5% (100) | 8% |
| Sharp object injury | 5% (100) | 1% |
| Tripping or falling | 5% (100) | 8% |
| Struck against or struck by an animal | 5% (100) | 3% |
| Particle in eye | 3% (60) | <1% |
| Bending, stooping, caught in/ under, pushing, pulling objects | 4% (80) | 3% |
| Contact temperature extreme | <1% (<20) | 3% |
| Carpal tunnel syndrome | <1% (<20) | 1% |
| Overexertion | 2% (40) | 7% |
| Miscellaneous | 3% (60) | 1% |

Figures do not add up to 100% because of rounding off.

Figures supplied by E.Henricksen from the United General Agency for the American Animal Hospital Association.

The US Bureau of Labor Statistics (BLS) analysed occupational injuries caused by animal patients in North America and Australia. Referring to the Australian study 'Occupational causes of injuries to veterinarians in Australia,[8] the bureau states in Australia working with animals posed unique hazard and such injuries accounted for most workers' compensation claims over a 12 month period with 31% of respondents losing a total of 360 days with a mean of 13.3 days. Over a 10 year period, 71% of survey respondents had been injured. The majority of physical injuries were bites from dogs and cats, cat scratches, scalpel blade cuts and back injuries from lifting heavy animals.[13]

Practice type (full-time versus part-time) was not significantly related, statistically, to the major animal-related injury rate among zoo veterinarians, but more years in practice has been significantly associated with highest number of animal-related injuries.[1]

**Nature of Injuries**

The most comprehensive studies of injuries to veterinarians have been carried out by Landercasper et al.,(1988)[9], recently by Hill et al., (1998)[1] and most recently by Gabel (2000)[14] and Jeyaretnam et al., (2000).[8] Nearly two-thirds of the 995 veterinary practitioners had sustained a major animal-related injury in their veterinary career and 17% had been hospitalized in the year prior to the study. Over 60% of the respondents had handled large animals with cattle being the large animal most likely to have caused injury.[9] The study of members of the American Association of Zoo Veterinarians while comprehensive, may not be extrapolated to the Australian zoo veterinarians. Other studies have shown horses have caused several injuries.[10,15] A study by Gabel (2000)[14] also found that the most frequent sources of animal-related injury were dog bites, being kicked or crushed by cattle, cat bites and scratches and horse kicks. The study by Jeyaretnam et al., (2000)[8] found similar type of injuries sustained by veterinary practitioners in Western Australia.

Table 3 summarises the animals noted as causing injuries in the studies of Thigpen and Dorn (1973),[2] Landercasper et al.,(1988)[9] and Langley et al.,(1995).[10] Kicks and bites caused the greatest number of injuries (70%) with crushes and scratches accounting for 15% of the total injuries. Landercasper et al., (1988)[9] study showed that 10% of respondents had missed at least one day of work due to injury in the previous year and 42% had missed work due to occupational injury in their veterinary career.

**Table 3. Number of veterinarians who sustained animal-related injuries in three US studies.**

| Animal | Thigpen & Dorn 1973 (25,386) | Landercasper et.al., 1988 (995) | Langley et.al., 1995 (1331) |
|---|---|---|---|
| Cattle | 36.5 (9266) | 46.5 (463) | 17.2 (229) |
| Horses | 1.3 (330) | 15.2 (151) | 13.8 (184) |
| Dogs | 12.1 (3072) | 24.2 (241) | 35.2 (468) |
| Cats | 1.9 (482) | 10.2 (102) | 28.4 (378) |
| Pigs | 2.0 (508) | 2.0 (20) | 2.2 (29) |
| Other | 1.0 (253) | 1.8 (18) | 3.2 (43) |

Over a 30 year period, the profile of animal injuries has changed with injuries inflicted by dogs and cats becoming more prevalent. The studies by Landercasper et al., (1988)[9] and Langley et al., (1995)[10] only asked about the animals involved in the most severe injury of the veterinarian's career while the earlier AVMA study[3] looked at all injuries reported for workers' compensation, which would also be indicative of more severe injuries. Hill et al., (1998)[1] investigated a wide range of physical, chemical and biological hazards amongst the zoo veterinarians. In recent years in the US, many small animal practitioners have become members of the insurance program sponsored by the AAHA and it is difficult to compare these results with the most recent AVMA report.[3]

Seventy-seven percent of veterinarians in the Landercasper et al., study (1988)[9] treated themselves through self-administration of antibiotics (67.5%), suture of lacerations (19.7%), and reduction of fractures or dislocations (3.6%). Veterinarians in practice for 6 years or more sustained substantially fewer injuries in the same timeframe than those practising for five years or less. There was no gender difference in the number of injuries sustained, nor did the type of practice affect the number of injuries, although large animals caused more severe injuries.[9]

While the zoo study among the veterinarians in the US[1] provides us with an insight into injuries and trauma experienced by veterinarians in the US, the study could not be transposed to the zoos in Australia as the species held in captivity in Australian zoos differ from the species held in zoos in the US. Studies among veterinary practitioners in the US[9-11,14] provide us with information on injuries sustained by veterinarians inflicted by domesticated animals. The figures may not accurately reflect what is happening either in Australia or in North America.

The states of Minnesota and Wisconsin have a large concentration of dairy cattle, biasing the sample towards large animal practitioners. Almost 60% of the Minnesota and Wisconsin respondents worked either solely or mainly with large animals, which is not the case among Australian veterinarians who are primarily small animal practitioners. In addition, Landercasper et al. (1988)[9] only had a 45% of veterinary practitioners responding to the questionnaire. It is possible that those veterinarians who had had an occupational injury or who had been injured in the previous year, were more likely to respond to the survey. Nor did their study adequately define injury or determine how many occupational injuries occurred per year.

Animal bites, being struck by an animal, scratches and lacerations are the most frequent cause of injury to veterinarians.[1,8,14,16,17] Injuries sustained by veterinarians are primarily lacerations and puncture wounds, with fractures and knocked out teeth being the second most common injuries followed by sprains, dislocations, torn ligaments, contusions and burns.[2,9] Legs (knees, ankles, feet and toes) were the most commonly injured area in the AVMA Group Insurance trust claims[3], followed by arms (elbows, wrists, hands and fingers) and head (face, chin, ear, nose and mouth). These three areas accounted for 61.7% of all reported injuries. Injuries to the back, spine and neck (excluding disc problems) accounted for 6.6% of the total sites of injury.[2] The study by Landercasper et al., (1988)[9] showed that hands were the most often involved (41.3%) followed by face (18.7%) and legs (18.4%).

The record of 134 patients admitted to a hospital as a result of trauma caused by cattle or horses showed that falls from horses were the most common cause of admission (33%), being kicked by a cow (21%), attacked by a cow (19%), attacked by a horse (13%) and kicked by a horse (8%). Only three (2%) of the patients were veterinarians, two of whom sustained facial injuries while examining cows for mastitis.[18]

### Musculoskeletal injuries and disorders

Back disorders accounted for 27% of all non-fatal occupational injuries sustained by zoo veterinarians in the United States involving days lost from work.[19] In a study among zoo veterinary practitioners in the US,[1] 60% of respondents reported a back problem and/or pain from repetitive activities at work. Due to back injuries from lifting of heavy animals or objects 11% had work time loss while 20% of participants had back pain and 55% had back problems from repetitive activities. The study shows that more than half of all zoo veterinarians received a back injury or disorder which is high enough figure to be of conern.[1]

In comparison, in a study among swine veterinarians, fifty-one percent of veterinarians complained of repetitive motion symptoms from administering injections to pigs or from bleeding pigs. Only 31% of respondents had back problems from lifting or moving swine.[11] Practice type, sex and years in service were not significantly statistically co-related with incidence of pain from repetitive motion in zoo veterinarians. Practice type was significantly associated with incidence of back injury, with full-time zoo veterinarians sustaining the most injuries. Also, zoo veterinarians with more years in practice experienced more back injuries and lost work time.[1]

The study by Landercasper et al., (1988)[9] reported that back injuries accounted for 8.9% of all major injuries. According to the 1993-1994 summary of workers' compensation losses for American Animal Hospital Association (AAHA) insured veterinarians (Table 2) back injuries caused by animal handling were the most expensive claims for small animal practitioners accounting for 12% of the total cost but comprising only 5% of all claims.

An analysis of the AVMA Group insurance Trust records show that 13% of injuries were due to animal-handling leading to hand and back injuries, while 48% occurred as a consequence of lifting animals. Injuries incurred when handling animals including strains and back injuries, accounted for more than 28% of the claims paid out. Other reported injuries were slips and falls.[3]

A study among the veterinary practitioners in the state of Western Australia revealed that several work days lost for veterinarians and their associates were due to injuries including whiplash from lifting of heavy dogs.[8]

**Necropsy Injury**

In the zoo study carried out by Hill et al., (1998)[1] necropsy injuries were reported by 44.1% (123/279) of respondents while study among swine veterinarians[11] reported that 36% sustained necropsy injuries (Table 4). The study by Landercasper et al.,(1988)[9] revealed that a number of veterinary practitioners cut themselves with scalpels but failed to indicate the cause for such injuries. The study could not statistically correlate the necropsy injury rate with sex, practice type and the number of years in service by the zoo veterinarians.

**Table 4. Number of respondents who reported necropsy-related injuries and the respondents who required medical treatment .**

| Necropsy-related injury | Injuries/illnesses reported (percentage with numbers) | Injuries/illnesses requiring medical treatment (percentage with numbers) |
|---|---|---|
| Knife wound | 87.0 (107) | 46.7 (57) |
| Infection | 18.7 (23) | 78.3 (96) |
| Chemical exposure | 9.8 (12) | 33.3 (41) |
| Other* | 8.9 (11) | 72.7 (89) |

* Other injuries/illnesses reported included bone splinters, serum sickness, injuries from incinerator explosion (injuries unknown), eye trauma, and zoonotic exposure (psittacosis, plague, mycobacterium bovis and rabies).

## Self-treatment

Even though, self-treatment has been common in the US among practising veterinarians, the study by Hill et al., (1998)[1] has not incorporated any question on self- treatment among the zoo veterinarians. In a study in North Carolina[9], self-treatment of animal-related injury was common. Three out of four veterinarians reported treatment of their own wounds including self-administration of antibiotics, suture laceration, and reduction of fractures or dislocation. Veterinarians in practice for six years or more sustained substantially fewer injuries than those practising for five years or less. There were no gender differences in number and types of injuries sustained, nor did the type of practice affect the number of injuries, although, large animals caused more severe injuries.[9] The incidence of self-treatment among veterinarians was high in this study. This might suggest that veterinarians lack confidence in the medical counterparts or the nature of their disease or injuries was considered trivial or that self-treatment proves and more cost-effective method of attending to non-serious injuries.

**Drug abuse and suicide**

So far no studies have been undertaken in the United States on drug abuse among zoo veterinarians. The study conducted by Hill et al.(1998)[1] although comprehensive, did not incorporate any questions on drug abuse among zoo veterinarians. Discussions with senior zoo veterinarians and retired zoo veterinarians in Western Australia suggested that substance abuse was not prevalent amongst veterinary practitioners in the zoological gardens in Australia.

A recent study conducted amongst practising veterinarians in Western Australia did not reveal any drug abuse among veterinary practitioners.[8] However, it was reported that in 1984, Michael Murphy a veterinarian who was practising in the suburb of Pemberton in Western Australia, had been a drug addict and a close associate of a drug dealer. Criminal sources said, "Murphy – previously thought to have died of a heroin overdose – was murdered by a Perth drug dealer." When his remains were found after five years of his disappearance, the police sources reported that the veterinarian had been a heroine addict and the most likely cause of death appeared to be a drug over dose."[20]

Xylazine (lignocaine hydrochloride) widely used as an injectable sedative, barbiturate and analgesics for animals, especially ruminants, has been used in several suicide attempts by veterinarians and staff by oral ingestion and intramuscular injection of high doses. Toxic effects of xylazine causes hypotension, respiratory depression, hyperglycaemia bradycardia, coma and death.[21] Three patients reported accidentally self-injecting small amounts of xylazine and developing mild bradycardia and hypotension, myosis and a feeling of disorientation, while two other patients required intubation and mechanical ventilation. With the increasing use of xylazine as a tranquillising agent, there is a possibility that human exposures may increase.[22] Multiple drug abuse with an injection of xylazine and ingestion of alcohol and chlorzepate ended in the death of a 36 year old veterinarian in the US.[23]

A study conducted in the US in 2002[24] stated that a 49 year old veterinarian had been a drug abuser for years before he started practising as a veterinarian and used to self-medicate on the job. The veterinarian sustained an injury while he was attending surgery on a horse. He self-injected himself with a shot of Demerol and wrapped his knee. Subsequent to attending the surgery of the horse, he reported for treatment of his injury at the emergency service. An Oklahoma police officer working as undercover for the State Board of Veterinary Medical Examiners mentioned that hydrocodone was the most abused prescribed drug. As a result of his investigation on 22 cases, five veterinarians in Oklahoma have either lost their licences or had them suspended due to drug use in the previous two years.[24]

A study conducted among health professionals in the US[25] found that chemical dependence has been a leading occupational hazard for physicians and other health professionals. The study compared the abuse of alcohol and other drugs among 1971 chemically dependent health professionals who have been assessed and/or treated by the Georgia Alcohol and Drug Associates. Significant differences were seen between professional groups with respect to age, sex, the kinds of substances abused, number of drugs abused and the route of administration. The prevalence of impairment from alcoholism, substance abuse and other mental disorders in the general population of adults may be as high as 19%.[26] While health professionals may be at no greater risk for these impairments than the general population, the damage done to the profession and to the public by those working as health professionals while impaired is of significant concern.[27]

A well-known but not much studied phenomenon is that suicide prevails among people who have easy access to a range of drugs. Dentists, pharmacists and psychiatrists are more prone, but all health professionals, veterinarians and farmers who also have easy access to drugs are at particular risk. British data on incidence of suicide among various occupations (1982-92) placed veterinarians at the highest risk among men followed by dentists, farmers, forestry workers and physicians.[28] A study among 3440 veterinary surgeons in Britain, from 1949 to 1975 showed a two-fold increase in mortality from suicide.[29] A study between 1979 to 1990 on suicides among men and women aged between 15 and 64 showed, that veterinarians are at highest risk with three times the expected number of deaths, while pharmacists, dentists, farmers and medical practitioners suffered less. The studies indicate that occupational stress and easy access to drugs were the major causes for high mortality among professionals.[30]

Coroner's extracts from the Western Australian Registrar General's Office in 1993 showed that of the 20 recorded deaths of veterinarians, the coroner confirmed four suicides including two of which were by pentobarbitone overdose. Comparable records are not available for other States in Australia. The Australian Bureau of Statistics (ABS) is unable to provide accurate data on the causes of deaths of veterinarians. In the classification used by ABS, veterinarians are included in the category "Other and related Scientists." During the past 10 years, ABS used two classifications for occupational codes. While veterinarians are included with 'other occupations' in both classifications, veterinary surgeons and veterinary parasitologists are grouped in one and veterinary pathologists and physiologists are grouped into another. Statistics for the states of Queensland and Victoria are not included in the ABS statistics.

Veterinary medicine may attract drug users because of the relatively easy access to drugs. A case of drug abuse was reported at San Antonio Small Animal Hospital in the US. An employee who availed extended bath-room breaks was eventually found to be injecting ketamine intravenously. Ketamine has become a popular drug for drug abusers.[31] A report by Ward and Byland (1982)[32] has shown that a veterinary assistant died of hepatic failure after sniffing methoxyflurane as a euphoriant.

Ketamine is sparingly used on human in the US, although widely used on small animals. Veterinary hospitals were targeted by drug users even in other states of the US for ketamine abuse. In their study, Western Michigan authorities have linked dozens of veterinary hospital break-ins during the year 2000 to young people trying to steal the drug for a quick profit. The animal anaesthetic, ketamine, most commonly used by veterinarians to tranquilize cats is very popular and found even in clubs and parties. In the Year 2000, more than a dozen clinics in Kent County have reported break-ins. In Ottawa and Allegan in the US, hospitals also have been targeted for ketamine abuse.[33] Addiction to narcotics among health professionals is not new. However, its extent in the veterinary profession is difficult to determine and further research into this area is essential.

Two thousand veterinarians in New Zealand were surveyed on the risk situation in the profession and 48.5% responded. The survey was carried out due to a number of suicides among younger veterinarians between 1996-2000. The result showed that a quarter of participants felt depressed reasonably often and 16% of participants acknowledged having considered suicide. The most interesting finding was that the veterinarians were unable to meet their own expectations with younger and female veterinarians being most affected. Even though, the pressure was prevalent among all veterinarians, it was very significant among rural veterinarians where there was increased work in dairying, shortage of veterinarians and the inability to meet the demand.[34]

Drug abuse and assault by people has been another form of physical injury to veterinary practitioners. Veterinary practices stock drugs such as pethidine, ketamine, barbiturates and many analgesics and staff are at risk of assault from drug addicts seeking drugs and cash. There have been several instances in Australia and overseas where veterinary staff have been assaulted for such reasons. In addition, occasionally, irate clients have been known to threaten and even hit the veterinarian. The Western Australian workers' compensation claims for veterinary services indicates only one instance of a person being assaulted in such circumstance, although there has been a recent incident in New South Wales of a life-threatening assault on a veterinarian and his wife (Fairnie H. personal communication, 1998).

In a study carried out among veterinary practitioners in Western Australia, seven veterinary practices reported one break-in each, eight practices two break-ins, and one practice six break-ins. The type of drugs stolen during the break-ins were: acepromazine, anabolic hormones, anaesthetics, antibiotics, cortizone, diazepam, eye and ear preparations, injections and pethidine, sedatives and vitamins. One veterinarian reported the theft of 40 different items during one break-in.[8]

**Motor vehicle accident**

In Australia, veterinarians especially in rural areas drive great distances and therefore motor vehicle accidents (MVA) are a common hazard confronting rural veterinarians, although there is a trend towards farmers and clients bringing animals from long distances into the veterinary hospital. However, the zoo veterinarians in Australia do not undertake extensive travel outside their zoo environment and thus rarely encounter MVA during their career.

The workers' compensation claims in the state of Western Australia during the period 1991 to 1996 show that 5% of all claims are for MVA. However, these accidents were not serious and only accounted for 12.6% of the claims' dollars. These figures related only to employees of veterinarians. A study of 1082 Illinois veterinarians reported that most veterinarians had driven between 10,000 and 20,000 miles (16,000 to 32,000km) in a year. Three hundred and thirteen (29%) had been involved in 416 MVA with 228 participants in one accident, 69 in 2, 14 in three and 2 in four accidents. The frequency of work-related MVA was directly related to the distance driven. Fourteen Illinois veterinarians had been killed in work-related MVA between 1950 and 1973.[16]

Motor vehicle accidents were the third most common cause of injury to veterinarians, accounting for 6.1% of work-related accidents. Of the 78 vehicles involved in accidents, 62 were driven by the veterinarians and the vehicles involved were motor cars, trucks, motor cycles and planes.[2] Thigpen and Dorn (1973)[2] also cited that accidents accounted for 55 % of the deaths among Missouri veterinarians between the period 1949 –1964, and 7.4% of the deaths reported among Californian veterinarians between the period1950-1962. The mortality pattern among the US veterinarians from 1947 to 1977 showed that mortality for MVA among veterinarians was high.[35] Veterinarians are subjected to life-threatening situations in their career. The study by Landercasper et al., (1988)[9] reported that life-threatening accidents have occurred requiring laparotomy and craniotomy. Small intestinal and pancreatic injuries were also reported. One veterinarian reported a carotid artery injury secondary to a blunt trauma.

The study by Hafer et al., (1996)[11] reported that the respondents in his study drove an average of 463 miles per week while working in swine farms. Thirty-six percent were involved in occupationally-related MVA. These included accidents in which the respondent was not the driver. Number of years in practice had a significant impact on a practitioner's involvement in a MVA.

Thirty percent of veterinarians in Wisconsin and Minnesota in the US spent more than 20 hours per week driving between farms; this is most likely a reflection of their having a large number of dairy clients.[9] It was noted that 32% of the veterinarians had not routinely worn seat belts and 44% did not always follow speed limits. At that time, the wearing of seat belts was not compulsory in the two states in the US.

In Australia, in a study of farmers' attitudes towards the use of veterinary services,[36] rural veterinarians drove considerably more than 20,000 miles (32,000 km) in any year. There are no accurate statistics available about the number of veterinarians involved in work-related MVA other than few reports for workers' compensation claims relating to employed veterinarians and staff.

A survey of accidents among German veterinary surgeons revealed that veterinary work which involves driving to rural farms represents a potentially high-risk occupation. Veterinarians experience numerous accidents and physical injuries during treatment. Analyses of the data revealed that work-related accidents are best predicted by work-related driving distance, risk involved, working hours, age, number of children, work related stress and safety attitude. This study did not reveal the mortality for MVA.[37]

In rural Western Australia, veterinarians working in multiple practices travelled extensively between practices and farms. Those who owned more than two practices drove between 1000 and 3000km per week. Small-animal practitioners in urban practice drove only a few kilometres. The distances driven annually by the respondents in the Western Australian study[8] among veterinary practitioners were greater (50-150,000km) than their counterparts in Illinois (16,000-31,998km).[16] However, the injury rate was 0.1% of all veterinarians compared with 1.3% in the Illinois study which may be the result of traffic densities or climatic variations. Evidence from the UK and the US suggests that the frequency of work-related vehicle accidents is directly related to the distance driven.[16,29]

A recent Australian study reported that fifty-four percent of veterinarians travelled an average of 553 km per week, with small animal practitioners travelling an average of only 54 km per week. There were eight MVA including two major accidents resulting in work days lost during the 12 month period in 1992-93. One veterinarian who travelled extensively reported having 15 major accidents over 10 years.[8]

**Injuries caused by equipment and instruments**

Incidents of accidental contact with patient's blood and blood products due to needle stick injuries or other sharp objects, spills, bites and scratches is recognized to be an occupational hazard amongst health care and veterinary medicine workers. The health care workers as well the veterinarians and their associate staff could contract diseases such as rabies, hepatitis, HIV and brucellosis by incidents of accidental inoculations.

Needles, scalpels and other instrumentation often cause injury in veterinary practice. Needle stick injuries are wounds caused by needles that accidentally puncture the skin and are very hazardous to zoo veterinarians who work with captive wild exotic and Australian species which are more unpredictable and dangerous than domesticated animals. A study carried out by Hill et al., (1998)[1], among zoo veterinarians in the US revealed that during needlestick injuries veterinarians were exposed to a number of agents including injection of fluid, animal blood, antibiotics, drugs, vaccines and toxic compounds. Table 5. There had been accidental injection of drugs and toxic compounds reported by the zoo veterinarians.

**Table 5 Number of respondents exposed to specific agents from needlesticks in a study among zoo veterinarians in the US.**

| Needle exposure agent | Number of respondents exposed |
|---|---|
| No injection of fluid | 173 (71.3%) |
| Animal blood | 141 (58.4%) |
| Antibiotics | 127 (52.3%) |
| Vaccines | 125 (51.6%) |
| Immobilizing agents | 42 (17.2%) |
| Other* | 23 ( 9.3%) |

* Types of other exposure agents were not reported

Eighteen (6.5%) zoo veterinarians in the cohort[1] experienced a needlestick injury that required medical treatment, including adverse reactions to injected agents, infections and severe lacerations. In a study among swine veterinarians seventy-three percent of veterinarians reported one or more needlesticks during their career as well as reporting injuries due to vaccines (40%) as the most common exposure agent.[11]

A thirty-month period study in a London teaching hospital revealed 447 incidents of accidental contact with patients' blood by staff. Of these, 75% of injuries were caused by needle stick or other sharp objects and the remainder by spills, bites and scratches. Fifty-five percent of nursing staff and 18% of doctors were affected by needle stick and other injuries.[38]

Injury from needles is a potential occupational hazard because of the possibility of introducing disease.[4] Many drugs used in large animal practice require larger quantities or more concentrations than those used for small animals or humans. An accidental self-injection of a large animal preparation could have serious consequences for veterinarians and their staff. Veterinarians have accidentally injected themselves with animal preparations and been hospitalized.[39,40] In the UK, a veterinarian who accidentally injected himself with a highly concentrated tranquilliser, etorphine, died before treatment could be administered to reverse the effects of the drugs.[41]

A survey of all female graduates of the US veterinary colleges for the period 1970 to 1980 was carried out to obtain information on health and occupational factors including data on needlestick injuries.[4] Sixty-four percent of participants in the survey reported to have sustained 2663 needlestick injuries. The nature of puncture injuries varied and the substances injected included vaccines, anaesthetics, euthanasia drugs, antibiotics and animal blood. Of the 438 needlesticks,16.4% resulted with a side effect including mild irritation, pain, swelling and soreness around punctured area. Nearly 12% of veterinarians experienced numbness and 4% had dizziness. Eighteen needlestick injuries (0.7%) caused severe and systemic illness with side-effects including nine cases of brucellosis and a bacterial illness. In this study, veterinarians in small and mixed animal practice demonstrated the high rate of injuries, with large and mixed animal practitioners demonstrating less injury rate. One accidental self-injection of a prostaglandin compound resulted in a spontaneous abortion, heightening awareness that occupational needle sticks may also represent a serious reproductive health hazard. The study also showed that more than 70% of veterinary students in their first year were women compared to just 10% in 1970.[4]

A study among the swine veterinarians in the US[11] revealed that 73% of respondents experienced at least one needlestick injury during their career. Females had an average of 4.3 needlesticks while males had an average of 2.8 needlesticks within a two year period of the study. Of the 73% respondents reporting injury, vaccines were the most common exposure (40%) followed by swine blood the next most common (37%), antibiotics (35%) and prostaglandin (1%). Ivermectin and clean or empty needles constituted most of the remaining 8% of needle stick injury exposure. Adverse effects from needlestick injuries included pain, local swelling, haematoma, infection, superficial abscesses and cellulites.[11]

The study by Hafer et al., (1996)[11] also showed that 15.5% of swine veterinarians reported equipment related injuries mostly from gates and chutes, snares, overhanging objects and electric shocks, whereas, in the study among zoo veterinarians in the US[1], 23.6% of respondents were reported to have been injured by equipment such as squeeze chutes, cage doors, ropes, knives and needles, catch poles, fork-lifts, dental drills and hanging scales.

Needlestick injuries have transmitted many diseases involving viruses, bacteria, fungi, and other microorganisms to veterinarians and their staff, health care workers and laboratory researchers.[42] In a survey of 99 Wisconsin veterinarians on the frequency and severity of accidental self-inoculation and other forms of exposure to vaccine of *Mycobacterium Paratuberculosis (Johne's bacterin),* eleven per-cent of the veterinarians reported one or more exposures including 19 needlestick injuries.[43] It is unlikely that needles or scalpels cause severe injuries alone. More likely, it will be the chemical or biological agents introduced at the time of the needlestick injury that cause severe problems.

Veterinarians may accidentally inject themselves with a needle during uncapping or recapping the needle or while filling the syringe. A study by Hafer et al.,(1996) [11] among swine veterinarians reported a higher rate of needlstick injuries sustained by female veterinarians (64%). This is similar to the percutaneous injuries mostly suffered by nurses (64.7%) and house-staff (74.1%) at a Philadelphia hospital in the healthcare industry.[44]

The National Institute for Occupational Safety and Health (NIOSH), part of the Centres for Disease Control and Prevention (CDC) has alerted the health care workers from job-related injuries caused by needles in syringes, intravenous delivery systems and other medical devices. It has been estimated 600,000 to 800,000 occupational needlestick injuries occur every year, which can lead to serious or potentially fatal infections with blood borne pathogens such as Hepatitis B virus, Hepatitis C virus or HIV.

Other equipment used in veterinary practice including nose tongs for cattle, halters[2], calf pulling equipment, metal cattle chutes, restraining equipment and even opthalmoscopes may cause injury especially to fingers, wrists and hands.[9] Apart from higher incidents of musculoskeletal injuries among nurses, medical professionals do not have high rates of occupational injuries due to physical causes. Veterinarians are at risk because they pull, push and lift animals, some of which are very heavy.

Hearing loss has not been widely reported in the general veterinary profession, although, three percent of zoo veterinarians[1] and 22% of pig veterinarians[11] have reported hearing losses. It is unlikely that equipment will cause hearing loss, however, domesticated barking dogs and wild animals such as dogs, cats and primates might prove a problem both to the staff in zoo veterinary practices and to neighbouring residents. Barking has been estimated often to cause sound pressures over 85 dB and even up to 105 dB. If occurring over an 8 hour period, this would be above the threshhold defined in current Australian legislation and might result in legal action against those in charge of barking dogs. [8] It is therefore important monitor the noise caused by dogs and other species in a zoo environment and take appropriate preventative measures to protect hearing of employees and others in the neighbourhood.

Other physical injuries to veterinary practitioners include burns from heat or ice. In Australia, frostbite is not a major hazard. Burns are more likely to occur from excess heat from steam valves such as those in autoclaves and radiators and from liquid nitrogen or cryogens. There is no other data on the occurrence of these injuries. Two US studies[1,11] reported 14% of zoo veterinarians and 31% of swine veterinarians experienced a cold or heat related problem from climatic temperature extremes and male veterinarians were significantly more commonly affected than females. A study by Elbers et al., (1996)[45] report that although veterinary medicine can be a rewarding occupation, veterinarians must deal with distinct and on-going health risk factors.

## Conclusion

Veterinarians are one of the highest risk groups for experiencing hazardous occupational conditions. Adverse health effects due to a range of occupational scenarios have been experienced by the veterinary profession for a long time. Occupational hazards are common in the agricultural industry and especially among veterinary practitioners.

Veterinarians have great potential for injury because they encounter large and uncooperative patients. Studies reveal that veterinarians often sustain animal-related injuries and accidents some of which have even led to hospitalization. A veterinarian has potentially more opportunity for being injured or developing illnesses than a medical or dental counterpart. Not only do veterinary patients frequently cause injuries such as bites, scratches, kicks, and gores but they can also transmit zoonotic infections.

Studies have revealed that physical hazards sustained by veterinarians include exposure to radiation; extremes of temperature; physical trauma inflicted by animals; needle stick injuries and cuts from scalpels; strains from lifting; slips from handling animals and car accidents when visiting patients. Ergonomic injuries are now a recognised physical hazard in the veterinary profession with repetitive tasks and manual handling overloads through lifting and restraining animals contributing to many physical problems among veterinarians and their staff. Injuries due to penetration wounds may also lead to serious viral and bacterial infections.

There has been an increasing public awareness of infectious conditions such as HIV, hepatitis B and hepatitis C. This subject has resulted an interest both in the medical and lay press and as a result has become an increasingly acknowledged issue to veterinary practitioners who are exposed to these issues.

Zoo veterinarians in Australia have to treat a number of wild species both native and exotic. Captive wild animals are unpredictable and dangerous and can inflict more severe injuries than domesticated species. The unpredictable behaviour of wild animal patients renders the administration of drugs and vaccines potentially hazardous.

It is generally perceived that the veterinary profession appears to have a low number of occupational diseases and injuries. The amount of trauma sustained by veterinarians during their career is higher than what has been identified in many studies. Veterinarians tend to minimize their injuries and are so motivated in their work that they rarely claim disability. Some veterinarians were uncomfortable about completing questionnaires as they do not want the high incidence of injuries to be known to medical insurers or to the researchers. Reported cases may be the tip of the iceberg as the available data does not take into account the injuries and diseases occurring with self-employed veterinarians not covered by workers' compensation insurance, but who should be covered through work disability insurance. Therefore, there is a definite need to assess accurately occupational hazards in veterinary practice including zoo practice and to determine the actual occurrence of these and ultimately to develop strategies to prevent these occupational injuries to the veterinary profession.

## CHAPTER 3.

## REVIEW OF CHEMICAL HAZARDS IN VETERINARY PRACTICE

### Introduction

Adverse health effects due to exposure to chemical hazards have long been experienced by members of the veterinary profession. Practising veterinarians of domesticated species are typically small business owners or employees who, as well as ensuring the well-being of companion animals and their owners, are essential to agribusiness economy having major responsibility for animal production and health of the nation's livestock industries. Veterinary surgeons in the zoo environment are government employees and most undertake preventive medicine, treatment, husbandry and enrichment of wild species. The daily life of a zoo veterinarian in Australia is anything but typical. However, the veterinarian has to apply his expertise across a range of fields. As in the health care industry, many chemicals are used regularly by veterinary practitioners. These chemicals are biologically active and staff in veterinary practices may be at increased risk of exposure to hazardous agents.

In the health care industry, although a wide range of chemicals are being used, the pattern of health effects associated with chemical hazards may make detection difficult unless information on chemicals is available. The four chemicals that are of concern for both health care and veterinary professions are: formaldehyde, glutaraldehyde, ethylene oxide and methyl methacrylate. Due to the growth in health care technology, use of chemicals has increased the potential risk of damage to health care workers as well as to the environment surrounding the work place. Any harmful consequences will depend on the nature and pattern of employees' exposure and the effect on the environment. Prolonged exposure to chemicals can be harmful.[38]

Veterinary practitioners treating domesticated and wild animals have to use large amounts of chemicals and the use of chemicals are on the increase due to increasing volumes of work. Chemicals are used for cleaning and disinfecting surgical and diagnostic equipment, for preoperative skin preparation and for other applications. Chemicals are also used as preservatives, antiseptics, detergents, bleaches and washing powder. Milligan et al.(1983)[46] report that there are over 900 chemicals which have been found to be teratogenic or to cause adverse reproductive effects. These chemicals and many more mutagens and carcinogens such as pesticides, sterilants, drugs, anaesthetic gases, laboratory solvents and other chemicals are listed in the Registry of Toxic Effects of Chemical Substances. In addition, there are over 3000 chemicals which could cause mutagenic effects and approximately the same number of chemicals may be carcinogenic. Chemicals such as acetamide, chromium salts, nickel salts and propanol used in veterinary practice can cause hazardous effects including teratogenicity, corrosiveness, carcinogenicity, allergic reaction[46] and lung damage.[47] A pregnant female is more susceptible to teratogens and abortifacients from the third week until the third month of her pregnancy. This type of physical hazard is of particular concern for those who are in the early stage of pregnancy and others who are about to conceive.[48] Examples of common chemicals that pose potential reproductive problems are formaldehyde (preservative), ethylene oxide (sterilizing agent), pesticides (flea dips, shampoos, sprays, spot-on products), dyes and solvents.

A number of potentially harmful chemicals are being commonly used by veterinarians and associated personnel. These include: formaline; inhalent anaesthetic gases such as isoflurane, halothane and nitrous oxide; antineoplastic drugs; ultrapotent narcotic analgesics; immobilising agents, disinfectants/sterilants such as ethyleneoxide and glutaraldehyde; pesticides and xylazine.

A corrosive chemical is one which destroys or damages the living tissue on contact; an irritant produces local irritation or inflammation; sensitisers causing an allergic reaction; explosive/flammable products will burn or explode if a source of ignition is present; asphyxiants cause suffocation due to lack of oxygen and could be toxic or poisonous causing damage to cells and tissues. The chemicals may possess a number of severe toxic effects. The main forms of chemicals are solids, dusts, liquids, gases, vapours and aerosols.[49]

Certain chemicals used within the health care profession have repeatedly prompted concern. A number of these products contain recognised irritants and sensitisers and consequently cause skin problems among cleaners, food preparation staff, maintenance workers, and other domestic and hotel service staff. Examples of chemicals that are recognised as causing health problems include: hypochlorite bleaches and disinfectants; strong alkaline cleaners; formaldehyde cleaners; epoxy resins used in glues and repair pastes; perfumes in soap, detergents and shampoos, and air fresheners, enzymes in soap powders; lanolin in soaps and shampoos, and even constituents of protective rubber gloves.[50] Even though some of these products are in use in veterinary practices, no studies have been undertaken on the effects of these chemical products amongst veterinarians and their associates.

Antibiotics, antineoplastic drugs, diethylstilbesterol (DES), non DES hormones, disinfectants, animal insecticides, solvents, formaldehyde, heavy metals, ionizing radiation, ethylene oxide, halothene, and non-halothane anaesthetic gases have been associated to some degree with reproductive disorders in animal studies.[51]

Chemicals may accidentally be spilt on the skin, inhaled, ingested or injected. Most of these agents used in the health care industry and veterinary or zoo industry are either inhaled or absorbed through skin or mucous membranes. However, veterinarians are also at risk of accidentally injecting into themselves vaccines, antibiotics, anaesthetics and animal blood during treatment of wild or domesticated animals.

Studies among veterinarians in the US show a higher incidence of leukaemia; Hodgkin's disease, cancers of the brain, colon and skin[35,52], higher rates of abortion from chemical, biological and radiological exposures,[53-55] acute pesticide associated toxicity than the general population.[56-58] They also show higher rates of zoonotic infections from exposure to biological agents,[10,59,60] occupational dermatoses from exposure to substances including iodine, benzylkonium, hibitane, scrub solutions, cleaning agents and chemicals,[61,63] respiratory tract illnesses,[62] and lesions in the blood vessels of the central nervous system.[18] Veterinarians experiencing higher rate of skin cancers may be due to exposure to sunlight, while leukemia have been associated with exposure to ionizing radiation.[52]

According to the OHS Act in the US, employers must list all chemical hazards encountered in the workplace and advise staff their existence and educate them in the appropriate handling of such hazardous substances. All containers must be labelled and information on the individual hazards must be maintained.[48]

**Exposure to chemicals**

A number of chemicals were identified as causing health problems such as headache, nausea or allergies including skin disorders and respiratory problems to veterinarians and their associates. Occupational exposure to some chemicals in the health care industry have been studied, but even for these chemicals, little information is available about the impact they have on the environment. In the UK, the University of Birmingham has provided occupational health services to the West Midlands Regional Health Authority including advice and assistance on occupational risks associated with the use of chemicals. Recent investigations have identified several potential substances causing problems such as glutaraldehyde, ethylene oxide, methyl methacrylate, methanol, xylene, propan-2-ol, mercury spillage, solvents and inks, perchloroehylene, anaesthetic and analgesic gases, resins and several other chemicals.[38] Some of those chemicals which are a common cause of concern in the health care industry are also used by veterinarians in zoos and veterinary practices in Australia, the UK and the US.[10,46,64,65]

In a study carried amongst West Australian veterinary practitioners,[8] the participants identified a number of substances used in their practices as hazardous. The substances included adrenalin, animal body fluids, antibiotics, benzalkonium chloride, bleach, cyclosporin, dark-room chemicals, detergents, disinfectants, euthanasia solutions, flea rinses, formaline, fluothane, glutaraldehyde, hydrogen peroxide, insecticide, insulin, iodine, isoflurane, ivermectin, liquid nitrogen, methylated spirits, pentobarbitone, potassium bromide, potassium hydroxide, prostaglandin, quaternary ammonium compounds, sodium hypochlorite, thiopentone, diazepam and xylazine. A number of respondents did not respond to the question. The eleven most hazardous substances and the range of quantities used per week by 30% of respondents were dark-room chemicals (100 – 400mL), fluothane (20-500mL), formaline (20-1000mL), glutaraldehyde (50-5000mL), iodine (500-1000mL), methylated spirits (5-2000mL), pentobarbitone (5-5000mL), pethidine (5-30mL), prostaglandin (2-100mL), thiopentone (5-500mL) and xylazine (5-760mL).[8] The substances causing problems as indicated by the respondents are shown in Table 6A and Table 6B.

Only six percent of the respondents in this study[8] reported that x-ray developers such as sodium hypochlorite or potassium hydroxide and hydroquinone used in their practices caused asthma, dermatitis or nausea to the veterinarians and their staff. Also in the West Australian study, three injuries due to chemical and biological exposures were reported among the veterinarians. A chemical burn was also experienced by a work experience student in a practice.

Workplace hazards can be defined as any conditions in the workplace that may adversely affect the health of an exposed person. Some hazardous substances in the work environment are easy to recognize and have an immediate irritating effect on the skin when exposed or during inhalation. Chemicals which are accidentally formed are not so easy to recognize. Some agents such as lead, mercury, cadmium and manganese may cause injury after several years of exposure. Toxic agents may not be hazardous at low concentrations.[66]

**Table 6A. Number of respondents experiencing health problems from exposure to various agents in the West Australian study[8]**

| Agents | Symptoms | Respondents (%) |
|---|---|---|
| Iodine, benzylkonium, hibitane scrub solutions, cetrimide spirits and cleaning agents | dermatitis, minor rashes, allergies, sneezing and coughing, sore hands | 41 |
| Pesticides/organophosphates (fenthion/malathion, asuntol), flea spray and rinses | headaches, nausea and skin allergy | 22 |
| Halothane | headache, nausea | 22 |
| Disinfectants such as iodine, quatenary ammounium compounds, chlorohexidine, and glutaraldehyde | Headache, dermatitis and dyspnoea | 20 |
| Cat, dog and deer hair, dog semen, rabbit fur | sneezing, allergy, hay fever and dermatitis, respiratory problems, swollen face/eyes | 17 |
| Glutaraldehyde and formaline | headaches, nose irritation watering of the eyes, dermatitis and respiratory problems | 10 |
| X-ray developer | dermatitis, asthma, nausea | 6 |
| Prostaglandin | dyspnoea and nausea | 5 |

**Table 6B. The amount of hazardous substances reported to have been used by veterinarians in the West Australian study[8]**

| Substances used by veterinarians | Quantity used per week (ml) |
|---|---|
| dark room chemicals | 100-400 |
| fluothane | 20-500 |
| formalin | 20-1000 |
| glutaraldehyde | 50-5000 |
| iodine | 500-1000 |
| methylated spirits | 5-2000 |
| pentobarbitone | 5-5000 |
| pethidine | 5-30 |
| prostaglandin | 2-100 |
| thiopentone | 5-500 |
| xylazine | 5-760 |

Chemicals are required for the treatment and care of animal patients. Veterinarians and their associated personnel may be exposed to anaesthetic gases, pharmaceuticals including antineoplastic agents, disinfectants including phenol,[67] formaldehyde, and sterilants such as ethylene oxide,[46,67] hexachlorophene, glutaraldehyde, anaesthetic gases, organophosphates and therapeutic agents. These agents can cause skin irritations, respiratory ailments, headaches, abortions, infertility and neoplasia.[46] A variety of pesticides to control fleas, ticks, and other insects and rodenticides often used in animal housing facilities are hazardous in nature.[67]

**Anaesthetic gases**

As far back as the 19th century, anaesthetic gases were known to be a health hazard to health professionals.[68] The NIOSH (1977)[69] estimates that in the US, over 50,000 veterinarians and their staff are routinely exposed to waste anaesthetic gases.[69] In the US, surveys of large and small animal operators using gaseous anaesthesia revealed that exposure concentrations range well above the maximum recommended by the NIOSH.[46] The NIOSH has recommended that exposure to halothane and methoxyflurane be limited to 2 ppm and nitrous oxide to 25 ppm. There is no limit set currently for isoflurane levels.[48] Exposure to waste anaesthetic gases has been associated with renal and hepatic disease, spontaneous abortion, congenital malformation, cancer, neurological and psychological disorders.[69-74] Potential adverse effects of nitrous oxide, halothane, enflurane and isoflurane are given below.[38]

**Potential adverse effects of various anesthetic gases**

*Nitrous oxide: Interference with the action of vitamin B 12 (resulting in megaloblastic anaemia and possible neuropathy; depression of white cell formation.

*Halothane: Severe hepatotoxicity although rare; (the risk seems to be increased by repeated exposures over a short period). Halogenated alkanes[75] may sensitise heart tissue to the effect of adrenergic stimulation.

* Enflurane and Isoflurane: These gases have not been associated with severe hepatotoxicity, but there may be an immunogenic effect on hepatic tissue in susceptible subjects.

Source: Environmental and Occupational Risks of Health Care. BMA 1994, P.48[38]

Australia has about 10% of the number of veterinarians as the US and similar types of veterinary practices. This could mean many

Australian veterinarians and their staff have the potential to be exposed to halothane, nitrous oxide, isoflurane and similar commonly used anaesthetic agents.

A study on the exposure to anaesthetic gases reported that female dental assistants exposed to unscavanged nitrous oxide for five or more hours per week had a significantly increased risk of reduced fertility and had a 59% decreased probability of conception compared with non-exposed female assistants. In the operating rooms which have used scavenging system, the probability of conception was not significant from that of non-exposed assistants. The study suggests that when high levels of nitrous oxide is used in operating rooms without adequate scavenging system, it can impair fertility in females. A scavenging equipment in good working condition will protect the reproductive health of women working with anaesthetic gases.[76]

The effects of gaseous anaesthetics on human reproduction are inconclusive. A study by Johnson et al.,(1987)[53] showed that exposure to anaesthetic gases was not significantly associated with adverse reproductive outcomes, but exposure to x-rays in veterinary practice was associated with an increased occurrence of spontaneous abortion. A comparative study on foetal loss to female veterinarians and lawyers in the US by Schenker et al.,(1990)[55] revealed that female veterinarians were more prone to increased foetal loss compared with their legal counterparts.

Although, there have been numerous studies conducted on the effects of occupational exposure to waste anaesthetic gas on the reproductive system, to date no prospective controlled studies have been carried out. There is more data on the effects of exposure to waste anaesthetic gas on pregnant women working in operating rooms than on those working in the veterinary field. A recent meta-analysis showed that occupational exposure to waste anaesthetic gas is associated with increased risk of spontaneous abortion. This study included 19 studies of various designs with anaesthetists, operating room physicians and nurses, dental assistants, hospital workers, health workers, veterinarians and veterinary assistants as subjects.[77] The College of Veterinarians in Ontario, Canada reported that there are 2745 practising veterinarians in the province and that approximately 45% of them are women.[78] Even though there is an increase in the number of women in veterinary profession in the US, the UK and in Australia, no control studies have been undertaken on the effects of exposure to waste anaesthetic gases.

In a survey of all licensed veterinary practitioners in North Carolina in the US, 88.1% of the 701 respondents reported that they used inhalation anaesthetics which included methoxyflurane (51.4%), halothane (43.6%) and isoflurane (39.1%). Anaesthetics such as nitrous oxide (12.3%), enflurane (2.4%), ether (1.6%) and other (0.6%) were less frequently used. Only 38.1% of the veterinarians used a waste anaesthetic gas scavenging system.[10]

Both inhalant and injectable anaesthetics are used extensively by veterinarians in zoos and in private practice to facilitate safe restraining of animals and provide humane conditions for diagnostic and surgical procedures. A US study in North Carolina by Meyer,1999[79] reports that extensive use of anaesthetic agents in veterinary medicine by animal workers in traditional veterinary practices and others in research, zoological park employees, private practitioners, municipal animal control officers and wildlife biologists may become chronically exposed to trace levels of waste inhalant anaesthetics during the daily performance of their duties and are at risk for accidental exposure to potentially lethal quantities of injectable anaesthetic agents during chemical restraint of animals.

A study of 462 female graduates from the School of Veterinary Medicine, University of California, US revealed that of the 339 small animal practitioners, 94% were exposed to waste anaesthetic gases with 27% not having waste anaesthetic gas scavenging systems at their practice.[17] In an evaluation of anaesthetic gas exposure involving 13 Utah veterinarians in 10 small animal practices, it was found that a number of staff were exposed to significant quantities of methoxyflurane and halothane. The use of scavenging systems such as ceiling exhaust fans resulted in a 38-fold reduction in exposure levels.[72] Scavenging measures could reduce anaesthetic waste gas exposure and reduce gas concentration from non-scavenged and poorly maintained anaesthetic machines. Passive venting to the outside, suction-drawn venting and the use of charcoal to absorb waste anaesthetic gases are other methods of scavenging used in veterinary practice (NIOSH 1986).[80] Effective scavenging and regular maintenance of anesthetic machines can reduce waste anaesthetic gases below the safe limit.

It is interesting to note that zoo veterinarians surveyed in the US[1] were more likely to use scavenger systems compared to the veterinary practitioners in North Carolina in the US,[10] (53% versus 31%). However, the use of active scavenging systems was significantly associated with a higher rate of adverse exposure to anaesthetic gas[1] with most of these respondents claiming that air monitoring to investigate exposure concentrations of gases had not been undertaken. There is no data available on air monitoring in veterinary facilities in the US, the UK and Australia.

In a study carried out among zoo veterinarians in the US,[1] 91% of veterinarians reported using inhalant anaesthetics and 10.9% experienced an adverse exposure to one of the listed agents. Table 7.

**Table 7. Number of zoo veterinarians who used anaesthetic gases in their practices in the US study**

| Type of Anaesthetic gas used | Number of veterinarians using anaesthetic gases |
|---|---|
| Isoflurane | 86.3 (218) |
| Halothane | 33.2 (84) |
| Nitrous oxide | 16.2 (41) |
| Methoxyflurane | 15.5 (39) |
| Enflurane | 2.9 (7) |
| Other | 2.9 (7) |

In comparison, a study carried out by Wiggins et al., (1989)[17] found that 83% of female veterinarians and a study carried out by Langley et al., (1995)[10] found that 88.1% of practising veterinarians have used inhalent anaesthesia. The zoo veterinarians in a study by Hill et al., (1998)[1] who administered isoflurane (78.6%) had the highest incidents of exposure followed by halothane (17.9%) and methoxyflurane (14.3%). The use of isoflurane was the most common anaesthetic gas used by the zoo veterinarians (Table 7). It has been found that female veterinarians in the cohort were most likely to experience an adverse exposure. Due to the reported association between chronic exposure to such anaesthetic gases and spontaneous abortion as well as other reproductive problems, female veterinarians were more inclined to report such adverse exposure than males.[53,54,70,80]

Even though, in the zoo veterinarians study in the US[1] isoflurane had been considered a much safer anaesthetic, the veterinarians in the cohort experienced headaches, nausea, sleepiness and light-headedness. The 33.2% of the veterinarians using halothane might have experienced such effects at a larger scale. The study did not indicate the adverse effects each anaesthetic gas had on the participants. However, a case of respiratory irritation with isoflurane was reported by one individual. Some participants experienced sleepiness, dizziness, dermatomyiositis with nitrous oxide and headaches, dizziness and nausea for methoxyflurane

Western Australian study carried out among veterinary practitioners[8] found the use of both gaseous and injectable anaesthesia in their practices. The gaseous anaesthesia was used by 88% of the veterinarians while injectable anaesthesia was used by 96% of the participants. Thirty percent of veterinarians indicated that their clinics were equipped with extractor fans or scavenging systems to extract waste anaesthetic gases and vapour. The number of units used by the practices is summarised in Table 8.

**Pesticides**

Pesticide can be derived naturally, produced synthetically or be an organism and covers a wide range of substances such as bactericides, baits, fungicides, herbicides, insecticides, lures, rodenticides and repellents. Many natural substances including extracts of pyrethrum, garlic, tea-tree oil and eucalyptus oil when used as pesticides become subject to the same control as pesticides produced synthetically.[81] Biological control of pets by organisms include dung beetle to combat bush fly and gambusia fish to combat the proliferation of mosquito larvae in water bodies.

**Table 8. Number of veterinary practices using scavenger units for extracting waste anaesthetic gases**

| No of veterinary practices using scavenger units | No of scavenger units per clinic |
|---|---|
| 1 | 9 |
| 1 | 5 |
| 2 | 3 |
| 9 | 2 |
| 26 | 1 |
| 48 | nil |

Pesticides include products such as flea powders and liquids used externally on animals, injections and other medicines administered internally for treatment and the use of pesticides is significant to veterinary medicine. Rodenticides are used specifically to control mice and rats in zoo facilities and in kennels and farms. Recently, a number of living organisms that can control pests have been registered as pesticides. Calicivirus has been used to control rabbit population in Australia.[81]

Organophosphates, carbamates and pyrethrins are frequently used pesticides in veterinary practice. In a North Carolina Study,[10] of the 701 veterinarians, 91.7% reported to have used at least one type of pesticide such as pyrethrins (88.3%), organophosphates (78.3%), carbamates (64.2%), and other types (8.3%). Veterinarians under 30 years of age are more likely to use pyrethrins than older veterinarians, while large animal practitioners were less likely to use pyrethrins and carbamates. Pesticide use resulted in 11.4% of respondents developing adverse symptoms with five cases requiring medical treatment for over-exposure. Large animal practitioners and younger practitioners were more likely to use pesticides without adequate protective gear resulting in symptoms of toxicity.[10] Organophosphates such as fenthion/malothian and various type of flea spray and rinses have caused headache, nausea and skin allergy among veterinarians.[8]

Pyrethroid exposure following regular indoor treatments with pythethroid containing dog flea powder was reported in a 42 year old woman who suffered from hair loss, gastrointestinal and non-specific symptoms. Biological monitoring of pyrethroid meta-bolites in urine using gas chromatography-mass spectrometry was conducted on the patient. The values were examined at admission and when followed up after four weeks it was found that the metobolites in urine was highly elevated. An inspection revealed that the patient lived in a humid and cramped dwelling. The study indicates that pyrethroids can cause neurotoxic symptoms and skin irritation. The author concludes that there are few data concerning chronic effects due to pyrethroid.[82]

A survey among 505 veterinarians was conducted to assess pesticide use in dogs and cats for the control of fleas, ticks, mites, flies and mosquitoes. Of the 55% of respondents, 63% reported the use of pesticides in their practice. The study revealed that they used

27 different types of pesticides with an estimated total amount of 650 lbs of pesticides. The pesticides that were in use were cabaryl (Sevin), dioxathion (Delnav), ronnel, phosmet (Imidan), and propoxur (Baygon). No major adverse health effects were reported among personnel attached to the veterinary practices during the period of survey. Based on the data it was estimated that 1,189 lbs of pesticide were used state wide treating dogs and cats in 1981.[83] The literature search could not find any other detailed studies in other states of the USA to assess the health effects on veterinarians from the use of pesticides. However, earlier studies have reported that the use of pesticides by veterinarians has resulted in adverse health symptoms.

**Chemotherapeutic agents**

Chemotherapy plays an important role in the treatment of cancer. Frequent use of chemotherapy in veterinary medicine may cause hazards to personnel. Exposure to anti-neoplastic drugs occur through skin or by inhalation. Antineoplastic drugs could cause hazard if they are not handled properly. Twenty-nine anti-cancer drugs have been found to be carcinogens, teratogens and/or mutagens.[46]

Due to the increased interest in veterinary oncology in recent years, more and more veterinary practitioners are administering and prescribing antineoplastic agents. Since antineoplastic drugs are only approved for human use, the package inserts do not mention some of the safety issues unique to veterinary clients and animal patients. In 1979, British journal Lancet first reported mutagenic activity in the urine of nurses working in a human oncology unit who were exposed to antineoplastic agents. Number of studies carried out subsequently have showed increased chromosomal alterations, hepatotoxicity, and abnormal reproductive outcomes among workers associated with antineoplastic drugs. The risk of exposure to chemotherapeutic agents is greatest during drug preparation and administration. The main primary routes of exposure is by inhalation of aerosols, direct contact and inhalation of spilled or improperly handled waste products. The other routes of exposure are handling of discarded items that have come in contact with chemotherapy such as syringes, catheters, gloves and contact with excreta from patients treated with chemotherapeutic agents. Antineoplastic drugs commonly used in animals are eliminated primarily in the urine and/or faeces.[84]

The use of antineoplasatic agents for cancer treatments has increased over the past two decades. Antineoplastic drugs when administered interfere with different biochemical pathways to arrest the growth of tumours and kill cells. While preparing, administering and disposing drugs, there is a possibility of exposure to veterinary staff through direct contact or inhalation. Other sources of exposures are contact with body fluid or effluent, vomitus, urine and faeces during chemotherapy treatments.[68] Twenty-nine anti-cancer drugs have been found to be carcinogenic, teratogenic and /or mutagenic.[46,68] Frequent chemotherapy treatment may result in occupational hazards to veterinary personnel and it is important to use personal protective equipment such as chemically restraint gloves and masks during preparation and administration of antineoplastic drugs.[85]

The most common exposures to antineoplastic drugs are through inhalation or skin contact although ingestion is possible.[86] Potential health problems associated with handling antineoplastic drugs include toxic effects on the skin, eye injuries, systemic problems, allergic reactions, carcinogenicity, mutagenicity, teratogenicity, and menstrual abnormalities.[87,88] In the zoo study by Hill et al. (1988),[1] 30.8% of respondents used antineoplastic drugs including chlorambucil, cyclophosphamide, daunorubicin, dactinomycin, mitomycin C, streptozotocin and uracil mustard on their patients. Three participants reported a spill while handling antineoplastic drugs and one reported an accidental exposure during administration. The study carried out by Haigh (1989)[89] also reported the use of similar antineoplastic drugs.

Some drugs commonly used by veterinary practitioners cause particular risk to pregnant women. The rapidly dividing cells are targeted by these drugs particularly in a pregnant woman and pose a significant risk to the foetus in case where the expectant mother is exposed. The exposure to the pregnant woman is usually through the skin or by inhalation. The range of drugs include alkylating agents (chlorambucil, cisplatin and cyclophosphamide), antibiotics (actinomycin D), antimetabolites (methotrexate), mitotic inhibitors (vincristine), and miscellaneous drugs, including hydroxyurea, L-asparaginase. Pregnant women should avoid handling these drugs and all individuals should reduce relevant exposure considering some of these drugs are excreted unchanged in patient vomitus and urine.[48]

**Prostaglandin**

Accidental injection of prostaglandin for control of oestrus timing in cattle and horses and induction of parturition could result in abortion among women. A study amongst the female veterinary graduates from the University of California, US found 92% of female large animal practitioners were exposed to prostaglandin.[17] However, there have been no reported cases of abortions occurring in female veterinarians due to prostaglandins in Australia. Prostaglandins causes smooth muscle contraction and could induce labor at any stage of pregnancy. These drugs can be absorbed through the skin. The veterinarians using this drug for any reproductive problems such as oestrus timing or for parturition should wear protective gear.

A study carried out between 1970 to 1980 among female graduates of all the US veterinary colleges found one accidental self-inoculation of a prostaglandin compound resulting in a spontaneous abortion, heightening awareness that accidental needle sticks may also represent a serious human reproductive health hazard.[4]

The potential dangers of prostaglandins to women raised an interesting legal issue in the US. The US Supreme court has ruled that the Pregnancy Discrimination Act does not allow employers to force pregnant employees to avoid certain tasks on the grounds that these might endanger the health of a foetus or the woman.[90] This practice may be followed in other countries including Australia.

**Formaline (formaldehyde)**

Exposure to formaldehyde has been associated with several adverse effects for those who come in contact with it. Stayner et al., (1988)[64] report that formaldehyde is mutagenic and teratogenic in animals and considered to be a potential carcinogen in humans. Even though there is increased risk of upper respiratory tract and lymphopoietic cancers due to exposure to formaldehyde, human epidemiological data is not conclusive.

Formaldehyde often used by veterinarians as a tissue sterilant and/or as a preservative for pathological specimens and causes adverse health effects such as dermatitis and irritation of the eyes and respiratory tract, while sensitisation for formaldehyde may lead to asthma.[65]

Workers in two day-care centers in Denmark experienced drowsiness, headache, upper respiratory tract irritation, eye irritation, and menstrual irregularities. This type of reactions were more common in those working in mobile units where median concentrations of formaldehyde were higher than else where.[91]

Some researchers have found an association between formaldehyde exposure and respiratory disease. Kilburn et al., (1985)[92] reported a significant increase in the frequency of chest tightness, cough, and burning chest pain in histology technicians exposed to formaldehyde at concentrations of 0.2-1.9 ppm. Formaldehyde has been identified as a cause of occupational asthma in health care workers and the first case was identified on a 41 year old nursing sister in a dialysis unit.[93] Formaldehyde can also cause both irritant and hypersensitivity dermatitis when in direct contact with skin in sufficient concentrations.[94] The current exposure limit for formaldehyde in the UK is 2.0 ppm (as a 10 minute short term maximum exposure limit – this limit should not be exceeded)[38]

The International Agency for Research on Cancer (IARC) has reported that there is sufficient evidence to implicate formaldehyde as a carcinogen in animals but that there had been limited evidence for its carcinogenicity in human. The IARC classified formaldehyde as class 2A carcinogen.[95] Known human carcinogens are chemicals that have been clearly demonstrated to cause cancer in humans. Formaldehyde has not been clearly demonstrated to cause cancer in humans and hence it has been classified as class 2A carcinogen. [95]

In the US study among zoo veterinarians[1] 40.2% of participants reported an adverse exposure to formaline. The nature of reactions include eye irritation (75.7%), respiratory irritation (61.3%), dermatitis (24.3%), and headaches. Dizziness or nasal irritation amounted to 4.5%. The use of formaldehyde or paraformaldehyde has caused reactions in 275 zoo veterinarians who have used these agents on equipment. The symptoms reported with formaldehyde or paraformaldehyde include respiratory irritation (6.2%), skin irritation (4.4%), and other reactions (4.4%) including eye irritation, nausea, vomiting, headaches, and chronic diarrhoea. The study also reported that females were more likely to experience an adverse exposure to formaline.

## Conclusion

Several chemicals are regularly used by veterinary practitioners and their associates for a number of purposes, as preservatives, antiseptics, detergents and bleaches. Some chemical agents metabolise and are excreated after administering to animal patients. Several other agents used therapeutically are recognized sensitisers and could cause asthma and respiratory problems. There is concern over cytotoxic drugs used for the treatment of malignant diseases and harm for those exposed to dangerous chemicals.

Because of the nature of their work, veterinary professionals and their associates are exposed to a range of occupational hazards due to chemical exposure including formaldehyde, anaesthetics, pesticides, allergens and chemotherapeutic agents.

It would be impracticable to abandon the use of chemicals in the veterinary sector. The use of chemicals should be limited in order to prevent or lessen adverse harm from exposure. It had been a difficult task to obtain accurate information from the manufacturers and suppliers of chemicals on the quantity of use, and levels of contamination for those chemicals and therapeutic agents discussed in this chapter. There is lack of information on some of the chemicals used in work places.

Even with the limited evidence available, some chemical exposures are sufficient to cause adverse effects to veterinary professionals. Formaldehyde which is commonly used in veterinary practices is probably the most comprehensively investigated chemical in the health care sector. It is still unclear whether it is carcinogenic or what levels of exposure is required to cause adverse health effects.

In a study carried out amongst veterinary practitioners in Western Australia, participants identified a number of substances used in their practices to be hazardous and have caused headache, nausea, allergies, skin disorders and respiratory problems. Of the chemicals identified, formaline and glutaraldehyde caused headaches, nose irritation, watering of eyes, dermatitis and respiratory problems. Toxicological evidence in humans is limited and extrapolation from animal experiments using such chemicals are not fully dependable and cannot be relied upon.

Veterinarians and staff may not always understand the consequences associated with chemicals. To avoid unnecessary exposure to toxic agents, it is important to provide advise to employees and others who are in contact with animals on the safe handling of antineoplastic drugs and waste products. Air monitoring system should be introduced in all veterinary facilities to assess the dangers associated with chemicals. Occupational safety should be part of the undergraduate curriculum and veterinary schools should take an active role to educate students on the value of preventive measures. Short courses in chemical use with practical training should be provided for veterinarians. There is also a need to provide a system for reporting chemical injuries and exposures in the veterinary facilities. It is also necessary to maintain policies and possibly impose the required restrictions to pregnant students and veterinarians. The ultimate responsibility regarding safety in veterinary premises lies with the employer in enforcing standards and providing the best possible working environment.

# CHAPTER 4.

# REVIEW OF BIOLOGICAL HAZARDS IN VETERINARY PRACTICE

## Introduction

Veterinary professionals in Australia are regarded as comprising a high-risk group for occupational hazards. Adverse health effects due to occupational hazards have long been experienced by this group. However, previous studies has been focusing mainly on zoonotic diseases, radiation and anaesthetics. Practising veterinarians are typically small business owners or employees who, as well as ensuring the well-being of companion animals and their owners, are essential to the agribusiness economy having major responsibility for animal production and for the health of the nation's livestock industries. The zoo veterinarian's responsibility is not only to prevent and treat diseases, injury and accidents but also breed and release endangered species.

Women have become an increasingly significant proportion of practitioners in the veterinary profession comprising of approximately 35% in Australia, while 20 years ago they formed less than 5%. Current student intakes into the four veterinary schools in Australia are predominantly female. Countries with comparable veterinary practices including the UK, the US, and Canada, also have an increasing number of female veterinarians. Mulvey and Langworthy (1987)[96] report that the profile of the veterinary profession is changing, and this may alter the pattern of work-related disease and injury in what was previously a male dominated profession.

Veterinary practitioners including zoo veterinarians are in frequent contact with a range of animals and are exposed to a number of allergens. The hazards for veterinarians include the potential for developing allergies, allergy-related diseases and zoonotic diseases.

**Allergies**

An allergy is an unusual or exaggerated sensitivity or response to any given substance. The term allergy has been widely used in the medical profession and by the public for many decades. Many pet owners feel that allergies are limited to symptoms such as excess tear production of the eyes, sneezing or skin irritations. The tendency to react physically to allergens is usually inherited, but may not manifest until later in life. However, allergic conditions from any specific irritant are rarely inherited. It has been proven that the age of onset of an allergic condition depends on the strength and degree of the genetic inheritance for the individual.[97]

Veterinarians are exposed to allergens from animals and their products such as hair[98], dander, urine,[98,97] scales, fur, saliva, and body wastes. These contain powerful allergens that can cause both respiratory and skin disorders[99] and chemicals that can cause irritation or allergic reactions.[45,98] Persons at risk include: pet owners, laboratory animal and veterinary technicians, researchers, veterinarians and others who have prolong and close association with animals. Others at risk include workers who handle animal products and other materials such as bedding and animal feed.

About 33% of animal handlers have reported allergic symptoms and approximately 10% have symptoms of animal-induced asthma. Sources of exposure to animal allergens vary with animal species. Inhalation is a method by which animal allergens can enter the body. After a period of time, often after several months, but occasionally after many years, an individual may inhale sufficient quantities of allergens to become sensitised and develop symptoms when exposed a second time even to a tiny amount of allergens. Other routes of exposure may be from animal bites or scratches.[100]

Even though veterinarians are exposed to allergens, dirt, and chemicals, there is very little epidemiological data on dermatoses among veterinarians. Atopic allergies seem to be major contributors to skin reactions among veterinarians, livestock farmers and animal handlers.[101] A study by Susitaival et al. (2001)[102] on skin diseases among a sample of Californian veterinarians revealed that 11% experienced a history of skin atopy while 63% experiencing respiratory atopy. More specifically, 46% reported to have experienced dermatoses during their career. Dermatitis on the hand and/or forearm was reported more than once during the previous year (2000) by 22% of female veterinarians and by 10% of male veterinarians. Dermatitis with work-related exacerbating factors was reported by 28%. Almost one out of five veterinarians reported skin problem related to contact with animals. Other factors responsible for aggravating allergic problems included medications (2%), gloves (4%), and chemicals (7%). Sixty-five percent of veterinarians reported animal-related dermatitis particularly due to contact with one animal species (dog, 66%; cat, 29%; horse, 9% and cattle, 8%). Sixty-six percent reported that the symptoms appeared minutes after contact with particular species of animal. The risk factors for the appearance of hand/forearm dermatitis during the previous 12 months and more than once during their career included a history of skin atopy, of childhood hand dermatitis, of respiratory atopy, and being a female.[102]

In epidemiological studies, prevalence of occupational hand dermatitis has been reported in at least 10% of workers in occupation with skin contact with allergens or irritants. This figure is much higher in occupations such as health care work, veterinary practice, dental health practice and hair dressing. The majority of occupational skin diseases are contact dermatitis, either allergic or irritant, affecting hands or forearms and open skin areas especially the face. New sources of allergic contact or protein contact dermatitis are regularly experienced, however, it is rather difficult to diagnose its cause.[101] A single case of allergic contact dermatitis has been reported in an equine practitioner who developed a painful erythematous swelling of the arm when performing ultrasonic rectal examinations to assess the state of ovaries and pregnancies. Patch testing revealed that the veterinarian was allergic to a new lubricant jelly, vet-lubrigel and its preservative bronopol.[103]

Small animals have been the major source of immunoglobulin-E mediated sensitisation particularly among veterinary practitioners. Saliva of cats, dogs, and other laboratory animals were found to be active antigens, while the most commonly inhaled allergens were epithelial tissues of animal hair and fur.[104] Such exposures caused allergic rhino-conjunctivitis or bronchial asthma.[10,104] Allergens found in saliva, dander, urine, serum and pelt of laboratory animals have caused allergic conditions such as sneezing, rhinitis, conjunctivitis, urticaria, tightness of the chest and wheezing among laboratory workers.[105]

Biogenic allergens include animal-derived proteins, fungi, terpenes, storage mites and enzymes. Allergens might be found in many industrial environments including fermentation processes, drug production and in biotechnology. In sensitized persons, exposure to allergic agents may induce allergic symptoms such as allergic rhinitis, conjunctivitis or asthma. Allergic alveolitis is characterized by acute respiratory symptoms like cough, chills, fever, head ache and pain in the muscles which might lead to chronic lung fibrosis.[66] Contact with the vaginal secretions or amniotic fluids of animals and the handling of intestines, pancreases and pig's blood have caused dermatitis in veterinarians.[99] Frequent exposure to allergens of animal origin, including blood proteins, ascarid worms and ectoparasites, increases the probability of veterinarians developing occupational allergic respiratory diseases.

Antibiotics used in veterinary practices may also cause skin and respiratory tract symptoms.[59,61,62,99,106] Several studies among veterinarians have indicated that antibiotics such as spiramycin, tylosin, penethamate, penicillin, neomycin and streptomycin cause dermatitis.[10] It has also been noted that iodine and providone-iodine can cause allergic contact dermatitis.[107,108] In a study among Norwegian veterinarians, 20.6% of the 699 respondents had symptoms from exposure to antibiotics, latex gloves and chemicals. Seventy-five per cent of the cases were skin related and 25% were respiratory tract related. Thirty-two cases were due to sensitivity to latex surgical gloves or powder within the gloves.[106] In a study among zoo veterinarians in the US, twelve percent of participants reported a skin reaction to latex gloves.[1] In two other studies conducted amongst veterinarians, 5% of participants in each study reported allergic or irritant reaction to gloves.[10,11]

Allergy from latex gloves which was first recognized in the late 1970s has been affecting a number of people in the work place and had become a major health concern. People who handle medical products containing latex in health care industry are exposed to latex and are at increased risk. It has been reported that 8-12% of health workers are sensitive to latex powder in the gloves. Between the period 1988-1992, due to exposure to latex, more than 1000 reports of adverse health effects and 15 deaths were reported to the Federal Drug Administration in the US.[109] Contact dermatitis is the most common immunologic reaction to latex.[110,111] Besides latex, other chemicals such as accelerators, antioxidants, powders, fillers, extending and slipping agents, are often added during manufacturing process may cause immediate or delayed contact reactions.[112]

Prevalence of allergy, lung function disorders or bronchial hyper-reactivity was studied in 102 Dutch veterinarians.[45] The cohort was subdivided into five professional groups of veterinarians predominantly working either with swine, cattle, poultry, companion animals and a sixth group of veterinarians who were not practicing at the time of the study. The mean age of the cohort was 43 years with 6 participants being females. Twenty-two percent of the participants were overweight, relatively more non-veterinary practitioners were overweight than practising veterinarians. Approximately 23% of veterinarians reported complaints of prolonged fatigue. The data suggested a relationship between complaints of prolonged fatigue and a higher than average number of working hours. A small proportion of veterinarians was sensitized against several allergens. There were no significant differences in the prevalence of distinct lung function disorder or bronchial hyperreactivity between professional groups. Respiratory complaints such as chronic coughing, chronic phlegm, blocked nose and sneezing were reported by the participants predominantly working in swine and/or poultry practice. The cause could have been irritation and/or inflammation of the first part of the trachea-bronchial tree that did not produce any measurable and permanent changes in lung function or increased bronchial hyper-reactivity. Skin tests indicated that respiratory complaints were probably not related to allergy against the panel of allergens tested.[45] Another study by Donham et al., (1977)[113] also reported a higher prevalence of respiratory complaints in pig and poultry veterinarians.

Studies have shown that veterinarians have a greater prevalence of asthma than control subjects. Asthma and infectious and obstructive respiratory diseases were more common among veterinarians. The prevalence of these diseases increased with the length of occupational exposure with veterinarians being allergic to both the animals they treated and to some of the therapeutic agents they used.[106]

The study among zoo veterinarians in the US[1] revealed that 32.2% reported an allergic reaction to animals. A history of allergy from insect bites and adverse reaction to latex were significant predictors of animal allergy. In comparison, females in another study were more likely to report allergies to animals.[10] According to Newill et al., (1992)[114] females working with laboratory animals were found to be a risk factor for hyper-reactivity. Cross-sectional studies of veterinarians and their associates[8,10-11,115-121] reported a prevalence of allergy to animals ranging from 7% to 44%.

A review on occupational allergy to animals by Seward (1999)[122] revealed that the participants' overall prevalence of allergic respiratory symptoms in exposed persons is about 23% with four to nine percent of exposed persons developing asthma. The allergic symptoms developed in exposed persons were related to the duration and intensity of exposure. The most prevalent dermatological findings were contact urticaria and eczematous dermatitis. Even though, a history of atopy was associated with the risk of symptom development, this factor had poor predictive value for any given individual.[122]

Zoo veterinarians in the US (38.4%) working in enclosed animal housing facilities, experienced allergic type symptoms including sneezing (26.5%) and eye-nose and throat irritation (25.8%).[1] In comparison, 95% of veterinarians working in swine confinement buildings have had at least one mucosal or respiratory complaint.[11] Eye-nose and throat irritation have been reported among 25% of veterinary students who visited a swine farm[123] and 95% veterinarians reported adverse effects from working in swine confinement buildings.[113] Allergic reactions reported from cross-sectional studies were rhinitis, conjunctivitis, coughing, sneezing, wheezing, asthma and rarely anaphylaxis.[115-121]

**Zoonotic diseases**

More than 200 animal diseases are transmitted to humans (zoonoses) causing a wide variety of illnesses. There may be undefined zoonotic diseases that pose infectious risks. Humans that are particularly at risk are mostly immunosuppressed or immunocompromised individuals or young children and the elderly.[124] Over 100 years of experience has shown that animal health and human health are closely related. Like human beings, domestic animals and wildlife are exposed to infectious diseases and environmental contaminants in the air, soil, water, and food and they can suffer from acute and chronic diseases from such exposures. Often, animals serve as disease sentinels, or early warning symptoms for the community. Animals can also reveal health hazards associated with environmental pollution.[125]

In the late 1980s, major outbreaks of infectious diseases emerged around the globe and surprised many scientists. Numerous reports identified erosion of public health infrastructure. Several new zoonoses have recently been identified. Many of these diseases were either known because of the infectious agents were unable to isolate and distinguish them from other chemical syndromes, or discovered accidentally.[126]

Zoonotic diseases with teratogenic and abortifacient effects include brucellosis, tuberculosis, cryptococcosis, listeriosis, lymphocytic choriomeningitis, Q fever, toxoplasmosis and Venezuelan equine encephalitis. Of these infectious diseases, toxoplasmosis and listeriosis are of main concern for the veterinary profession.[48]

Although veterinarians have experienced problems with zoonotic diseases, few studies have been undertaken to assess the prevalence of zoonotic diseases amongst veterinarians. Personal contact with Centres for Disease Control in Atlanta, US and with the AVMA has shown that there is very little information on occupational zoonoses in veterinarians. Therefore, even in the US, which has a good reputation for research on this topic, the available literature/documentation is limited.

Zoonotic infections can be transmitted via animal bites, arthropod vectors, especially ticks and mosquitoes, and direct contact with animals. Infections also can be contracted indirectly by ingestion of contaminated food or water or contact with contaminated hides, wool, or fur. Occupational groups at risk are animal workers, fisher persons and others working with zoonotic pathogens.[127]

Bovine Spongiform Encephalopathy (BSE) sometimes referred to as 'Mad Cow Disease' and Creutzfeldt-Jakob Disease (CJD) belonging to the unusual group of progressively degenerative neurological diseases known as transmissible spongiform encephalopathies (TSES) is of great concern to veterinarians and medical personnel around the world. Since 1996, in Europe evidence has been increasing for a causal relationship between on-going outbreaks of BSE and a disease in humans called new variant Creutzfeldt – Jakob disease (nvCJD). Both disorders are invariably fatal brain diseases with unusually long incubation periods measured in years and are caused by an unconventional transmissible agent (a prion). There is strong evidence that the agent responsible for the human cases was the same agent responsible for the BSE outbreaks in cattle, the only known food animal species. Transmission of this agent from cattle to humans is still unknown.[128]

Even though BSE disease appears to be not prevalent in Australia, the incubation period for this disease is 3-8 years and this makes it difficult to rule out its prevalence at any given time, considering the delayed onset of symptoms etc. Therefore, this disease remains a concern for Australians. From 1986 to 2000, nearly 99% of all BSE cases have occurred in the UK. But endemic cases of BSE were also reported in other European countries including Belgium, Denmark, France, Switzerland and Ireland. From 1995 to 2000, 79 cases of nvCJD were reported in the UK, three in France and one in Ireland[128] and in 2003 one case has been reported in Canada.

Since June 1986, five cases of spongiform encephalopathy have been found in zoo ungulates in the UK. Recent press reports on these cases have highlighted the need for zoos to be vigilant because of the limited knowledge of spongiform encephalopathies in captive zoo species. These are largely based on experience of BSE and scrapie.[129]

Zoonotic diseases can be mild or serious for veterinarians and their staff.[60] Since they are directly exposed to the infectious agents, large animal and public health veterinarians are more at risk of developing such zoonotic diseases as brucellosis, tuberculosis, leptospirosis, salmonellosis, and Q fever. The range of zoonoses to which veterinarians can be exposed in Australia has been outlined by Stevenson and Hughes (1988).[130] Veterinarians attending the National Annual Conferences of the AVA were surveyed serologically at intervals from 1975 to 1982 for exposure to a number of zoonotic agents[131] and the diseases included brucellosis, leptospirosis, Q fever, toxoplasmosis and chlamydiosis. The cohort tested comprised of all types of veterinarians including academics, administrators, and students. Of these, 23% showed evidence of previous exposure to two or more infections. The most common zoonotic infections were brucellosis and toxoplasmosis followed by Q fever. Antibody titres to leptospiral infections were demonstrated in only 2.7% of those tested. The highest prevalence of previous exposure to zoonotic disease agents was observed among veterinarians undertaking meat inspection (67%), laboratory scientists (50%) and medical personnel (50%). It was noted that 24% of veterinary nurses also showed serological evidence of exposure to some of these infectious agents. Clinical signs associated with these infections were reported only by those carrying out meat inspection.[131] Some zoonotic diseases such as toxoplasmosis can produce teratogenic effects, however, most female veterinarians in Australia are aware of these effects on pregnancy.

The 1977 survey of 1182 Illinois veterinarians[18] revealed that 42.7% had experienced a zoonotic infection. Thirty-four percent of accident-free veterinarians had experienced zoonoses but the figure was 16% higher among veterinarians with a history of three or more accidents. The significance of this has yet to be determined. A North Carolina study[10] of over 700 veterinarians showed a third had had one zoonotic infection during their career. The infections were: dermatopytosis (58.3%), cat scratch fever (19%), rocky mountain spotted fever (6.9%), brucellosis (5.7%), lyme disease (1.6%), erysipeloid (1.6%), psittacosis (1.5%), leptospirosis (0.8%), toxoplasmosis (0.8%), tularaemia (0.8%), tuberculosis (0.4%), Newcastle disease (0.4%) and pasteurellosis (0.4%). Overall accidental exposure to the rabies vaccine occurred in 27% of respondents and of these, 30% were small animal practitioners, 22% were mixed animal practitioners while 5% were large animal practitioners. Exposure to vaccines including distemper, hepatitis, leptospirosis, parvovirus, equine influenza, feline leukemia, canine para influenza, hog cholera, intranasal bordetella, pseudorabies and bovine viral diarrhoea amounted to 17.2%. It is noteworthy that the majority of veterinarians in this study had been immunized against rabies (86.8%) and tetanus (87.3%) with one-sixth of the cohort exposed to vaccines.[10] However, the report failed to mention if any infections, diseases or problems occurred as a result of the adjuvant.

Numerous animal-associated infections due to such organisms as *Bartonella henselae (cat scratch disease), Rhodococcus equi, Mycobacterium marinum, Cryptosporidium spp, Giardia lamblia, Toxoplasma gondii, Campylobacter spp, Salmonella spp and mycrosporidium spp*, all infections to which veterinarians are exposed, have been detected in HIV positive patients.[132,133] and yet these diseases have not been a cause of great zoonotic concern to veterinarians. Veterinarians in the past were exposed to many potentially serious infectious diseases including rabies, glanders, brucellosis and anthrax. Rabies and glanders are exotic to Australia. Bovine brucellosis is no longer considered to be a zoonotic risk in Australia because of its eradication from cattle. However, brucellosis from feral pigs is of concern in some areas where cases of human disease due to porcine brucellosis have been reported from the southern half of Queensland and northern New South Wales.[134] There is a population of 23.5 million wild pigs covering 40% of the land space of Australia. They compete with sheep and cattle for feed, kill livestock and cause soil erosion. Wild swine carry animal diseases including leptospirosis, a potentially fatal affliction that can cause jaundice, fever and kidney failure in humans.[135]

Even though, brucellosis in cattle has been eradicated from Australia this disease is prevalent worldwide, including the US. Corbell (1977)[136] reports that brucellosis, also known as undulant fever or Bangs Disease is a systemic infection caused by Brucella species, small Gram-negative coccobacilli that can infect cattle with B. abortus, goats and sheep with B. melitensis, pigs with B. suis and dogs with B. canis. Four veterinarians, four veterinary students and a farmer were exposed to RB51 strain disease while attending to an attempted vaginal and caesarean delivery and a necropsy on a stillborn calf that died due to Brucella abortus infection. Six women and three men who attended to a heifer and a calf, without wearing adequate protective clothing including gloves, masks, or eye protection were exposed to placenta blood and amniotic fluid. The National Animal Disease Centre in the US, identified the causal agent as the RB 51 vaccine strain. Investigations revealed that the 14 month-old heifer that delivered the calf was not known to be pregnant when she was vaccinated with RB51 strain. Investigations revealed that at the time of vaccination the heifer was eight months pregnant.[136]

Experts of infectious diseases are at present concerned about emerging or re-emerging diseases. The study by Gleeson (1997)[137] reports that the Australian bat Lyssavirus may be a newly emerged infectious agent, because of the occurrence of the fatal human disease in Queensland soon after the discovery of this virus in bats.[137] The genus Lyssavirus consists of more than 80 viruses and has been classified under the rabies serogroup, most of which only rarely causes human disease. The genus Lyssavirus, rabies serogroup, includes the classic rabies virus, Mokola virus, Duvenhage virus, Obodhiang virus, Kotonkan virus, Rochambeau virus, European bat Lyssavirus types 1 and 2 and Australian bat Lyssavirus.[138]

Lyssavirus may be previously an unrecognized endemic animal and human pathogen that rarely caused diseases in species other than bats. Between the years 1996 and 1999, Australia has had three newly described zoonotic viral diseases. The Hendra virus with fruit bats as its natural host, has been associated with the death of two men and a number of horses in Queensland. Australian bat Lyssavirus found in flying foxes and bats and closely related to the classic rabies virus, has been responsible for the deaths of two Queensland persons associated with bats. The third virus, Menangle virus, an apparently new virus in the family Paromyxoviradae, causes fatal disease and malformations in pigs and possibly influenza-like symptoms in humans. There have been no reports of veterinarians developing any of these zoonotic diseases. Although the Hendra virus was transmitted to its two human victims from horses and therefore such a virus might place equine veterinarians at risk, it has not been found to be highly contagious.[139]

Rabies is a viral disease that produces fatal encephalitis in human and other mammalian species. In developing countries where canine rabies is still endemic, almost all of human rabies deaths are due to dog bites. Death is inevitable in an individual who develops clinical symptoms of rabies.[140] Rabies is found world wide except in Australia, New Zealand, New Guinea and Oceania. Great Britain and Sweden were among the first countries to eradicate rabies. Subsequently, several other countries including Japan, Taiwan, Hong Kong and Malaya have also eradicated this disease.[141]

Human rabies reflects the prevalence of animal infection and the extent of contact the animal population has with humans. Fewer than 5% of cases in the developed world occur in domestic dogs, whereas cats and cattle are responsible for as many as 20% of cases. Undomesticated canines such as coyotes, wolves, jackals and foxes are most prone to rabies.[138] The major risk of rabies comes from contact with the saliva, body fluids or tissue of infected animals. Animals which are susceptible to rabies are all mammals, but in particular, wild animals including foxes, bats, skunks and raccoons. Amongst livestock species it affects mostly cattle but occasionally horses, sheep, goats, pigs and also domestic cats and dogs.[141] Traditional veterinary practitioners and through recommendations from the public health officials effective measures have been to control rabies in dogs and prevent human fatalities. However, these professionals have not been able to adequately address the problem of rabies in wild life.

The likelihood of rabies entering Australia is rather remote as strict quarantine regulations are in place. The only channel that rabies can gain entry into Australia is through sea vessels such as yachts and boats entering with infected rabid animals. If by chance this disease enters into Australia, it might be rather difficult to detect as there is an abundant different species of feral population occupying Australia which can harbour the disease unnoticed. Rabies is prevalent in many developing countries including India, Pakistan, Bangladesh, Burma and Sri Lanka as well as in developed countries such as the US (except in the Hawaiian State) and is causing serious problems to wild and domesticated animals as well as to humans. Wild animals such as foxes, feral dogs and jackals are reservoirs they make it difficult to control this disease.

Mycobacterial infections are common among humans. Of these infections Mycobacterium tuberculosis (TB) is the most common and acquired by inhalation of aerosols carrying tubercle bacilli and is of greatest concern. Non-tuberculous species of mycobacteria may also cause infections in immuno-suppressed humans and could be acquired from environmental sources.[142] The study by Michalak et al., (1998)[143] report that between 1994 and 1996, three elephants from an exotic animal farm in Illinois died of pulmonary disease due to Mycobacterium tuberculosis. In October 1996, another elephant showed up culture-positive for Mycobacterium tuberculosis. Twenty-two handlers at this animal farm were screened and of those, eleven responded positive to tuberculosis and one had smear-negative and culture-positive active to tuberculosis. The investigation revealed that the isolates from the four elephants and the handler with active tuberculosis were the same strain and that there is transmission of Mycobacterium tuberculosis between humans and elephants.[143]

Zoo keepers have to work very closely with native and exotic species for breeding and exhibit purposes. A study in the US[144] reported that seven zoo keepers working with an infected white rhinoceros were suspected to have been infected with Mycobacterium tuberculosis via aerosols generated while cleaning the barn of rhinoceros. The skin test carried out among the keepers was positive but none had clinical symptoms. In certain occupational settings such as zoos and abattoirs, Mycobacterium bovis may be an occupational hazard.[144]

The study among zoo veterinarians in the US[1] revealed that of the 278 zoo veterinarians in the cohort, 28/84 and 24/84 experienced a zoonotic infection with ring worm and psittacosis being the most common. Table 9.

Of the 84 respondents who experienced a zoonotic infection, five were hospitalised for leptospirosis, campylobacteriosis, echinococcosis, herpes virus A1, giardiasis and three were hospitalised for psittacosis. Asymptomatic workers also reported seroconversion to zoonotic diseases such as hepatitis, toxoplasmosis, psittacosis, and lyme disease. Eight veterinarians in the cohort converted to positive on tuberculosis skin tests. The study indicated that more females than males had acquired a zoonotic infection.

The study by Hill et al., (1998)[1] also revealed that veterinarians were exposed to bites and scratches to rabid animals. The zoo study did not identify whether these individuals had a current rabies vaccination at the time of exposure; however, 10.8% of the individuals exposed did not have a current vaccination at the time of the survey.[1] Herpes virus simiae (B Virus) is found to be prevalent among wild macaques and may cause fatal meningoencephalitis in humans, usually from bites and scratches.[145]

**Table 9. Number of zoo veterinarians who reported zoonoses in a US study.[1]**

| Zoonosis | Number of infected zoo veterinarians (84/278) |
|---|---|
| Ringworm or other superficial Fungal infection | 28 |
| Psittacosis | 24 |
| Other* | 17 |
| Scabies | 9 |
| Amoebiasis | 4 |
| Campylobacteriosis | 4 |
| Salmonellosis | 4 |
| Giardiasis | 4 |
| Shigellosis | 3 |
| Erysipeloid | 2 |
| Staphylococosis | 2 |
| Hepatitis A,B,other | 2 |
| Pinworm or hookworm | 1 |
| Tuberculosis | 1 |

* Other included listeriosis, leptospirosis, histoplasmosis, herpesvirus A1, tularemia, brucellosis, echinococcosis, antibiotic-resistant, *Escherichia coli*, callitrichid hepatitis, enteritis.

The study carried out among veterinary practitioners in Western Australia[8] reported several work-days loss to veterinarians due to human and zoonotic diseases. Zoonotic diseases were regarded as a health hazard by 20% of veterinarians in the study group, however, only 3% reported having a zoonotic disease. Forty-seven respondents (54%) indicated that they and their staff had lost a total of 407.5 work days over a 12 month period due to non-occupational diseases such as influenza whereas there were just 7 work days in total loss in three practices from zoonotic diseases, including ring-worm and cat-scratch fever. Participants were asked to list major occupational health and safety issues in their practice and the zoonotic diseases nominated included toxoplasmosis, cryptococcosis, leptospirosis, psittacosis and chlamydiosis. While 8% of the veterinarians identified zoonotic diseases as a potential risk to themselves and their staff, only 4% stated that zoonotic infections had occurred.[8]

The Annual report of the National Notifiable Diseases Surveillance System (NNDSS) (2001)[146] states that "brucellosis, leptospirosis and Q fever infections were nationally notifiable in 1999. In New South Wales neither hydatid infection nor ornithosis were notifiable diseases and ornithosis was not notifiable in Queensland. Zoonotic diseases in Australia are not found in all states and territories. The Northern Territory has never reported a case of Q fever and has only reported a single case of hydatid in 1994. A total of 1,001 notifiable zoonotic infection cases were received by NNDSS in 1999, which accounted for 1.1 per cent of all the notifications. Most notifiable zoonotic infections reported in Queensland were 569 (57%) and in New South Wales were 222 (22%). Queensland had the highest notification rates for Q fever (8.5 per 100,000 population), leptospirosis (6.2 per 100,000 population) and brucellosis (1.4 per 100,000 population). Victoria had the highest notification rates for ornithosis (1.4 per 100,000 population) and hydatid infection (0.4 per 100,000 population) No notified cases of zoonotic infections were reported in Western Australia.[146]

### Reverse Zoonoses

Reverse zoonoses are diseases that are communicable from human beings to animals. Diseases such as Mumps virus, Infectious hepatitis, Corynebacterium diphtheriae, Staphylococcus aureus, streptococcus pyogenes, Giardia lamblia and Mycobacteria tuberculosis that are transmissible from humans to animals including nonhuman primates, cattle, deer, beavers, dogs and elephants[125] are shown in Table 10.

**Table 10. Infectious diseases communicable from human to animals and transmitted back to human.**

| Agent | Human disease | Animal disease | Animal |
|---|---|---|---|
| Mumps virus | Mumps | Parotiditis | Dogs |
| Infectious hepatitis | Hepatitis | Hepatitis | Nonhuman primates |
| Corynebacterium diphtheriae | Diphtheria | Ulcers on teats, mastitis | Cattle |
| Staphylococcus aureus | Furunculosis | Furunculosis, mastitis | Cattle |
| Streptococcus pyogenes | Pharyngitis, scarlet fever | Mastitis | Cattle |
| Giardia lamblia | Nausea, flatulence, diarrhoea | None known | Beavers |
| Mycobacteria tuberculosis | Tuberculosis | Tuberculosis | Deer, elephants, dogs. |

The outbreak of reverse zoonoses started in Los Angeles in 1996 with the death of two circus elephants with Mycobacteria tuberculosis. Subsequently, another elephant died at the Los Angeles zoo with Mycobacteria tuberculosis.[125]

A number of human viruses may be transmitted to animals such as human herpes virus type 1 which can infect large primates like gorillas, chimpanzees and orangutans. In the wild, there had been an outbreak of poliovirus infection among chimpanzees derived from humans which killed and crippled numerous chimpanzees. The main zoonotic agents in birds include chlamydia, salmonella and campylobacteria .[147]

**Conclusion**

Prevalence of a range of hazardous exposures exist in veterinary medicine. These include allergens and biological agents which cause zoonotic infections. A variety of microbes present considerable risks for veterinarians. Infections are acquired from direct contact with animal patients and some times through repeated exposures including animal body fluids.

Zoonotic diseases could cause ill-effects to both male and female veterinarians and some of these diseases can produce teratogenic and abortifacient effects. Such diseases include brucellosis, tuberculosis, Q fever, toxoplasmosis and listeriosis.

Studies have indicated that asthma and respiratory diseases are more common among veterinarians. Prevalence of these conditions increased with the length of occupational exposures. It has also been found that veterinarians are allergic not only to the animals they treat, but also to some of the therapeutic agents they use in the practice.

The literature review showed that there is considerable variability of exposures exist within the profession while there had been no resources to measure the exposure levels within veterinarians. This review shows several situations in zoo veterinary practice where hazardous exposure may occur.

Individuals with a family history of allergy do inherit such conditions and they should take suitable precautionary measures to avoid exposure to allergens. The use of protective gear, better ventilation and good cleaning of the animal enclosures in zoological gardens could decrease exposure to animal allergens. Veterinarians developing irritant reactions to latex gloves should eliminate unnecessary use of gloves and veterinarians with systemic reactions to latex should avoid exposure to any latex containing products. Non-latex gloves that can provide the best overall chemical resistance include nitrile and neoprene gloves. It is important to consult the manufacturers to determine which gloves are best suited for specific chemicals.

Veterinarians should have a baseline serology taken when they begin their career in zoological gardens. Up to date vaccinations also should be taken against diseases which are common in the Australian environment. Frequent serological monitoring will benefit immuno-compromised individuals because they may develop more severe infections.

## CHAPTER 5.

# REVIEW OF RADIATION SAFETY IN VETERINARY PRACTICE

## Introduction

Like many scientific revolutions the invention of the x-ray was discovered accidentally 108 years ago. Professor Roentgen of Wursburgh, announced the discovery by a note to the British Medical Journal of the remarkable photographic effects which he ascribes to a new kind of radiation. Roentgen made this discovery while investigating the effects of cathode rays that were produced by electrical discharges. Veterinary profession received an official information about the discovery of x-rays from a reprint in the veterinary record (1896).[148]

X-rays penetrate many substances to a greater or lesser degree depending on the material and the penetrating power depends on the energy. Today, the x-ray invented by German physicist provides diagnostic imaging services to see inside a living person to diagnose the type of fracture and even to locate foreign particles such as bullets and safety pin lodged in the body. An x-ray picture is produced when a small amount of radiation passes through the body and exposes a film on the other side of the patient. An image is produced when different tissues absorb different amounts of the x-ray beam.[20]

Veterinarians are challenged by an imposing group of occupational hazards including radiation. Radiography in veterinary hospitals, as in human hospitals, is a vital tool in the diagnosis of disorders and treatment of patients. The use of radiography is well recognized in human and veterinary medicine. The use of radiography has become much more beneficial to the veterinarians than their medical counter parts who diagnose and treat humans who will be able to describe their problems. Infrequent exposure to radiation such as having radiographs taken of oneself is accepted as an insignificant variable in overall health.

Long term exposure to low doses of radiation has been linked to genetic, cutaneous, glandular and other disorders. High doses of exposure can cause skin change, cell damage, gastro-intestinal and bone marrow disorders that can be fatal.[149] In recent years, there has been an increase in the use of radiology for diagnostic and therapeutic purposes and the major source of radiation exposure for veterinarians in practice is from x-ray machines and radioactive materials.

The medical use of radiation constitutes the largest artificial source of radiation to the population (Jacob C. personal communication, 1999). Exposure to ionizing radiation can be regarded as a major occupational health hazard because it is carcinogenic and mutagenic at all doses.[12,47,51,150-152] However, at very high doses, death from direct effects may preclude cancer development ( Fox R. personal communication, 1997). Veterinarians are frequently exposed to ionising radiation as most of them remain generalists taking their own x-rays whereas, in human medicine, exposure has been minimised for most medical practitioners due to the presence of specialists in radiology.[150]

X-rays are produced by the interaction of rapidly moving electrons with a tungsten target in an x-ray tube and the beam that emerges from the aperture of the tube is the primary beam. The heterogeneous primary beam is composed of x-rays of widely varying levels and is used in the production of a radiographic image.[153] Major sources of exposure for those who are involved in radiographic procedures are from radiation leakage or failure to keep themselves out of direct or secondary beam rays. Personnel involved in x-ray procedures should not be subjected to the primary beam.[38,68,154] All ionizing radiation energy arising from x-rays or radioactive materials when absorbed by biological tissues may cause excitation or ionization.[38,68,154,155]

The raising of an electron or molecule to a higher level without the ejection of the molecule or electron is excitation. Whereas ionisation is the release of an electron from its molecular binding and occurs when radiation energy is strong enough to eject one or more electrons or molecules. The distinctive character of ionising radiation is the localised release of great quantities of energy. The energy produced through a single ionising event is more than enough to break a strong chemical bond.[155] Chemical bonds are not as relevant for radiation protection as nuclear attraction.

When x-ray photons are absorbed by the tissue, the ionisation effect that takes place depends on the clinical composition of the absorbing cells and on the number of ionisations or exposures to that tissue.[155] Cell damage can be either sublethal or lethal.[150,156] The ionisation may cause minor repairable impairment or even death of the affected tissues. Changes in a cell due to ionisation may affect the functioning of the adjoining cells and in some cases the whole organism. In human and in animals such effects could cause somatic or genetic effects.[38] Even though, the damage to the tissue by radiation is still not clearly understood, it is known the deoxyribonucleic acid (DNA) is the most sensitive cellular component, the principal target when a cell is exposed to radiation.[38,155]

When x-rays are absorbed by biological tissues, it is possible they will interact directly with the critical targets in the cell, thus causing ionisation or excitation which leads to a number of direct actions on the biological tissue. Radiation may also interact with other targets which include nucleic acids, enzymes, lipoproteins, structural proteins, polysaccharides, membranes and intracellular organelles. Ionising radiation damages the living tissue by altering the macro molecules.[38,68,155,156] Figure 2 schematically illustrates the biological effects of radiation on living cells.

DNA consists of two strands that form a double helix and each of these strands is composed of deoxynucleotides which contains the genetic code. The types of damage ionisation causes on DNA molecules are single strand breaks, double strand breaks, base deletions, base substitutions, and DNA cross-linking. A single strand break is of less significance as this is readily repaired by using the opposite strand. If there is a misrepair in the single strand, it may result in mutation. A double strand break is the most important lesion produced in chromosomes by radiation and the interaction of two double-strand breaks may result in cell death, mutation or carcinogenesis.[155]

**Figure 1. Biological effects of ionising radiation**

Radiation
↓
Charged particles
↓
Atomic interactions
↓
Ionisation occurs
↓
Physical and chemical changes
↓
Biological effect
(eg. Damage to DNA)
↓

| ↓ Cell death | ↓ Cell transformation |
|---|---|

Cell transformation ↓

| ↓ Cancer | ↓ Hereditary defects |
|---|---|

Source: British Medical Association, June 1994 (p.56)[38]

Even as far back as 1937, Wantz and Frick, while demonstrating at an x-ray clinic at the Okalahoma meeting of the AVMA in 1935, found that two veterinarians were showing signs of early x-ray burns although they were entirely ignorant of what was causing these burns.[148] Over the years radiologists have suffered many severe radiation injuries from radiography and even today, there are cases of skin lesions due to radiation on the hands of veterinarians.[38,68,157,158]

X-rays destroy living tissues and can cause severe bums when human flesh is exposed to their action for a long time. Their destructive power is used in x-ray therapy. Exposure to radiation may lead to cancer, which can be fatal, although, the process by which cancer is induced by radiation is not clear. In the past, different types of malignant diseases have been reported in humans exposed to high doses of radiation.[38,68]

While some persons exposed to radiation contract cancer, the probability of an individual contracting cancer is dose, and dose rate dependent. Seriously harmful effects such as dominant mutations leading to genetic disease and chromosomal aberrations predominantly occur in the first and second generations after exposure, while recessive mutations contribute to the general pool of genetic damage in subsequent generations. Despite an awareness of the genetic effects of radiation, there has been no study showing the genetic effects in human caused by radiation. Even World War two atomic bomb survivors and their descendents did not show an increase in the natural incidence of genetic abnormalities. However, it has been recognized since early studies on x-rays and radioactive materials that exposure to high levels of radiation can cause clinical damage to the human tissues. Long term epidemiological studies of populations exposed to radiation, especially the survivors of the atomic bombing of Hiroshima and Nagasaki in Japan in 1945, have demonstrated that exposure to radiation has a potential for the delayed induction of malignancies.[68]

**X-ray machines in veterinary practice**

Most of the x-ray machines are produced mainly for the health care industry and are used by qualified radiographers. The veterinary surgeon with less experience in radiographic technique may find it difficult to obtain an apparatus to suit his requirements. There has been an increase in the use of radiography by veterinarians.

Radiographic equipment are used by veterinary practitioners in their clinics and hospitals and in veterinary practices in the zoological gardens of Australia. The radiographic machines used in veterinary practices are of three types: portable, mobile and fixed. These machines can last for many years if maintained carefully. Portable x-ray machines have often been used extensively before re-sale, and have little second-hand value, whereas, larger second-hand x-ray machines are in demand. Powerful fixed machines are available, but the cost of installation and maintenance are very high. The mobile units used in hospitals must be well cared for and regularly serviced, and should continue to provide good performance, even when purchased second-hand.[159]

Of the two types of portable machines, one has controls on the head, and the other has a separate control panel, preferable for small animal practice. It allows the operator to stand further from the primary beam during exposure. The range of output of a portable machine is usually up to 80-100kV and 10-60mA.[159] The length of the exposure switch cable determines how far the operator can stand from the patient and the tube. This length is set by standards and regulations (Jacob C. personal communication, 1999). Use of x-ray equipment producing high milliamperage (mA) and high kilovoltage (kV) will permit brief exposure times to overcome the effect of sudden movement by an animal during radiography.[159]

There is a considerable sale of second hand x-ray machines for veterinary clinics and hospitals due to the high cost in purchasing new machines. Sometimes old machines could be unsafe mainly due to radiation leakage. Ionising radiation to which veterinarians and their associates were exposed during an equine radiography was investigated in 1974.[160] The investigation cited previous equine radiographic studies carried out as far back as 1960 by Trainer et.al. using a Victoreen R-meter with 25 R chamber and an Ekco radiation monitor type N571. The body exposure doses received by veterinary assistants was 2.5 R to 400 R per hour while radiographers received 0.75 R per hour. As portable machines were not available at that time, assessments for body exposures were made only with mobile and fixed machines. Wood et al., (1974)[160] compared the effects of x-ray machines, x-ray techniques and the use of lead rubber gloves for radiation exposure to the hands for a mobile machine and three portable machines. The size of the primary beam was the main factor in determining the exposure. The results showed that the two portable x-ray machines fitted with beam limiting devices recorded the highest rate of exposure while the mobile x-ray machine fitted with light beam diaphragms recorded the lower exposure levels. The use of light beam diaphragms on all machines to control the primary beam was found to be most effective in equine radiography and the use of cassette holders was recommended to avoid exposure to hands.[160]

Exposure to ionising radiation from diagnostic radiographic machines may also be higher in animal hospitals than in human hospitals and laboratories for a number of reasons including using older radiographic equipment and manual restraint of an animal during radiographic examination.[55] Practically all radiographic equipment for humans are used by qualified radiographers whereas a veterinarian with limited knowledge and experience in radiography, has to act both as radiographer and radiologist to produce a radiograph of diagnostic quality.

The Radiation Safety Act of Western Australia (1975)[6] controls all uses of radiation for Western Australia. The Act covers the use of a range of ionising and non-ionising radiation and requires equipment and substances, and the premises in which they are used, to be registered. Persons using radiation must be licensed or be acting under the direction and supervision of a licensed person. Personal supervision means that the licensee must be on the registered premises or the field site. To obtain a license to carry out veterinary radiography, an applicant must be a qualified veterinarian and have passed a radiation safety examination equivalent to that given to the final year students at the School of Veterinary Studies at Murdoch University, Western Australia. However, a pass in the radiation safety examination is not of itself a license to use x-ray equipment.[6]

A Radiation Safety Officer has to be nominated by the registrant, usually the owner, to be fully responsible for ensuring radiation safety. The registrant should ensure that the equipment is only used by approved persons, the equipment complies with the relevant regulations and standards, and all those who are involved in radiographic examinations are individually monitored for exposure to radiation using a personal monitor.[6]

Persons selling x-ray equipment are also required to be licensed and the sale of x-ray equipment to an unlicensed person is an offence. Veterinarians purchasing x-ray equipment should apply for registration within 14 days of purchase.[6]

## Testing of x-ray machines

The Radiation Health Section of the Health Department of Western Australia, administers the Western Australian legislation under a statutory body, the Radiological Council. In Western Australia, officers from the Radiation Health Section carry out periodical inspection of x-ray equipment and have found that poor radiography and poor radiation safety prevail in veterinary practices. The frequency of such inspections in Western Australia has decreased due to the increase in the number of x-ray units in use and available resources. Test results show that most x-ray units do not comply with the radiation safety requirements. Often beam collimation is not visible; both films and screens are dirty, damaged, mismatched or inappropriate; and film processing is not carried out properly. Other problems of significant importance connected with low cost x-ray machines include inaccurate tube voltage (kVp), non-linear tube output, inaccuracy in exposure time, inaccurate results from the light beam collimator, and insufficient beam filtration.[157]

## Collimation of the x-ray beam

All x-ray machines should have some means of collimation for the restriction of exposure of the x-ray beam on to a particular area, thereby collimating the primary beam to as small an area as possible. It is important, both for the production of good radiographs and for safety reasons the size of the beam should be restricted to the minimum necessary for the examination. Tight collimation will reduce exposure to the primary and scattered radiation thereby improving safety standards and image quality.[161,162] Plates and cones are simple but time consuming to change from one size to another but a diaphragm could be easily adjusted.[162]

Veterinarians often have to act as both radiographer and radiologist. As radiographer, he must endeavor to produce films of the highest quality. As radiologist, he must critically examine the standard of the radiographs produced before attempting to interpret them. This will enable him to make allowances for any technical faults and should help prevent their repetition.[162]

Veterinary radiographic equipment is often older and may lack features such as collimators and fast film techniques that help to reduce exposure to radiation.[55] Use of a light beam collimator for the x-ray beam to reduce scatter radiation is a newer method of collimation, whereas, fixed metal diaphragms and circular cones are unsafe methods of collimation that are no longer considered adequate to reduce scatter radiation. Therefore, their use is strongly discouraged.[150,159]

By using a light beam diaphragm (LBD), adequate collimation can be achieved and this will give a visible display of the extent of the beam and permits for very tight collimation.[160,161] Unless an LBD is used, manual restraint of animals should not be undertaken, and the accuracy of the LBD should be checked on a regular basis using metal markers such as coins or paper clips. When an LBD is used outdoors on sunny days, the bright light cannot be seen and this makes collimation more difficult.[161] It is advisable that the LBD is used in the dark, or under shade to produce better films.

The amount of scattered radiation that persons may be exposed to, depends largely on the beam cross-sectional area and the volume of material irradiated. Unnecessarily large beams can increase the risk of primary beam exposure to staff restraining animals.[157] The incident photons of the primary beam are scattered by the electrons in the body of the patient when x-rays are taken for diagnostic purposes and, individuals who remain in x-ray rooms during radiography will also be exposed to ionising radiation.[163] Large and small animal patients are exposed to scattered radiation which can affect the gonads during diagnostic radiography. Therefore, the use of a shield is recommended to protect the testicular area and prevent possible genetic damage.[160,164,165]

The radiation dose to staff can be reduced by ensuring that the primary beam is restricted to the area of interest by means of a collimator. If a light beam collimator is not provided with an indication of the beam size at the various focus-film distances used, or if the illumination is inadequate, additional cones or aperture diaphragms should be used during outdoor radiography to restrict the beam to the size of the x-ray film used.[5]

**Pregnant staff**

During the past three decades there has been an increase in women entering the veterinary profession. The impact of some of the occupational hazards specifically radiation exposure on the health of practicing female veterinarians is an area of concern. However, exposure to ionizing radiation is a potentially serious occupational hazard to both male and female veterinarians.

Radiation protection standards do make special provision for females of reproductive capacity. Once pregnancy is confirmed, generally within a period of two months, arrangements should be made to ensure that the pregnant woman works only under conditions where the doses received during the remainder of the pregnancy would not exceed 3 months of the pro-rata annual dose equivalent limits for occupationally exposed persons.[5] When a radiation worker is pregnant, the dose limit for external radiation exposure is 2mSv for the remainder of her pregnancy and for internal radiation exposure, the dose limit is 1/20$^{th}$ of the Annual Limit Intake (ALI).[6]

The size and rapid growth pattern of the human embryo and foetus are highly sensitive and very susceptible when exposed to dangerous substances such as radiation even in small amounts.[12,46] The pre-implantation stage of the foetus which occurs 8 to 10 days after conception has been regarded as the most susceptible period when exposed to radiation.[54] It is now believed that the first month is not particularly radio- sensitive (Fox R. personnel. communication, 1998). The somatic effects such as mutation and genetic effects that may result from irradiation of the unborn, could lead to foetal development problems and mental retardation.[46] Foetal death, congenital abnormalities, likelihood of childhood leukaemia, aplastic anaemia and the gravity of the risk depend on the dose and the gestational age at the time of exposure.[12,166]

In-utero irradiation causes spontaneous abortion, intra uterine growth retardation and congenital malformation.[167-169] Though there are no adverse congenital effects when exposure to lower doses of radiation over a short period of time occur, epidemiologic studies have shown an increased risk of childhood cancer after prenatal irradiation.[168,169,170] When female trainees under 18 years of age are engaged to take x-rays, a guideline should be provided to prevent exposure to high doses of radiation.[171]

Those under the age of 16 including the owners of the animals should be prohibited from assisting in radiographic procedures, and pregnant women should be excluded from the vicinity of the radiographic work.[153] Exposure to ionizing radiation by female veterinarians who could be in the early stage of pregnancy should be carefully controlled and monitored.[12]

It is suggested that pregnant women wear a foetal monitoring dosimeter or pocket dosimeter if exposed to ionizing radiation and the foetal dosimeter to be worn under a lead apron at waist level, when a lead apron is required to be worn.[172]

**Radiation shielding for x-ray rooms**

When an x-ray machine is used outside a defined x-ray room or areas such as farms, stables or kennels, it must be ensured that animals are restrained adequately, the x-ray beam is collimated to the focused area and the operator and others in the vicinity are protected from radiation exposure. Small animal radiography should be carried out in a defined x-ray room. When it is not possible to bring the animal to the x-ray room, radiography may be undertaken outside in a defined area.[5]

The building in which radiography is carried out should have walls to provide extra shielding from radiation. Gyprock stud walls transmits approximately 15% of a 70 kVp primary beam of x-ray while a single solid clay brick wall transmits less than 1% under the same conditions (Jacob C. personal communication, 1999).

In Australia, it is a requirement to use a protective screen with a viewing window of protective glass when the x-ray work load is beyond 2000 milliampere seconds per week. The protective screen should be at least 2 metres high and 1 metre wide with a lead equivalent 0.5 mm. However, the regulatory authority in each state of Australia should be consulted about screen requirements.[5]

Regulations in the UK state that when radiography is used outdoors for diagnostic purposes, the area should be walled off or fenced. When horizontal beam is used, the area should be selected so that the beam is directed towards an adequate, thick wall ( eg 2 mm lead equivalent double brick or 175 mm concrete structure). If an x-ray is taken in an open area, the operator should ensure that no person is in the line of the useful beam. If an unauthorized person is in the controlled area, the operator shall not take any x-rays until that person is no longer in that area.[171]

**Lead equivalent of shielding devices**

Table used for x-ray examination should have a protective shielding equivalent to 0.5 mm lead on the sides and, 1mm lead underneath the table top to protect the lower limbs of the user. Appropriate protective devices such as aprons, gloves and shields of lead rubber suitable for hands and forearms must be available for persons likely to be in the controlled area during radiography. Protective clothing is only adequate against scattered radiation and is not designed to protect persons against the primary beam.[161]

It is the requirement in Australia that protective gear such as aprons and gloves have a lead equivalent thickness of 0.25 mm and not less than 0.5 mm when energies above 100 kV peak are used.[5] While in the United Kingdom, aprons and gloves should have a lead equivalent of not less than 0.25 mm for x-rays up to 150 kV are used and that drapes have a lead equivalent thickness of 0.5 mm under the same conditions. Use of 0.35 mm lead equivalent gloves in the UK are strongly recommended.[171]

Protective clothing such as lead aprons, gloves and sleeves should be carefully handled and stored.[5] Lead aprons should be rolled and not folded during transport to avoid damage.[161]

**Restraint of animals and use of ancillary equipment**

According to the NHMRC Code of practice for the Safe Use of Ionizing Radiation (1982),[5] an animal shall not be manually held for radiography unless for clinical reasons. In Australia and the UK, it is a requirement that if manual restraint is applied, those holding the animal should be positioned as far as practical from the path of the primary beam in addition to wearing protective aprons, gloves or hand and fore arm drapes. Even if a person is protected adequately with proper devices, it is important that no part of the body should ever be exposed to the primary beam. Immobilisation of animals can be achieved by mechanical means, tranquillisation or anaesthesia which will eliminate or reduce the radiation hazard from manual restraint, and assist in the reduction of image blurring due to movement.[5,171]

During radiography, animals should be restrained adequately, positioned correctly and comfortably. Thin, long, loosely filled sand bags may be draped across the patient or wrapped around limbs for restraining animals. Foam troughs can be used for positioning animals for dorsal or ventral recumbency. Small animals and birds can be restrained using cotton bandage, tape or elastoplast. Radiolucent gags can be used for dental radiography.[173]

It may be necessary for the film cassette holder to be supported manually when x-rays are taken on large animals. However, there is the possibility that the person restraining the animal or supporting the cassette holder may concentrate on the task rather than avoid the primary beam, and thus, there is a greater risk of being irradiated. As horizontal beams are the most hazardous, it is necessary to control and direct the horizontal beam to avoid irradiating persons assisting in x-ray procedures.[5]

Radiographs are still being taken with fingers and sometimes the whole hand of a person restraining an animal, being exposed.[171] It is important that an animal should definitely not be manually restrained and manual restrain of animals should not be allowed, unless the x-ray machine is provided with a light beam diaphragm.

**Therapeutic X-ray machines and treatment**

In Australia, x-ray therapy in veterinary practice is increasing in use. Radiotherapy includes the use of x-rays, gamma rays or beta emitters such as strontium-90 eye plaques or yttrium-90 colloid for intra-articular joint treatment. In the state of Western Australia, use of veterinary radiotherapy is less common than in the states of Victoria and New South Wales (Munslow-Davies L. personal communication, 1998). In recent years, chemotherapy treatment has been used successfully for certain small animal tumours and it is important that cytotoxic drugs are used properly for cancer treatment. Veterinarians should be aware of the tumour that is being treated, type of drug used for treatment and the handling and disposal of potentially carcinogenic substances. Growth of neoplasms can be temporarily slowed by chemotherapy treatment, but resistance to the drugs used may develop rapidly.[174] Most of the drugs used for cancer treatment are potentially harmful to all tissues. Therefore, is important that disposable gloves be used during chemotherapy treatment.

In human medicine, x-ray machines for therapeutic purposes may be used only in specially designed buildings or rooms within hospitals or clinics under the immediate control of a radiation oncologist and supported by experienced physicists and radiotherapists. "Radiotherapy machines work at somewhat higher energies than diagnostic x-ray machines, usually of the order of from 3keV to several mega electron volts (1MeV=1000keV) and may produce electromagnetic radiation (ie x-rays) or accelerated particles such as electrons. The absorbed dose in the target tissue is necessarily large, however, some healthy tissues are invariably irradiated, and there is a small risk of inducing cancer in them. Radiotherapy departments operate with strict controls and working patterns which prevent unauthorised access to treatment rooms and limit the potential exposure of staff." ( Page 62)[38] In veterinary medicine, it is more difficult to follow such standards perhaps in university hospitals.

**Radiation Safety Officer (RSO)**

According to Radiation Safety Act (1975)[6] the registrant (usually the owner) must appoint a Radiation Safety Officer (RSO) with prior approval of the Radiological Council to be responsible for the safe use of ionising radiation in the premises where x-ray equipment, radioactive substances, lasers and/or transilluminators are used. The Radiation Safety Officer may be required to pass an examination in radiation safety conducted by or on behalf of the Radiological Council in accordance with the Radiation Safety Regulation (1980) or posses an approved qualification.[6]

The Radiation Safety Officer is required to implement all legislative requirements such as registration, working rules for the safe use of x-ray equipment and operation of radioactive substances, licensing, monitoring, recording of personnel doses, reporting, surveying and quality control checks. Even though, certain duties are assigned to the RSO, the liability of complying with the Act and the regulations remains the responsibility of the registrant. If the RSO fails to carry out the instructions of the registrant, he/she may be contravening the Act.[6]

In the UK, the Radiation Protection Supervisor, preferably a partner or senior member of veterinary staff, should ensure that the use of ionising radiation is carried out in accordance with the requirements of the regulations and also advise their veterinary staff on the use of radiation. Any person appointed to this position should hold a

Diploma in Veterinary Radiology with an interest in radiography or be a health physicist who has an interest in veterinary radiology.[171]

**Maintaining of radiation dose records**

In Australia, whenever a person is appointed to work with ionising radiation, the employer shall request all exposure dose records of that employee from the previous employer.[5] These records shall be available for inspection as and when required by the individual worker and the regulatory authority.

**Films and film processing**

The main goal in radiography is to produce a radiograph of diagnostic quality. The diagnostic value of x-ray films may be reduced in veterinary radiography because of film faults and errors in the dark room. Failure to provide sufficient time, space and equipment for the production of radiograph could make the film loose its diagnostic value.

It is important that the size of the room is adequate and not cramped so that processing chemicals will not contaminate the screens and films and help in maintaining strict cleanliness.[157,162] In Australia, proper facilities for film processing have to be considered. In addition, fast film and film-intensifying screen combinations compatible with acceptable image quality should be used. Attention has also been directed towards the use of appropriate safe lights, testing for light leakage, storage of unexposed films away from heat, chemical and radiation contamination, use of film on a first-in, first-out basis to prevent the build-up of old stock, replenishing processing solutions regularly and following correct procedures with respect to developing, fixing, washing and drying films.[5]

Use of proper equipment and correct procedures can reduce exposure times.[171] Inspection of veterinary practices in Western Australia have shown gross film underdevelopment. In one case, it was found that the processing solution had not been changed for several months and there was a mould or fungus on the surface of the solution. In another case, the developer solution was steaming due to excessive heating.[157] Time-temperature development as recommended by the manufacturer is essential. The solution used for film processing should be changed on a regular basis, the developer solution should be maintained in good condition and the waste chemicals should be disposed of according to the regulations laid down by the local water authority in each state of Australia. To minimise exposure times and produce good quality radiographs, processing tanks should be fitted with thermostatically controlled heaters and floating lids to reduce the oxidation rate of the developer.[157]

Poorly processed radiographs cost the same to produce as those of diagnostic quality, the former costing time, energy and resources and leading to increased exposure to radiation through repeat radiographs. Modern films and screens manufactured by reputable companies are of good quality and performance. Veterinarians use only very small quantities of films and chemicals compared with the medical profession and the choice of a particular brand of film often depends on the technical service provided by the manufacturer. It is important to match the manufacturers' recommended chemicals used for the film processing and to ensure that correct time-temperature development is followed (Wyburn RS. Personal communication, 1997; Jacob C. personal communication, 1999).

**Glutaraldehyde and its effects**

Glutaraldehyde came into widespread use in health care later than formaldehyde and is still used less in the industry than formaldehyde. There is less information available about its possible adverse effects. However, some effects have been identified.

It has been reported that 2% glutaraldehyde has caused dermatitis among workers in endoscopy units and among staff exposed to glutaraldehyde while processing films for x-ray purposes. These symptoms occurred despite current UK exposure limits of 0.2 ppm (10 minute short term exposure limit).[107,175,176]

Reported effects in the staff included watering of the eye, rhinitis, breathlessness and dermatitis. Exposure to glutaraldehyde also can cause occupational asthma.[100,175] Another study has described local irritation and non-specific symptoms such as nasal catarrah and obstruction, smarting of the throat, headache, and nausea occurring significantly and more frequently among health workers regularly exposed to glutaraldehyde.[175]

Glutaraldehyde causes Irritant effect to the respiratory tract and occasionally becomes severe to cause recurrent epistaxis (nose bleeds). Sensitisation effect may also be relevant in provoking dermatitis and asthma. Several cases of occupational asthma following exposure have been reported. The amount and nature of exposure required to cause this effect is unclear. However, very small dose, below the UK exposure limits, presumably sufficient to cause asthma in pre-sensitised subjects. No epidemiological evidence is available on the incidence of cancer in populations exposed to glutaraldehyde. Glutaraldehyde is less volatile than formaldehyde, the levels of exposure are lower than formaldehyde.[175]

There are no data on the possible environmental effect of glutaraldehyde outside the work place because the usage is less in the health care industry compared to formaldehyde. This chemical is potential for causing harm less than that of formaldehyde but this has not been proven.[38] In the US, the NIOSH Hazard Evaluation and Technical Assistance (HETA) branch has issued a number of Health Evaluation Reports on skin irritation in hospital workers exposed to glutaraldehyde.[69] In a study carried out in 1993 by the South Australian Occupational Health and Safety Commission, dermatitis of the hands, arms and/or face was diagnosed in a number of health care workers ( White C. personal communication, 1996).

Glutaraldehyde is commonly found in commercially available cold sterilising agents for medical, surgical, veterinary and dental equipment. Glutaraldehyde is also used as a tissue fixative in radiographic solutions and x-ray developer solutions. Sensitization to glutaraldehyde can occur, causing some persons to experience severe reactions to very small exposures.[100] Glutaraldehyde which is sometimes a component of radiographic film developer containing between 8 - 45% glutaraldehyde is added for softening and swelling the film emulsion and to reduce the possibility of mechanical damage to the film surface. Glutaraldehyde has an irritating effect on human tissues and the action is enhanced when heated or in the activated alkaline form. Exposure to glutaraldehyde over a long period of time has been reported as causing damage to vocal cords and loss of sensation in the mouth, throat and oesophagus.[177]

Material Safety Data Sheets (MSDS) are the primary sources of information for workers employed in the handling, use, storage and disposal of industrial chemicals, especially those which are classified as hazardous substances. Glutaraldehyde is a hazardous substance which is used in approximately 40 different products in Australia.

**Disposal of dark-room chemicals**

Staff working in the dark-room may also suffer adverse health effects from exposure to fumes released during processing of films. The processing fumes may cause health effects as a result from sensitisations to one or more chemicals contained in the fumes. All processing solutions used as developer should be heated to the correct temperature and stirred thoroughly before use. Film should be agitated to ensure even development and to remove air bubbles trapped on film surfaces which prevent development. After development, film should be drained and washed thoroughly in clean water before fixing. The developing solution should be discarded and replaced after three months because of reduced performance caused mainly by oxidation.[178]

Disposal of used dark-room chemicals is controlled in Western Australia by the water authority of Western Australia and regulations are laid down for industrial waste policy and photographic processing waste. It is a requirement in Western Australia, that a permit be obtained from the authority, to dispose of dark-room chemicals. When disposing of dark-room chemicals, silver bearing solutions should not be discharged into the sewerage without silver first being recovered, or else it has to be transported to a special collection site. Non-silver bearing solutions must pass through a dilution tank and acidic solutions must be neutralised. The industrial waste policy requires all veterinary practices to have a silver recovery unit or facility to transport off site any silver bearing solutions, dilution tank with a capacity of 50 litres, a facility to conduct pH testing, to carry out silver testing on a weekly basis, and to maintain a daily/weekly log book for testing waste chemicals to ensure maximum use of chemicals and to minimise wastage.[179]

Film faults due to poor dark-room technique are probably the most consistent problem in veterinary radiography, standardisation of the development process is relatively simple. A light proof room with running water should be available for effective film development.

**Ventilation in the dark-room**

To prevent build up of fumes in the dark-room, adequate ventilation should be provided and an air-conditioner or exhaust fan should run continually if, and when, glutaraldehyde is used as a radiographic film developer.[180] Though, there is mention in the NHMRC Code of Practice (1982)[5] or in other Australian regulations of ventilation in dark-rooms, in the UK, it is recommended that ventilation equipment in the dark-rooms including ducting, fan assemblies and filtration units should be designed and constructed to facilitate proper maintenance, cleaning and decontamination.[171]

## Conclusion

Veterinary practitioners and veterinarians in zoo practice come in contact with several potentially carcinogenic exposures in the course of their occupation. Of these, ionizing radiation from x-ray machines is of great concern to veterinarians. Over the years there has been much publicity about the ill-effects of radiation exposure, but persons who get exposed to radiation are still ignorant about the risks associated with radiation. No radiation dose is entirely free from risk and it is not sufficient merely to comply with a limit. As far as possible, doses below the limit should also be reduced. Diagnosis and treatment of certain animal diseases requires x-ray procedures and x-ray therapy and often a number of x-rays are taken to diagnose a disease condition of an animal. It is therefore important that veterinary practitioners should endeavour to avoid radiation exposures of themselves and their associates.

Primarily, proper x-ray generating equipment complying with the Australian Standard should be used to obtain radiographs of diagnostic quality with the least exposure to the veterinarian, the patient and others in the vicinity. Radiation safety begins with having proper x-ray equipment. When considering purchase of a new or upgrading of an existing equipment, preference should be given for the purchase of certified equipment. X-ray machines whether new or second hand must be evaluated annually, serviced and maintained. The x-ray generator must have accurate time and mA/kVp stations. There must be an automatic line compensation to guard against sudden drops or surges in electrical power to the unit. Servicing does not avoid radiation leakage, since all tubes tend to have some form of leakage. Faulty equipment and inadequate personal protection could cause unnecessary risk to veterinarians and staff.

Veterinarians and those who take part in manual restraint of animals during radiography should adhere to the safety standards in protecting themselves from radiation at all times. Manual restraint of animals should be done only when absolutely necessary. More importantly, lead lined barriers and/or lead impregnated plastic shields such as protective gloves and aprons should always be used and tested regularly by visual and x-ray methods. The design and construction of the x-ray room should provide a safe environment and ensure adequate radiation protection for all persons in the area. Safety signs, written safe operating procedures and safety policies should be displayed in appropriate areas.

The staff working with x-ray machines should have sufficient training and experience in radiological procedures, adhere to strict operating rules and regulations and monitor exposure levels. Proper training reduces the number of repeat/unnecessary radiographs and reduces radiation exposure. Proper collimation of the primary beam to the restricted area in order to isolate the area of concern will minimize exposure. The veterinarian working in a zoological garden and other veterinary practitioners using x-ray machines should maintain proper records of radiation doses, including multiple exposures of staff exposed to radiation, and should rotate x-ray duties amongst staff.

The NHMRC Code of Practice for the Safe Use of Ionizing Radiation (1982), Radiation Safety Acts and Radiation Safety Regulations are framed in order to minimize exposure to ionizing radiation. The Statutory Authorities in all states of Australia should inspect and monitor all veterinary premises and equipment in the zoological gardens and other private veterinary practices on a regular basis to ensure that they are complying with the NHMRC Code of Practice and Radiation Safety Acts. These preventive measures will enhance the safe use of ionizing radiation and create a safe and healthy working environment for all veterinary personnel and their associated staff.

# CHAPTER 6.

# DISEASE, INJURY AND ACCIDENTS AMONG ZOO AND PRACTISING VETERINARIANS

## Introduction

Veterinarians are at increased risk from many occupational hazards. A number of studies carried out overseas to asses the prevalence of exposure levels for occupational diseases among veterinarians have shown that veterinarians are subjected to trauma, radiation, zoonoses, drugs, vaccines, anaesthetic agents, pesticides, insecticides and allergens from animals.[1,9,10,12,15,17,18,29,45,81,181,182,] No comprehensive studies have been carried out on occupational hazards among veterinary practitioners in Australia other than the two studies carried out in Western Australia. Most of the information available in Australia is anecdotal. The two comprehensive studies carried out in Western Australia reported a range of physical injuries, chemical exposures, occupational zoonoses, allergic conditions, radiological hazards, stress and suicide prevalent among veterinary practitioners and their staff.[8]

Each zoological facility in the world differs in the make-up of its own animal collection. Selections of species for zoological gardens are made, considering the suitability of the new environment to which they have to adopt as the immediate surroundings and the management of captive wild animals have direct and important bearing on their well-being. Australian zoo collection comprises of native and exotic species including Australian fauna, birds, hoofstock, carnivores, primates, reptiles, amphibians and fish. The species held in the Calagary zoological gardens in Canada differs very much from that of the Australian zoo collection. The range of species in the Calagary zoo include invertebrates such as leaf cutter ants, peppermint shrimps, black widow spiders, salt water damsel fish, trout and coi; amphibians such as leopard frogs, tadpoles and crested toads; birds including endangered whooping cranes, water fowls and Eurasian eagle fowls; and mammals from Asian elephants to lowland gorillas, from pigmy lories to tree kangaroos and from fruit bats to moose.[183]

Veterinary career in a zoo environment is very challenging, as the veterinarians encounter numerous hazards when they work with wild species. They may be harmed at work due to injuries inflicted by animals; traumatic or venomous attacks that can result in fatality; radiation exposures and other work-related hazards. Climatic injuries from heat and cold are not common in Australia as in the US, the UK and Canada. Veterinarians and animal keepers in zoological gardens are an integral part of the animals' life in captivity and they establish mutually beneficial relationships with the animals, however, the natural behaviour of the captive animals remains unchanged. When compared with their counterparts treating domesticated animals, veterinarians and their associates in a zoo environment are subjected to a number of risks while handling and treating dangerous animals such as elephants, lions, tigers, snakes and rhinos.[183]

Many wildlife species are difficult to look after, capture, restrain and diagnose. Treatment of disease conditions in captive wild animals does not differ substantially from that of domesticated species except when the animals have to be restrained. Majority of zoo animals resent manual restraining and require the use of anaethesia or sedative during treatment and surgery. Specialist knowledge and years of experience have to be gained by veterinarians to treat the diversified species of wildlife in captivity. Therefore, zoo veterinarians also have to develop the expertise and gear to handle the clinical cases without contracting occupational hazards.[183]

To provide a satisfactory means of handling occupational injuries and to insure the workers from work-related hazards, workers' compensation laws were developed in the US in the 20th century. Before this law was enacted, an employer was responsible for an injury sustained by an employee in the workplace only if the employee could prove that the employer was negligent. By 1911, the first workers' compensation laws were enacted in the US and by 1980, 88% of all wage and salaried employees were covered under job injury laws. The laws provide coverage for personal injuries caused by accidents arising out of and in the course of employment.[184] Subsequently, the workers' compensation laws came into effect in Australia. Though workers' compensation records have provided some insight into occupational injuries among veterinary practitioners in Western Australia, these are limited to employees in veterinary practices. As self-employed practitioners are privately insured against injury and disease by dozens of insurance companies, it was very difficult to obtain accurate statistics.[8] The veterinary practitioners in zoological gardens in Australia are state government employees and are insured by state government insurance organizations. These employees are covered by an insurance award.

Veterinarians are exposed to a number of carcinogens during their career and the exposures include radiation, anaesthetic gases and pesticides. Veterinarians are at risk due to poorly maintained x-ray equipment, use of insecticides, and contact with carcinogenic zoonotic organisms. Few studies have suggested that veterinarians are also at increased mortality from lymphohaematopoietic cancer, melanoma, and possible colon cancer. Other occupational groups such as veterinary nurses, animal handlers, farmers, dentists, radiographers and anaesthetists may also be at risk from these exposures.[185] A study carried out by Hill et al., (1998)[1] among all members of the American Association of Zoo Veterinarians identified physical injuries, radiation exposure, adverse formaline exposure, animal allergies, zoonotic infections and insect allergies among zoo veterinarians. Female veterinarians reported a higher rate of zoonotic infection, insect allergy, and adverse exposure to anaesthetic gas, formaline and disinfectants/sterilants.

An epidemiological study of several professional groups of Dutch veterinarians found that 20% of the 102 veterinarians surveyed had changed their careers from being practitioners to non-practitioners because of work-related health problems. The nature of occupational hazards experienced by those veterinarians while working with swine, cattle, poultry and companion animals included allergies, lung infections, respiratory disorders and bronchial hyperreactivity.[45] Hafer et al., (1996)[11] in their study among swine veterinarians, identified the prevalence of several allergic conditions in the study group. Similar studies on allergies to individual species have still not been carried out in Australia.

**Physical injuries**

The wild animal species held in captivity in zoological gardens are dangerous and the severity of injuries inflicted can be serious in nature due to the unpredictable behaviour. The study by Hill et al., (1998)[1] among zoo veterinarians in the US reported significant findings including major animal-related injuries (61.5%), back injuries (55%) and necropsy injuries (44.1%). Gender, length of experience and practice type also affected the number and type of incidents encountered in practice. The study also found that zoo veterinarians with more years of experience were likely to sustain major animal-related injury and hospitalization with lost work time. Veterinarians working full-time in zoo practice for many years strained their backs causing musculoskeletal injuries ignoring the occupational safety regulation.

The study carried out among the veterinary practitioners in Western Australia[8] showed that physical injuries (71%) were the main cause of work days lost for veterinarians and their staff. The physical injuries reported were traumatic injuries, exposure to radiation, cuts from surgical instruments, substance abuse and motor vehicle accidents. The study found that 66% of the female staff of child-bearing age have taken x-rays in their practices and 50% of participants did not comply with the regulations on the use of protective gear.

A study among 25,386 male veterinarians from the 50 US States and the District of California on injuries sustained while handling large animals found that most injuries were sustained when stepped on or pawed by an animal. Veterinarians were bitten, kicked, gored, knocked down, trampled, run over or fallen upon by their patients during examination, treatment, restraint and or castration of animals. The major injuries sustained were strains, dislocations, bruising, contusions and fractures. During treatments, veterinarians cut themselves, slipped and fell on the ground, or hurt themselves while jumping off fences, with injuries to the legs, hands and head. Most veterinarians were injured in the afternoon than in the morning, which may be a reflection of lack of concentration rather than some other cause.[2]

A North Carolina survey among veterinarians in 1995 showed that, over 67.8% of the 701 veterinarians sustained a major animal-related injury in their career and 8.2% had been hospitalized.[10] According to a study conducted in Minnesota and Wisconsin,[9] 64.6% of practising veterinarians reported a major animal-related injury including dog bites (92.3%), bovine kicks (87.6%), cat bites (81%), cat scratches (72%), equine kicks (62.7%), equine bites (32.8%), and porcine bites (12.3%). The mechanism of injury varied. The most severe injuries reported by veterinarians were animal kicks (35.5%), bites (34%), crushes (11.7%), scratches (3.8%) and other causes such as patient pushing, goring, head butting, trampling and falling on the veterinarian (14.9%).

Another study[17] of Californian female veterinarians revealed that the major injuries were from animal bites, predominantly dogs and cats (17%), being struck by animals (6%), scratches mostly by cats and minor lacerations (3%). Large animal practitioners reported more injuries than the small animal practitioners. The study found that the year of graduation was not associated with the type of injury sustained by the female veterinarians.[17] A national survey of swine veterinarians in the US showed the highest reported physical injuries were due to needlestick (73%), pain from repetitious motion such as squatting, kneeling and bending over (51%), post-mortem (36%), back problems from lifting or moving animals (31%), hot or cold whether problems (30%), motor vehicle accidents (28%) and diagnosed hearing impairment (22%).[186]

An analysis of the AVMAGIT[3] records show that animal bites, animal handling, slips/trips/falls and zoonotic diseases were the main reasons for compensation claims amounting to more than US four million dollars annually in losses. Thirteen percent of injuries were due to animal-handling leading to hand and back strains, while 48% occurred as a consequence of lifting animals. Other reported injuries were slips and falls. Animal bites accounted for almost half of all claims, but represented only 16% of claim dollars with cat bites representing 54% of all bites.[3] A summary of these causes of injuries and diseases and the percentage of claims in US dollars are shown in Table 11.

**Table 11: Workers' compensation claims for injuries and illnesses sustained by veterinarians in the US**

| Causes of Injury | % of claims | % of claims Dollars (US) |
|---|---|---|
| Animal Handling | 13 | 28 |
| Slips / Trips / Falls | 9 | 23 |
| Animal Bites | 49 | 46 |
| Zoonotic Diseases | 12 | 12 |

Source: Smiths and Stilts JAVMA, Vol. 209, No.3 August, 1996.[3]

The survey among veterinary practitioners in Western Australia[8] showed that over a five year period between 1988-1992, two hundred and thirty-eight veterinary practices had paid a sum of $764,154 in premiums (Table 12), while the amount received in claims was only $36,778 for 38 veterinary practices (Table 13) over the same period. Several respondents in the study group commented on the disproportionate insurance premiums paid in respect of the injury rate reported and payouts.

**Table 12. Amount of premium paid to veterinary practitioners in the West Australian study**

| Year | Responses | Range ($) | Median Premium Paid ($) |
|---|---|---|---|
| 1988 | 31 | 158-7492 | 3206 |
| 1989 | 39 | 197-7343 | 3098 |
| 1990 | 49 | 147-9330 | 3066 |
| 1991 | 55 | 84-9617 | 3335 |
| 1992 | 64 | 32-9692 | 3286 |

**Table 13. Workers' compensation claims by veterinarians in the West Australian study**

| Year | No of claims | Total amount claimed ($) | Median Amount claimed ($) |
|---|---|---|---|
| 1988 | 3 | 4200 | 1840 |
| 1989 | 5 | 8387 | 1677 |
| 1990 | 12 | 12223 | 1619 |
| 1991 | 8 | 3087 | 386 |
| 1992 | 10 | 7561 | 756 |

**Injuries caused by equipment and instruments**

The sharp objects including needles, scalpels and other medical instruments can puncture the skin, cause injuries and could become potential source of infection to veterinarians in the zoo and private industry. In a study by Hill et al., (1998)[1] among zoo veterinarians in the US, 86% of participants reported one or more sticks and of these, 6.5% required treatment for needlestick injuries including adverse reactions to injected agents, infections and severe lacerations.

Accidental exposure to vaccines and pharmaceutical products is common in veterinary practices. While in the North Carolina study[10] veterinary practitioners reported needlestick exposures to rabies vaccine (27%) and brucella vaccine (6.7%), a study by Wiggins et al., (1989)[17] also reported that veterinarians experienced accidental exposure to rabies vaccine (6%), brucella vaccine (3%) and prostaglandin (24%). A study by Patterson et al., (1988)[43] reported that, of the 11% veterinarians exposed to Mycobacterium paratuberculosis bacterin, 2.5% reported an adverse reaction. Other vaccines which have caused illnesses for the veterinarians included aerosol vaccine against Newcastle Disease,[187] ovine-ecthyma vaccine,[188] infectious bursal disease vaccine and possibly feline-panelukopenia-calcivirus-rhinotracheitis-pneumonitis-vaccine.[189] In a study carried out in Britain 45% of veterinarians frequently reported injuries. Accidental self-injection with vaccines was the most common injury reported. Half the technical staff and two thirds of the veterinary staff reported an injury during their careers and of these, 70% were being serious enough to necessitate time off work.[59]

**Ionizing radiation**

There is considerable use of ionising radiation for diagnostic and therapeutic purposes both in veterinary practices and there is potential for persons involved in radiology to be exposed to radiological hazards.[5,55,150,171,190-196] Exposure to ionizing radiation during radiography may pass unnoticed due to lack of physical sensation and the delay in the onset of symptoms from any damaging effects. When animals are restrained for radiography, sometimes fingers, the whole hand and in a few instances, other portions of the person restraining an animal are visible on x-rays.[158,197-201]

A study carried out by Hill et al., (1998)[1] among zoo veterinarians in the US reported that 88.5% of the participants performed radiographic examinations and of those, 88.1% wore protective clothing such as lead shielding 90-100% of the time while 28.7% of the veterinarians who took x-rays wore film badges 20% of the time. Those who did not wear protective shielding were exposed to ionizing radiation during radiographic examinations. The study[1] also revealed that veterinarians are exposed to radioactive isotopes used for research activities or implants in cancer treatment. The radiation dosage received by a veterinarian in daily practice depends on the number of x-rays taken, the type of radiographs taken in a given period, the type of protective gear used during radiography, the procedure followed as well as the type of machine used and the machine settings. Using film badges during veterinary radiography will enable the veterinarian to estimate the average amount of exposure received in a given period. Veterinarians should reduce the time of exposure to radiation, distant themselves from the x-ray machine and use appropriate lead shielding to protect themselves from ionizing radiation.

A study among 29 Central Ohio Veterinary Practices in the US[150] showed that, although veterinary practices provided lead aprons and gloves as protection against radiation, the gloves were not always worn during x-rays. Only seven veterinary practices had ever tested the lead aprons and gloves for leaks and damages. Safety training was provided only in ten veterinary practices, while film badges for estimating radiation exposure levels were worn in 16 practices. Collimators to reduce scattered radiation were used in 29% of the practices. The researchers noted that the walls and doors were lead lined in the x-ray room in only two practices, while lead shields were available in only five practices.[150]

Work practice and hazard exposure among 457 female veterinarians of a major US veterinary school was assessed in 1985.[17] The study found that eighty-two percent of the participants reported potential exposure to ionizing radiation. Of these practitioners, 57% took x-rays fewer than five times per week and 21% took five to nine x-rays per week. X-ray exposure was most prevalent in small animal practitioners with 90% exposure as compared to large-animal practitioners with 77% exposure. Seventy-six percent of the participants physically restrained animals when taking x-rays one to four times per month. Of the 375 veterinarians who reported taking x-rays, 41% did not wear film badges. Also small animal practitioners restrained animals more frequently than large and mixed animal practitioners.[17]

Radiographic equipment used by veterinary practitioners is reported to be older than the machines used by medical practitioners and may lack features such as filters, collimators and fast film techniques which can help reduce exposure.[55,148,159] It is well accepted that, to avoid exposure to radiation, veterinarians and/or technicians should restrain their animal patients using anaesthesia or sedatives during radiography.[5,12,148,157,158,171] Many veterinarians have expressed concern about exposure to ionising radiation from diagnostic radiographic examinations and consequently taken some precautions when taking x-rays.[17,46,150,201]

The study among veterinary practitioners in Western Australia[8] had three questions on veterinarians' use of radiography. The study revealed that, 94% of the cohort spent up to 28 hours per week taking x-rays with a mean of three hours per week. Nine clinics did not use lead shields and diaphragms and thirty-nine clinics including ten large animal and three mixed animal practices did not use cassette holders while taking x-rays. Twenty-four percent of participants believed that radiation exposure is a major occupational health and safety issue.

Studies reveal that veterinary practitioners are not taking precautionary measures during x-ray procedures and the study among veterinary practitioners in Western Australia[8] reported that 63% of participants did not undertake any safety training subsequent to their veterinary undergraduate course. Training in all aspects of radiography is highly desirable for those who are involved in radiography. Training in practical radiography will help veterinarians to adopt safe practices that will minimize radiation risk to all persons involved.

**Anaesthetic gases**

The type of anaesthetic gases that are being used by health care and veterinary industries include nitrous oxide which is used as an analgesic and anaesthetic as well as volatile hydrocarbons such as halothane, enflurane, isoflurane, desflurane and sevoflurane which have replaced ether and chloroform.[38] Most veterinary practices have an anaesthetic equipment for delivering these agents to animal patients. The methoxyflurane which was commonly used is now infrequently used in veterinary practices. There is no permissible exposure limits for anaesthetic gases in Australia.

Exposures to anaesthetic gases occur in hospital based operating rooms, recovery rooms, dental clinics and veterinary facilities. It is estimated that more than 200,000 health care professionals including anaesthesiologists, nurse anaesthetists, dentists, veterinarians and their associated personnel are potentially exposed to waste anaesthetic gases and are at risk from occupational illnesses. Even though, there have been a significant improvement in the control of anaesthetic gas pollution, occupational exposure to waste anaesthetic gases still occurs.[38]

A study on 14 private veterinary practices was conducted to determine methoxyflurane concentration during surgical procedure.[32] The study found that four practices exceeded the maximum recommended concentration of 2 ppm. Nitrous oxide concentration determined in three operating rooms without the use of waste anaesthetic gas scavenging averaged 138 ppm. When the waste anaesthetic gas was scavenged, the nitrous oxide concentration went below the maximum recommended concentration of 25 ppm.[32] A study by Gardener et al., (1991)[202] confirms that adequate ventilation and gas scavenging should be employed and properly maintained to control waste anaesthetic gases. Effective exhaust system will reduce exposure to waste anaesthetic gases.

No anaesthetic machine is totally free from leakage.[203] Waste anaesthetic gases escape into the operating room from a number of sources including leaks from the tank valves, defects in tubing and hoses and from spillage when veterinarians and staff are filling the vaporizers. Leakage may also occur when the machine is left switched on without use or when the gas flow control valves are left open.[8,38] Veterinarians can also be exposed to waste anaesthetic gases from poorly fitting face masks, or improperly inflated tracheal tube and laryngeal masks.

The study by Hill et al., (1998)[1] among zoo veterinarians in the US showed that 48.7% of respondents in the survey had adverse exposure to inhalant anaesthetic agents including isoflurane, halothane and nitrous oxide and other hazardous substances. Several studies have reported significant number of spontaneous abortion in exposed female anaesthesiologists.[204,205-207] Exposure to anaesthetic agents including halothane may cause adverse pregnancy outcomes in health-care personnel. High levels of exposure to gaseous anaesthesia such as halothane has resulted in abortion and infertility among women.[53,202]

In Ontario, Canada, 45% of practising veterinarians were females. Even though, studies were carried out on the effects of occupational exposure to waste anaesthetic gases on the reproductive system, no prospective control studies were undertaken. The author reports that there were numerous data available on the effects of exposure to waste anaesthetic gases on pregnant women working in the medical facilities than those in the veterinary field.[78] A study by Schenker et al., (1990)[55] demonstrated that rates of spontaneous abortion and low birth weight infants were statistically similar among female veterinarians and lawyers. The level of waste anaesthetic gas in veterinary facilities depends primarily on the presence of gas scavenging systems, good anaesthetic practices, periodic examinations and maintenance of anaesthetic machines. The author reports that "the occupational exposure to waste anaesthetic gas is not associated with increased risk of major malformations. Risk of spontaneous abortion might be slightly increased. However, the risk can be reduced if not eliminated by good waste anaesthetic gas scavenging systems."[77]

Veterinary practitioners in Australia use both injectable and gaseous anaesthesia with the most common gaseous anaesthetic agents being halothane and methoxyflurane. In a study carried out among veterinary practitioners in Western Australia[8], the number of hours per week spent by veterinarians on gaseous and injectable anaethesia is summarised in Table 14. Other gaseous anaesthetic agents used in veterinary practice in Australia are nitrous oxide and enflurane. Halothane is much more toxic than other anaesthetic gases. In the Western Australian study,[8] gaseous anaesthetic exposure was identified to be a major health hazard with 21.8% of participants stating that halothane exposure causes headache and nausea. In the USA, there have been reports of similar effects on those exposed to halothane.[54,73,74]

A Californian study on female veterinary graduates showed that, of the 379 veterinarians exposed to anaesthetic gases, 27% did not use waste anaesthetic gas scavenging to decrease exposure, and 32% spent over 10 hours per week in areas where anaesthetic gases were used.[17]

**Table 14. Gaseous and injectable anaesthesia used by veterinary practices in Western Australia**

| Type of Anaesthesia | No of veterinarians | Median hours per week |
|---|---|---|
| Gaseous | 77 (88%) | 11 |
| Injectable | 84 (96%) | 9 |

Air monitoring can be used to evaluate workplace exposures. A study by Jeyaretnam et al., (2000)[8] among the veterinarians in Western

Australia found that air monitoring has not been undertaken in veterinary practices. The study by Hill et al., (1998)[1] among zoo veterinarians in the US showed that air monitoring for exposure levels were not conducted in 59.5% of zoo practices and 14.4% did not know whether air monitoring was done in their clinics. In the US, the OSHA recommends that air sampling for anaesthetic gases be conducted every six months to measure worker exposures and to check the effectiveness of control measures.

**Pesticides**

Pesticides also pose an element of risk in the veterinary work place and the pesticides used include pyrethrin, organophosphates, chlorinated hydrocarbons and carbamates. Entry into the body is by dermal, respiratory, oral and through cuts and abrasions.[17,208] Pyrethrins have been associated with cutaneous and respiratory allergic reactions but their systemic mammalian toxicity is relatively low. Organophosphate and carbamate toxicity is associated with acute central nervous system effects and cases of organophosphate toxicity have been already documented in veterinary and animal health care workers.[58,209] In a North Carolina study,[10] adverse symptoms to pesticides exposure were reported by 80 participants. Females showed a slight tendency to report more adverse symptoms than males (14.4% versus 10.1%). Veterinarians over 44 years of age were the least likely to report adverse symptoms.[10]

The study among veterinary practitioners in Western Australia[8] showed that 22% of veterinarians suffered from headaches, nausea and skin allergy due to the use of pesticides, organophospates (fenthion/malathion/asunthol), various types of flea spray and rinses. In a study carried out among zoo veterinarians in US,[1] 85% reported some form of contact with pesticides when working with animals. Of these individuals, 8% experienced an adverse reaction, with reported pyrethroid exposures resulting in six cases of skin and eight cases of respiratory reactions. Carbamates were associated with three skin reactions and three respiratory reactions. Organophosphates caused three skin reactions, four respiratory reactions and two episodes of nausea.[1]

Veterinarians and associated personnel may experience adverse effects from acute or chronic exposure to insecticides, but these effects have often been incorrectly attributed to other occupational exposures.[208,210,211] The reproductive capacity of a female veterinarian can be impaired by some toxic agents which modify the process of regulating hormonal levels. A number of reproductive functions such as onset of puberty, ovulation, menstrual cycle and implantation could be affected.[51] Veterinarians should take precautionary measures to prevent toxicological and legal problems arising from improper use of insecticides[211] and avoid repeated exposures to insecticides.

**Zoonoses**

Studies have found zoonotic diseases including brucellosis, tuberculosis, cryptococcosis, listeriosis, lymphocytic choriomeningitis, Q fever and toxoplasmosis to cause health problems to both male and female veterinarians with some of these diseases producing teratogenic or abortifacient effects. The two most common zoonoses to pregnant women are toxoplasmosis and listeriosis. The women are at risk from listeriosis and there are indications that listeria infection may be the primary cause of repeated spontaneous abortion. A study carried out in the UK and Ireland[212] between 1967 and 1994 reported ten cases of cutaneous listeriosis with papular and pustular lesions on the arms and hands of veterinarians and farmers. The infection was transmitted from the foetus or the cow after manual delivery or still births.[212] In the US, it is estimated that some 3000 infants are born each year with congenital toxoplamosis. The main risk to female veterinary personnel in small-animal practice is through contact with cat faeces. Approximately two- percent of perinatal mortality in the general population may be due to listeria infection. Large-animal practitioners are at a higher risk due to the preponderance of cases in sheep, goats and cattle.[46]

Zoonoses in Australia have been reviewed by Stephenson and Hughes (1988)[180] although, their review is not specific to veterinarians. Giesecke and Barton's serological survey[131] of Australian veterinarians revealed that in 1975, 14.1% of veterinarians had antibodies against bovine brucellosis.[131] However, in 1992, the percentage carrying positive serum agglutination test (SAT) titres was 52.7% with the highest prevalence of 87.5% in large-animal practitioners and 66.5% in laboratory diagnosticians and veterinarians in industry. In 1975, 0.9% of veterinarians demonstrated antibodies against leptospirosis which increased to 1.2% in 1976. In 1975, 28.7% of veterinarians showed evidence of exposure to Q fever, while in 1992, only 13.2% carried phase 1 and/or phase 2 antibodies. Sero positivity for toxoplasmosis was 16.2% in 1976, 41.7% in 1981, and 39% in 1982. Positive titres for chlamydiosis was 46.6% in 1981, 12.7% in 1982 and 7.1% in 1992.[131]

In Arizona, 11% of veterinarians had exposure to an animal transmitted disease,[213] while exposure to rabies was the most frequently reported zoonotic disease for livestock officials in the US.[214] Bites from animals do not pose a zoonotic risk of rabies for Australian veterinarians because Australia is free from that disease. While at one time brucellosis had been a hazard, it is no longer a problem in Australia because of its eradication through Brucellosis Tuberculosis Eradication Campaign (BTEC).[215] Other zoonotic infections may be transmitted to veterinarians from animal injuries and accidental self-injection.

Zoonotic infections which are common among veterinarians may frequently be serious and potentially fatal. The studies carried out in the US[59,216] showed that ring-worm (dermatophytic infection) has been reported by 24%-26% of veterinarians. A study by Caprilli et al., (1979)[217] reported that females were more likely to have ring-worms of the body which has been confirmed by Langley et al., (1995)[10] which showed 20.7% of respondents reporting a history of ring-worm infection with females more likely to have been infected.

The study among veterinary practitioners in Western Australia showed that zoonotic diseases such as toxoplasmosis, cryptococcosis, leptospirosis, psittacosis and chlamydiosis are major occupational health and safety issue. While eight percent of the veterinarians identified zoonotic disease as a potential risk for them and their staff, only four percent stated that zoonotic infections had occurred.[8]

A study carried out among the zoo veterinarians in the US[1] reported that, of the 265 respondents 17.7% had baseline serology taken when they began their career as zoo veterinarians. Of these, 6.4% reported a change from their baseline serologic titre. A change in serology at some point in their veterinary career was reported by twelve participants. Serum changes included seroconversions in *Shigella*, Lyme disease, hepatitis A and hepatitis B, high titre to callitrichid hepatitis virus and elevated *Leptospira sp.* titre. The majority of veterinarians in the study group (86.8%) did not know if their serum level had changed.[1]

A study by Hill et al,.(1998)[1] also showed that fifty-six percent (156/278) of the respondents had their meals closer to the animal enclosures while 47.5% had their meals in the laboratories. Twenty two percent of respondents in the study group did not have a designated area for their meals thus forcing them to have food around animals or in laboratories. The prevalence of poor hygiene practices and lack of dining facilities may have contributed to the incidence of zoonotic infections among zoo veterinarians.

A study by Atrenstein et al., (1991)[218] reported human infection with hepatitis B virus (simian herpes virus) as a consequence to a needle stick injury. Investigations on the prevalence of hepatitis B in the primates at the zoological gardens, Perth, Western Australia during the year 1994 found two species of gibbons infected with hepatitis B virus. Staff in the primate section at the zoological gardens were not immunized against hepatitis B during the time the virus was detected in the gibbons. The presence of this virus had significant implications for the staff as well as for animal transactions and for possible reintroduction of animals into the wild. Staff who had contact with primates were tested for Hepatitis B and found that none were positive (Controy J. personal communication, 2001). The Los-Angeles Zonoses Manual[125] has listed forty-two wildlife diseases that can be transmitted to humans some of which are listed in Table 15.

## Table 15. Zoonoses of wildlife

| Infectious agent | Primary host(s) | Diseases in animals | Diseases in people |
|---|---|---|---|
| Yellow fever virus | Nonhuman primates (mosquitoes) | No apparent disease; death | Yellow fever |
| Dengue viruses | Nonhuman primates (mosquitoes) | No apparent disease | Dengue fever |
| Japanese B encephalitis | Birds, pigs, horses, cattle (mosquitoes) | No apparent disease;domestic animals may die | Encephalitis |
| Tick-born encephalitis | Rodents, birds, goats, cattle (ticks) | No known apparent disease | Encephalitis |
| Rabies virus | Weasel-skunk, civet ferret, families with bats, foxes, skunks most important; also dogs, cats cattle | No apparent disease; death with paralysis | Excitation, paralysis, death |
| Chlamydia psittaci | Psittacine birds, pigeons, poultry | No apparent disease, death | Fever, cough, pneumonia |
| Coxiella burnetii | Wild ungulates | No apparent disease | Q fever |
| Brucella spp | Wild ungulates, dogs | No apparent disease; abortion | Brucellosis |
| Pseudomonas pseudomallei | Rats, mice, rabbits, ruminants, dogs, cats, nonhuman primates | No apparent disease; death | Pulmonary abscesses, septicaemia |
| Borrelia | Deer, mice, raccoons | Not known | Lyme disease |
| Trypanosoma brucei var Gambiense and var Rhodesiense | Wild ungulates (tsetse flies) | No apparent disease; death in coma | Meningoencephalitis |
| Trichinella spiralis | Wild carnivores, wild pigs | No known apparent disease | No apparent disease; muscle invasion death |
| Fasciola hepatica | Snails, fish, cattle, sheep, goats, camel, deer, rabbits | No apparent disease; death | Acute hepatitis, choleocystitis, cirrhosis |
| Schistosoma spp | Snails, rodents, baboons | No apparent disease; death | Colitis, hepatitis, cystitis |
| Dracunulus medinensis | Wild carnivores, nonhuman primates (water fleas) | No known apparent disease | Skin ulcers |

Source: Zoonoses, County of Los Angeles – Dept. of Health Services, Public Health Programs and Services – Disease Control Programs, Veterinary Public Health and Rabies Control, Zoonoses Manual Los Angeles.[125]

**Allergies**

Allergy to animals has been of increasing concern to veterinarians and others both in zoo and private practice. Veterinarians due to their profession are in close contact with animals in their day-to-day activities and are exposed to allergens of animal origin such as hair, dander, urinary proteins, blood proteins, and ectoparasites. Long and frequent contacts may increase the potential for the development of occupational allergic respiratory disease. No studies have described allergy to animals among zoo veterinary practitioners in Australia.

A recent study in Western Australia has revealed the prevalence of allergic conditions among veterinary practitioners.[8] Seventeen percent of the study group indicated that cat, dog, guinea pig, rabbit and deer hair contributed to allergies such as sneezing, hay fever, swollen face and eye and dermatitis which is confirmed in other studies.[1,10,45,104,219] Exposure to animal origin allergens such as ascarid worms, saliva, hair, fur, dander, urinary proteins, blood proteins, and ectoparasites have been identified as causing occupational allergic rhino-conjunctivitis and other respiratory problems.[96,104]

The study by Hill et al.,(1998)[1] among zoo veterinarians in the US has showed that 20.3% of veterinarians were allergic to at least one animal species including cats, dogs, horses, rabbits, cows and pigs. A study in Netherlands among veterinarians who had respiratory disease symptoms revealed that large animal practitioners were twice as likely to have chronic cough symptoms, chronic phlegm, production and asthmatic attacks. Those who worked for more than 20 hours per week with swine had a three-fold increase in chronic cough and phlegm production.[219]

A study among veterinarians in North Carolina by Langley et al., (1995)[10] showed one hundred and forty two (20.3%) participants were allergic to at least one species of animal. Allergies to various animals reported were: cats (16.6%), dogs (7.4%), horses (5.3%), rabbits (3.9%), cows (2.1%), hogs (1.1%) birds, gerbils, guinea pigs, rats, ferrets and camels (2.9%). The frequency of allergies reported due to animal contact was 26.1% among females and 17.6% among males. Females were more likely to be allergic to cats (22.5% versus 13.8%) and rabbits (6.3% versus 2.7%), no other allergic problems by gender were found for other species. A study carried out in the US among the two species of rabbits and rats in laboratory animals, found that these species are most frequently reported to have caused allergic reactions.[117] Cats were the most frequently reported species causing allergic symptoms among veterinarians in North Carolina,[10] while feline and birds have caused highest incidence of allergy to the zoo veterinarians in the US.[1]

The US study among zoo veterinarians[1] reported that 14.2% (39/275) of respondents were allergic to insects including bees, wasps, fire ants and fleas. Female veterinarians were more likely to report insect allergies. Veterinarians working full-time or part-time reported fewer insect allergies than those in other practice types. Veterinarians in zoo practices for 12-17 years reported more insect allergies than veterinarians with fewer or greater years of experience.[1] In the general population, males were more likely to report allergic reactions to insects.[220]

In two studies among veterinarians, five percent of respondents in each survey reported allergic or irritant reactions to latex gloves.[10,11] The study among zoo veterinarians in the US[1] found 12% to have reported skin reaction to latex gloves. Zoo veterinarians may be at higher risk for developing latex sensitisation. The reasons for the differences are not clear, but suggested causes include a higher frequency use of latex or contact with other latex containing material. The reaction to latex ranges from contact dermatitis, contact urticaria, rhino-conjunctivitis, asthma and anaphylaxis.[1]

Allergic symptoms vary among persons who become sensitised to animals. Serious reactions to an inhaled allergen may result in asthma symptoms including cough, chest tightness, wheezing, or shortness of breath. Mild reactions includes sneezing and runny nose. In sensitised persons, reactions often occur soon after the exposure to the animal product, but they may be delayed for two to eight hours or more.[100]

The results of a study carried out in Singapore zoological gardens on occupational asthma caused by handling an orangutan revealed that animal allergens causes asthma in animal handlers and veterinarians.[221] Occupational asthma among primate keepers has not been reported previously. The skin tests carried out on the 36-year old male animal handler in his first year of employment showed that he was sensitive to cats, dogs and birds. In the second year, the animal handler developed acute allergic reactions such as rhinitis, conjunctivitis and contact urticaria whenever he handled deer and other hoofed animals. In the seventh year, the handler developed cough, wheezing and dyspnoea while handling orangutans (Pongo pygmaes) and developed asthma attacks immediately after hugging and cuddling the animals. Symptoms persisted in spite of inhaled bronchodilator and steroid treatments. When stopped handling orangutans, the animal handler no longer experienced asthma. Again, when came in contact with orangutan, the animal handler developed dry cough, audible wheezing and shortness of breath.[221] A recent discussions the author had with veterinary practitioners, including two zoo veterinarians in Sri Lanka revealed that a majority of them (60%) experienced allergic conditions including sneezing, wheezing, cough, phlegm production and eye-nose-throat irritation while working in animal housing facilities. Animals to which the veterinarians were allergic included tigers, kudus, primates, cattle, dogs, cats, rabbits and poultry. The studies suggest that there is potential for veterinarians including zoo veterinarians and animal handlers to become allergic to certain species of animals.

**Dermatitis**

Dermatoses are considered to be allergic or toxic in nature. Occupational dermatitis is caused when the skin is exposed to irritant chemicals, allergens, antibiotics such as tylosin, penicillin, neomycin, streptomycin, penethamate, antiseptics and disinfectants.

Veterinarians experience occupational dermatitis due to a number of substances used in the practice. In a study, nine veterinarians were treated within a year for occupational dermatitis caused by spiramycin, tylosin, penicillin and its derivatives. The sensitisation was from exposure to substances while preparing injections and treating mastitis in cows.[61] In a patch test carried out among 26 veterinarians for occupational dermatitis, 15 were found positive to veterinary drugs, bovine tuberculin or disinfectants while some veterinarians were sensitive to antibiotics and procaine.[222] Allergic contact dermatitis was caused by common irritants such as organic solvents, acrylics, glues and chemicals derived from plants. Chemical irritants such as alkalis and chlorine or bromine-containing compounds caused dermatitis and even onycholysis.[223]

Film processing chemicals including phenidone, hydroquinone, sodium or potassium carbonate, sodium or potassium hydroxide, sodium bromide, sodium sulphite and glutaraldehyde may cause severe adverse reactions such as eye irritation, allergic contact dermatitis, headache and nausea in some individuals.[157]

**Stress and trauma**

Veterinarians in practice are subjected to a number of physical and mental labour and may have to experience high levels of stressful situations including complications due to overwork, under staff, malfunctioning equipments, demanding clients, animal deaths, interpersonal conflicts, high noise levels and loss of self-confidence. The veterinary practitioners in zoological gardens have to undertake various tasks which include ordering drugs and chemicals, carrying out dual role, overseeing the general running of the hospital, supervision of the operation, breeding and release of endangered species, quarantine operation and public relations. Heavy professional work and responsibilities in the face of situations in a zoo environment where available skills and knowledge may be inadequate and non-job responsibilities can cause considerable mental stress to the veterinarians. A study by Landercasper et.al, (1988)[9] report that fatigue at the conclusion of a long working day may lead to loss of usual caution for veterinarians in practice.

Stress has been associated with loss of appetite, ulcer, mental disorder, migraine, lack of sleep, emotional instability and maintaining relationship with co-workers. For pregnant women, mental stress and fatigue associated with pregnancy will cause occupational hazards. Veterinarians may be at increased risk of prescription drug abuse from easy access and ability to self-prescribe. Substance abuse is considered to be a major occupational health hazard among physicians and health professionals. Veterinarians are also at risk from similar occupational hazards.

A survey among New Zealand veterinarians[34] showed that, of the 970 respondents, 16% indicated that they considered committing suicide. Due to the inability to meet their demands and increased work load the participants experienced depression. The shortage of veterinarians in rural areas was due to unattractive lifestyle and better wages overseas. The findings of the survey revealed that, not only the younger and female veterinarians but also the rural veterinarians were mostly affected. However, there was no simple answer to reduce the shortage and alleviate occupational stress among veterinarians. This study led the veterinary bodies to find a quick and suitable solution in overcoming this problem.[34]

While there is some anecdotal information, no comprehensive studies on stress have been carried out among veterinarians in Australia. However, a study by Jeyaretnam et al., (2000)[8] among the veterinary practitioners in Western Australia revealed that suicide rates among veterinarians are believed to be quite high. Studies carried out in the USA show higher suicide rates among veterinarians when compared to the general population.[18,35]

There is little information available about the actual amount of substance abuse in veterinarians in the US and the UK. Presumably no comprehensive studies have still been undertaken in Australia on substance abuse. Drug abuse may be high, but at an unrecognised levels among Australian veterinarians and it is an area of concern. Work-related stress could cause serious impact on physical and mental health. Managing a veterinary clinic involves several after hours of work, financial pressure and staff-related problems. The rural veterinarians experience more stress than their urban counterparts due to a number of reasons mainly due to financial difficulties.

**Conclusion**

There is prevalence of occupational disease and injuries among veterinary practitioners which includes physical injuries and trauma, chemical hazards, radiation exposure, leukemia, Hodgkin's disease, cancers of the brain, colon and skin. Studies have also identified occupational injuries including abortion among female veterinarians. Veterinarians have experienced acute pesticide associated toxicity, occupational dermatoses and lesions in the blood of the central nerves system.

In US, only one study has been carried out amongst zoo veterinarians and two studies have been carried out among the veterinary practitioners in the state of Western Australia on physical including radiological, chemical and biological hazards. The studies have revealed that veterinarians have experienced occupational injuries and illnesses and there is a need for a comprehensive safety and industrial program for veterinarians in zoo and private practice.

## CHAPTER 7.

## SURVEY AMONG ZOO VETERINARIANS IN AUSTRALIA

### Introduction

Clinical and epidemiological studies have identified the prevalence of injuries and illnesses among veterinary practitioners in zoo, govemment and private industries. There is lack of information and a comparable data from overseas on disease, injury and accidents sustained by the veterinarians. So far, no comprehensive study has been undertaken on the prevalence of occupational hazards among zoo veterinarians and there is no information available on the number and magnitude of occupational hazards.

The proposed survey aimed to determine the major risk factors associated with the veterinary practices in zoological gardens and wildlife parks. A questionnaire was developed in consultation with Dr Milos Nedved, Associate Professor at Edith Cowan University; Dr Andrew Thompson, Professor at Murdoch University; Dr Thomas Spalding, senior practising veterinarian; Mr Ray de Groot, Radiation Physicist; Mr Colin Jacob, Radiation Health Officer and also with reference to the NHMRC Code of Practice for the Safe Use of Ionising Radiation in Veterinary Radiology (1982).[5] The questions were prepared taking into account the discussions I had with many other personnel who had experience in the health care, veterinary and in zoological environments.

This study will identify areas of occupational concerns and recommend appropriate intervention strategies to prevent and/or reduce occupational hazards for the veterinarians and non-veterinary staff in veterinary practices.

**Materials and Methods**

A self-administered questionnaire was used to investigate work-related disease, injury and accidents including radiation among zoo veterinary personnel. A 13 page questionnaire comprising of 58 questions was used as the main method of data collection. The questionnaire was pilot tested with two senior veterinarians and was mailed to 22 veterinarians in zoological gardens and five were mailed to wildlife parks in Australia. The list of the zoo practices was obtained from the Human Resource Section of Perth Zoological Gardens, Western Australia. Self-reporting techniques were used to determine the demographic characteristics of the profession and staff, and to obtain data on occupational hazards sustained by zoo veterinarians.

The questionnaire focused on the cause of disease, injury and perception of hazards in the practice, demographic aspects such as the number of staff employed, hours of work per week and percentage of representation of each species of animal in an yearly case load. Questions on physical injuries included major animal-related injuries, self-treatment, necropsy injuries, needlestick injuries and musculoskeletel injuries. The questions on radiological hazards included the type of x-ray machines used in the practice, number of x-rays taken, staff involved in radiography, use of protective gear and lead equivalence, restraint of animals, compliance with the NHMRC Code of Practice (1982)[5] and other safety issues. Chemical exposure included substances causing hazards, antineoplastics, Inhalant anaesthetic agents, formaline, disinfectants and sterilants. Biological hazards were on zoonotic diseases, allergies and other reactions such as animal allergy, latex allergy and safety issues.

Responses to the questionnaire were received from November 2000 through February 2001. A second questionnaire was mailed to the non-respondents followed-up by telephone calls. Twenty (74.1%) completed questionnaires from zoological gardens in Australia were returned. Three senior veterinarians were on leave and responses were received from the acting veterinarians. The two veterinarians who did not respond had been in service only for a short period of time and were not willing to participate in the survey. The directors/managers of the five wildlife parks who could not respond to the questionnaire informed that the animal species in their collection were treated by private veterinary practitioners located in close proximity to their wildlife parks and that no data was available to assess the prevalence of occupational injuries for the locum veterinarians.

There were no other studies which could provide information on the nature of occupational hazards and the preventive strategies that are in place in zoological gardens, the information obtained by me from scientific personnel, radiation as well as occupational health and safety specialists were of valuable assistance for this study. To compare the nature of injuries sustained by veterinarians in a developing country, information were collected from veterinarians in government, private and zoological garden environments as well as from health care personnel in Sri Lanka. The data collected from various sources were used in developing preventive strategies to minimize occupational hazards in zoo and other veterinary practices.

## Analysis

The data collected from the questionnaires were identified by a number, coded numerically and entered into a data bank using VAX software package. Simple frequency calculations were performed on responses to 58 questions on the demographic and occupational hazards to tabulate occupational injuries and to identify specific areas of concern.

The data on injuries and illnesses were categorized into six groups: demographics, physical injuries, radiological hazards, allergies, biological hazards and chemical hazards.

## Results of the Survey

The survey revealed that the zoological gardens in Australia employed 34 veterinarians comprising of twenty-two full-time, five part-time, five casual and two locum veterinarians. Questionnaires were only mailed to veterinarians who have completed two years of full-time service in zoological gardens. Of the 20 veterinarians who responded, 45% were females. They study also revealed that the veterinarians had been working an average of 59 hours per week. The zoological gardens employed 39 full-time and 23 part-time nurses; 14 full-time zoo keepers, 9 full-time clerical and 5 other full-time workers.

Of the practice type, 32% were birds, 22.3% were Australian fauna, 18.3% were hoofstock, 11.2% were primates, 11% were carnivores and 5.2% were mixed animals such as reptiles, herbivores, tree kangaroos, aquatic species and small mammals.

**Physical Hazards**

In this study, 60% of zoo veterinarians indicated that they sustained one to three physical injuries at their practices over a five-year period. The nature of injuries were crushes, bites and scratches with some injuries requiring medical treatment. Seventy percent of zoo veterinarians in the survey indicated that they have self-treated most injuries. In response to the question on whether the participants have been hospitalised for an animal-related injury, 15% indicated that they sustained fractures, kicks and bites which necessitated hospitalisation. Fifty percent of participants sustained back injuries due to lifting or moving animals or heavy objects within the past five years with five lost days from work. The study revealed that thirty percent of participants sustained injuries and infections while performing necropsies and the nature of the injuries were due to knife wounds. The study also reported 25% of the veterinarians have had work-related minor motor vehicle accidents.

Ninety percent of participants in the study group indicated that they sustained needlestick injuries 1-3 times (six respondents), 4-6 times (seven respondents), 7-9 times (one respondent) and 16+ times (four respondents) while injecting medicines, vaccines or while taking blood samples. The type of agents the respondents were exposed to as a result of needle-stick injury included animal blood (70%), antibiotics (70%), anaesthetics (40%) and vaccines (35%). One participant experienced a needle-stick injury while treating crab-eating macaque that was herpes B antibody positive, which required medical treatment.

## Radiology

The questionnaire also focused on radiological and other hazards prevalent in zoo veterinary practices. Participants were asked on the type of x-ray machines used and the problems encountered, number of x-rays taken, protective shielding, staff involved in radiology, restraint of animals, film processing and compliance with the NHMRC Code of Practice (1982)[5] in order to identify the risk factors associated with radiation and recommend intervention strategies to prevent or reduce radiation hazards.

*X-ray machines used in veterinary practice*

Two questions were asked on the type of x-ray machines used in veterinary practices in zoological gardens. The survey identified three types of x-ray machines were in use. These x-ray units comprising 9 portable, 11 mobile and 8 fixed machines were used by all the respondents (100%) in the study group.

Participants were asked the year of purchase of the x-ray machines in their practices in order to ascertain the length of time these machines have been in use, and the responses are summarized in Table 16.

**Table 16. The number and type of x-ray machines purchased between 1971 to 2001**

| Period of purchase | portable | mobile | fixed |
|---|---|---|---|
| 1971-1981 | 1 | 4 | 1 |
| 1982-1992 | - | - | - |
| 1993-2001 | 4 | 2 | 1 |
| unknown | 4 | 5 | 6 |

The survey revealed that the participants did not know the date of purchase for 54% of the x-ray machines of which some were second hand and 7% of the x-ray machines had never been serviced. This indicates that the use of old and second hand machines have been common in veterinary practices.

*Personnel involved in x-ray procedures*

The questionnaire requested information on veterinarians and non-veterinary staff taking x-rays. The survey revealed that eleven male and nine female veterinarians were involved in taking x-rays at their practices. Male and female veterinarians and staff taking x-rays are shown in Table 17.

**Table 17. Percentage of male and female veterinarians and staff taking x-rays in zoo veterinary practices**

| Male vets (%) | Female vets (%) | Male staff (%) | Female Staff (%) |
|---|---|---|---|
| - | 30 | - | 70 |
| 100 | - | - | - |
| - | 100 | - | - |
| 100 | - | - | - |
| 90 | - | - | 10 |
| 100 | - | - | - |
| 90 | - | - | 10 |
| 50 | - | 15 | 35 |
| 100 | - | - | - |
| - | 98 | 1 | 1 |
| - | 50 | - | 50 |
| 95 | - | - | 5 |
| - | 75 | 25 | - |
| - | 20 | 20 | 60 |
| - | 75 | 25 | - |
| 40 | - | 30 | 30 |
| - | 60 | - | 40 |
| 100 | - | - | - |
| 100 | - | - | - |
| - | 98 | 1 | 1 |

The zoo veterinary practices took an average of 10 x-rays per week. The breakdown of number of x-rays taken by the number of practices are shown in Table 18.

**Table 18. Number of zoo veterinary practices taking x-rays per week**

| No of practices | No of x-rays taken |
|---|---|
| 5(25%) | 1-5 |
| 10(50%) | 6-10 |
| 2(10%) | 12-15 |
| 2(10%) | 18-30 |
| 1( 5%) | 30-40 |

The questionnaire also requested information on female veterinarians and staff taking x-rays during pregnancy where they could have possibly received radiation doses. Only one of the nine female veterinarians and one of the eleven non-veterinary staff indicated that they took x-rays while they were pregnant. However, the stage of pregnancy was not noted.

*Protective gear used for radiology*

The responses received on protective gear used for taking x-rays by the zoo veterinary practices and the frequency of use are shown in Table 19.

The protective gear used by the staff in the zoo practice included lead gloves (55%), lead aprons (75%), personal monitor (60%), thyroid shields (50%), lead sleeves (20%) and protective glasses (15%). The frequency of use of protective gear by the staff was 5-100%.

**Table 19. Type of protective gear used for taking x-rays in zoo veterinary practices.**

| Type of protective Gear | Percentage and number of practices used | Frequency of use (%) |
|---|---|---|
| Lead gloves | 85% (17) | 10-100 |
| Lead aprons | 95% (19) | 10-100 |
| Protective glasses | 10% (2) | 5 -100 |
| Thyroid shields | 65% (13) | 5-100 |
| Personal monitor | 90% (18) | 20-100 |
| Lead sleeves | 35% (7) | 10-100 |

More than ninety percent of the veterinarians in the study group did not have knowledge of lead equivalence for lead aprons, lead gloves, lead sleeves and thyroid shields while none of the participants knew the lead equivalent thickness of personal monitor and protective glasses used during x-rays.

Participants were asked how frequently they checked personal protective equipment for potential x-ray leaks and the responses are shown in Table 20. Forty percent of participants did not respond to the frequency of checks carried out on protective gear.

The different methods used to check the personal protective equipment for damage is shown in Table 21. Sixty-five percent of the participants did not respond to the question on the methods used to check the protective gear.

**Table 20. Frequency of checks carried out on protective gear in zoo veterinary pracices**

| Frequency of checks | No of practices |
|---|---|
| Monthly | nil |
| Quarterly | nil |
| Six monthly | nil |
| Annually | 15% |
| Rarely | 15% |
| Never | 30% |
| Unknown | 40% |

**Table 21. Methods used to check protective gear in zoo veterinary practices**

| Method used | Respondents (%) |
|---|---|
| Visual | 3(15%) |
| Visual and radiographical | 2(10%) |
| Radiation laboratory | 1 (5%) |
| Never checied | 1 (5%) |
| Unknown | 13(65%) |

*Restraint of animals for radiography*

When asked to report on the frequency of use of sedative/tranquilliser, general anaesthesia and chemical restraint of animals compared with manual restraint while taking x-rays, the responses received are summarized in Table 22.

**Table 22. Restraint of animals for radiography by veterinarians**

| Use of sedative/ | | | | No of respondents | | |
|---|---|---|---|---|---|---|
| Tranquilliser | Never | Rarely | Some -times | Mostly | Always | No response |
| | 0% | 1-30% | 30-70% | 70-90% | 100% | |
| sedative tranquilliser | 0 | 35 | 10 | 10 | 5 | 35 |
| general anaesthesia | 0 | 0 | 5 | 70 | 25 | 0 |
| manual restraint(staff) | 5 | 60 | 5 | 0 | 0 | 30 |

When asked to report on the percentage of animals manually restrained for x-ray purposes, the survey revealed that sixty-five percent of veterinarians and 40% of nurses manually restrained up to 40% of animals for x-ray purposes. A zoo keeper also assisted in restraining animals during x-ray procedures. The survey revealed that 50% of veterinarians and 40% of staff received injuries such as bites, kicks and scratches while restraining animals for x-ray purposes.

*Availability of NHMRC Code of Practice (1982) and maintaining of log book and radiation dose records.*

The survey revealed that 15% of zoo veterinarians did not have a copy of the NHMRC Code of Practice (1982)[5] at their premises. Forty-five percent of respondents did not maintain a log book to record procedures and exposure factors (kVp, mA, exposure time, focus film distance) of all radiography undertaken. Radiation dose records of the veterinarians and the staff employed in veterinary practices were kept in the premises by 70% of veterinarians. Of these, 10% retained the records for 5 years, 20% for a number of years, 20% for 7-20 years and 20% for an unknown period. No responses were received from 30% of the participants.

*Film processing and use of glutaraldehyde*

Fifty percent of the respondents used manual method of film processing while 45% used automatic developers. One participant used both manual and automatic method while another participant indicated that the film processing was done at the local hospital by manual method. Glutaraldehyde was used by 10% of the participants for processing of x-ray films. Fifteen percent did not know the type of chemical used for film processing.

**Biological Hazards**

Allergens

The survey revealed that zoo veterinarians spent an average of four hours per day in an animal housing facility. Fifty-five percent of veterinarians experienced allergic reactions to animals due to working in enclosed animal housing facilities. The nature of allergies sustained were sneezing (55%), eye-nose-throat irritation (25%), wheezing (20%), skin irritation (25%), coughing (10%), phlegm productions (10%), headaches and other symptoms (20%). Twenty percent of the participants experienced animal allergies due to number of species including marsupials, equids, cervids, canids, felids including cheetahs and tigers, meercats and bovids including greater kudus and gazelles.

In this study, participants have not experienced an adverse reaction when applying topical medication, however, 20% of the participants have experienced allergic symptoms when using latex gloves.

Zoonotic diseases

In response to the question on zoonotic infection or disease acquired while handling zoo animals 40% of the veterinarians reported to have contacted ringworm, psittacosis, scabies and paronychial infection. Thirty percent of respondents reported to have undertaken a base line serum level test at the start of their employment at the zoological garden while 70% did not undertake base line serum level test. One participant who was vaccinated against diseases such as hepatitis A, B and rabies reported that the titres have increased for diseases the participant was vaccinated.

Vaccination

The study found that zoo veterinarians have been vaccinated against tetanus, hepatitis, measles, polio, rabies, typhoid, tuberculosis, Q fever and cholera and the responses are given in Table 23.

**Table 23. Number of zoo veterinarians immunised against diseases**

| Disease | Vaccinaion |
|---|---|
| Tetanus | 95% (19) |
| Hepatitis A & B | 80% (16) |
| Typhoid | 70% (14) |
| Measles | 85% (17) |
| Polio | 80% (16) |
| Rabies | 70% (14) |
| Q Fever | 15% (3) |
| Tuberculosis | 10% (2) |
| Cholera | 05% (1) |

Tuberculin tests have been undertaken by 70% of participants while 25% were not tested against tuberculosis.

**Chemical Hazards**

A number of chemicals were identified as causing health problems such as headache, lethargy, nausea, dizziness, sneezing, dermatitis, respiratory arrest and other respiratory problems as well as eye, nose and throat irritation. The substances causing problems as indicated by the respondents are shown in Table 24.

**Table 24. Percentage of zoo veterinarians experiencing health problems due to the use of chemicals and other agents.**

| Chemicals/Agents | Problems | Respondents |
| --- | --- | --- |
| Formaline | Nausea, dizziness, headache, sneezing, respiratory problems, eye-nose-throat irritation, headache and nausea | 70% |
| Isoflurane, halothane | Headache, lethargy, headache and nausea | 50% |
| Disinfectants such as chlorohexidine, iodine, glutaraldehyde chlorine bleach and dimethylsulfoxide | Dermatitis, headache and nausea, eye irritation, mouth irritation, headache and fumes | 30% |
| Dogs, cats, equids, cervids, bovids, marsupials, meercats greater kudus and gazelles | sneezing, wheezing, respiratory problems, phlegm production, skin irritation, eye-nose-throat irritation, dermatitis | 55% |
| Latex gloves, fibre glass resins | skin irritation, fumes | 25% |
| Other (avisafe, immobilon) | Dermatitis, headache, respiratory problem | 20% |

Participants identified the following substances used in zoo practices as hazardous: formaline, isoflurane, halothane, chlorohexidine, iodine, glutaraldehyde, dimethylsulfoxide, avisafe, and chlorine bleach.

Anaesthetics

On the use of inhalant anaesthetic agents, the study found that isoflurane had been used by all participants. Both Isoflurane and halothane have been used only by 15% of participants. One participant used isoflurane and sevoflurane. The study also found that veterinarians had spent almost ten hours on gaseous anaesthesia. The question pertaining to the use of injectable anaesthesia was not incorporated in the questionnaire.

Even though the study found 80% of the zoo practices do have in place a protocol/protection when using dangerous substances such as etorphine (Immobilon), fifteen percent of participants who did not respond indicated that they were unaware or have not had protocol/protection in place in their practices.

Pesticides

Seventy-five of participants have experienced adverse reaction including headache, nausea and skin allergy while using pesticides on animals.

Protective equipment

Protective equipment used while handling chemicals and anti-neoplastic drugs by the participants in the survey include gloves (60%), protective glasses (30%), lead aprons (10%), goggles (5%)

and facemasks (5%). It is commendable that one participant had used all protective gear including face mask. Thirty percent of participants did not respond to the question on the use of protective gear.

In response to the question on the percentage of time personal protective equipment was used by the participants, the study showed that the protective equipment was used 90-100% by 20% of participants, 60-79% by 40% of participants and 40-59% by 30% of participants.

Scavenging system

Ninety percent of participants reported that their clinics were equipped with a range of extractor fans or scavenging systems to extract waste anaesthetic gases and vapour. The types of scavenging units used in zoo practices included vacuum scavenger unit, hose fitted to the door opened to outside, scavenger hose attached to the anaesthetic system, connecting hose with one way valve, passive system to outside outlet and scavenging tube fitted through the window.

The study also indicated that the scavenging systems were always used by 75% of zoo veterinarians while 15% of participants used the scavenging system sometimes. Five percent of participants indicated that they did not use scavenging systems in their practices.

In this study, 95% of zoo veterinarians indicated exposure levels of hazardous chemical agents were not conducted in their clinics by air monitoring, while one participant did not respond to the question.

**Major animal-related incidents/accidents**

The participants in the study group were asked to identify the major accidents/incidents in their practice. Seventy-five percent of zoo veterinarians sustained a major animal-related injury in their practices. The nature of injuries included fracture, bruising, trauma during manual restrain, cut with scalpel blade while performing necropsy, back injury from heavy lifting of animals and objects, needle stick injury, animal attack and bite including snake bite and bite by red panda, crush, scratch and laceration. Other injuries were trampling by an animal, serious trauma/soft tissue injury with cut and suspected exposure for immobilon.

**Stress and trauma**

The survey revealed that 60% of zoo veterinarians experienced occupational stress and trauma during their career. The causes for such stress and trauma included mental anguish, lack of confidence in zoo therapy, low income, long hours of work, staff shortage, heavy workload, personality conflicts, inter-departmental conflicts, management problems, peoples' politics, inadequate support, insufficient resources, working under incompetent managers, animal deaths and zoonoses. Other issues such as lack of facilities for manual restraint, shortage of vehicles in the practice; inadequate training for zoo keepers; lack of communication among departments and veterinarians were also reported by the participants.

**Major occupational health and safety issues**

When asked to list major occupational health and safety issues in their practices, the nature of major health and safety issues nominated included physical injuries including radiation as well as chemical and biological hazards. Participants identified animal bites and scratches; injuries from lifting heavy animals and objects as well as injuries from sharp objects such as needles and instruments. They also experienced trauma associated with handling and restraining of animals, incorrect use of instruments and inadequate ergonomically designed equipments. Radiation exposure was also reported by the participants. Exposures to dangerous substances, drugs and immobilizing drugs; chemicals such as formaline and isoflurane vapour; disinfectants and exposure to blood were reported. The zoo veterinarians identified zoonotic diseases as a potential risk for themselves and their staff. The source of contracting zoonotic diseases were due to frequent handling of faeces particularly of non-human primates; postmortem exposure and infection from lyssa virus in bats.

## DISCUSSION

### Physical Hazards

*Animal-related injuries*

The findings of the survey among zoo veterinarians in Australia confirm other studies that report a high rate of occupational injury among veterinary professionals. Animal behaviour being unpredictable, renders the administration of drugs and vaccines to animals potentially hazardous to veterinarians and staff. Animal bites, scratches and crushes were the most common causes of injuries reported. The nature of injuries included crushed hand by a rhinocerous; bites by spider monkey, orangutan, crab eating macaque, possum, black-footed rock wallaby, kangaroo and cockatoo;

and scratch and bite by chudith. In the study carried out by Hill et al.,(1998)[1] among zoo veterinarians in the US, 61.5% of veterinarians sustained at least one major animal-related injury while, 75% of zoo veterinarians in Australia also reported a major animal-related injury during their career which included fracture, trauma during manual restrain, back injury, needlestick injury, animal attack by red panda and snake bites. The study carried out in Western Australia among veterinary practitioners[8] also showed that 71% of participants received 162 animal-related injuries over a 10 year period. Fifteen percent of zoo veterinarians in Australia were hospitalized for injuries including fracture of the tibia while restraining an ostrich, fracture of the jaw/comatose condition from a kick by a horse and monkey bite while 17.8% of zoo veterinarians in the study by Hill et al., (1998)[1] were hospitalized as a result of crocodile, cougar, fisher and snake bites. Surgery to repair severed nerves/tendons and broken bones, head injury from camel kick, crush injury and animal bites had also been reported in the US study. These results are consistent with a study in North Carolina by Langley et al., (1995)[10] which indicated that 67.8% veterinarians and a study by Landercasper et al., (1988)[9] which showed that 64.6% of veterinarians reported a major animal-related injury during their career. Table 25.

**Table 25. Animal-related injuries (%) reported by veterinarians in Australia and in the US**

| Australian zoo study, 2001 | Jeyaretnam et al.,[8] 2000 | Hill et al., 1998[1] | Langley et al., 1995[10] | Landercasper et.al., 1988[9] |
|---|---|---|---|---|
| 60.0% | 71.0% | 61.5% | 67.8% | 64.6% |

In contrast, the study among swine veterinarians[11] revealed that 12.5% received a major-animal related injury which may be due to treating one type of domesticated species.

Necropsy injuries have been reported by 30% of the Australian zoo veterinarians where as in the study by Hill et al., (1998)[1] in the US, 44.1% of respondents reported necropsy injuries. Majority of injuries in both studies were due to knife wounds. The study among swine veterinarians by Hafer et al., (1996)[11] also reported similar injuries (36%).

*Self-treatment*

The study revealed that self-treatment has been common among the zoo veterinarians in Australia with 70% self-treating their injuries. Eventhough self-treatment has been commonly reported among veterinarians in the US studies, the zoo study by Hill et al., (1998)[1] and the study among the veterinary practitioners in Western Australia[8] did not request information about self-treatment of injuries by veterinarians. In a more wide-ranging study in the US by Landercasper et al., (1988),[9] 77% of veterinarians self-treated their injuries including suture of lacerations (19.7%), reduction of fracture or dislocation (3.6%) and self-administration of antibiotics (67.5%). The incidence of self-treatment was high in Landercasper et al., (1988)[9] study as well as in the Australian zoo study. However, the study among zoo veterinarians in Australia did not request the nature of injuries self-treated by veterinarians. It is likely that Australian veterinarians would have similar treatment regimes to their US counterparts. This reflects that the veterinarians may not have confidence in the medical profession or the trivial nature of their disease or injuries support self-treatment. It is presumed that veterinarians have their own physicians, but for their convenience they self-treat their injuries. However, if a serious injury or infection occurs, the veterinary practitioner should seek medical treatment instead of self-treating his/her injuries.

*Needlestick Injuries*

Needlestick was the most frequent injury reported by veterinarians in Australia and in the US. Ninety percent of participants in the study among Australian zoo veterinarians have sustained needlestick injuries and were exposed to animal blood, antibiotics, anaesthetics, and vaccines. While the study by Hill et al., (1998)[1] among zoo veterinarians in the US revealed that 87% of veterinarians reported needlestick injuries, another study by Hafer et al., (1996)[11] also reported that 73% of swine veterinarians to have sustained needlestick injuries. Table 26.

**Table 26. Percentage of respondents exposed to specific agents from needlestick injuries**

| Exposure Agent | No of Veterinarians exposed (%) |
|---|---|
| Animal blood | 70 |
| Antibiotics | 70 |
| Anaesthetic | 40 |
| Vaccine | 35 |

*Musculoskeletal injuries*

Fifty percent of zoo veterinarians in Australia experienced back problems during the past five years which is consistent with studies by

Hill et al., (1998)[1] and Hafer et al., (1996),[11] which reported that over 50% of veterinary practitioners to have suffered back problems from repetitive activities involving lifting and moving animals during treatment. The study among West Australian veterinarians also reported incidence of back injuries from lifting of heavy animals.[8] The use of proper lifting techniques while lifting heavy animals, objects including furniture is advisable to reduce back injuries to the veterinarians.

Motor vehicle accidents also contributed towards occupational injury in the zoo veterinary profession. Motor vehicle accidents among zoo veterinarians in Australia is insignificant (25%) when compared with the Western Australian study among the veterinary practitioners.[8] In the West Australian study veterinarians working in multiple practices travelled extensively between practices and farms and had more motor vehicle accidents. The Australian zoo veterinarians may not be undertaking extensive work-related travel and evidence from the UK and the US suggest that frequency of work-related vehicle accidents is directly related to the distance driven.

**Radiological Hazards**

*X-ray machines used in zoo veterinary practices*

The survey revealed that 100% of the respondents in the zoological gardens and wild life parks in Australia used both new and second hand portable, mobile and/or fixed x-ray machines in their practices. Of the machines used, thirty-nine percent were mobile, thirty-two percent were portable and 29% were fixed x-ray machines. The study carried out among the veterinary practitioners in Western Australia by Jeyaretnam et al., (2003 in press)[224] also reported that 81% of the respondents used new or second-hand either portable, mobile or fixed x-ray machines. Portable machines were the most commonly used by the veterinarians in the study group in Western Australia because of their lower cost and easy transport which is necessary especially for rural practitioners. The x-ray machines used in the zoological gardens are not owned by the veterinarians and do not require to be transported away from the premises. The veterinary practitioners in the West Australian study were mostly small-animal practitioners and they used x-ray machines especially suitable for their practices. This confirms the study carried out by Dennis (1992)[159] which showed that portable machines formed the largest group of x-ray machines found in veterinary practices because of their low cost and multipurpose or diverse use.

Of the 28 x-ray machines used by the zoo veterinarians in this study, six machines had been used for 20 to 30 years and 25% were less than eight years old. It should be noted that veterinarians in zoo practice were not aware of the year of purchase of more than 50% of the machines. However, the participants in the West Australian survey knew the date of purchase of 80% of the machines.[224] The veterinarians in zoological gardens are employees of the Australian State Governments and the x-ray machines are owned by the respective zoological gardens, whereas the x-ray machines in veterinary practices in Australia are owned by private veterinary practitioners. The zoo veterinarians were unable to provide the date of purchase of the x-ray machines, presumably these machines were not purchased during their period of service. Discussions with the zoo veterinarians revealed that x-ray machines had been in the zoos for several years. The study by Hill et al., (1998)[1] amongst zoo veterinarians in the US did not indicate the type and year of purchase of the x-ray machines used in their practices.

Many zoological gardens had secondhand machines which could be unsafe unless they are properly maintained with regular servicing. X-ray machines should be monitored and serviced at least once a year. In Australia, the use of x-ray machines in veterinary practices for taking x-rays including dental are governed by the NHMRC Code of Practice for the safe Use of Ionising Radiation.[5] Plant, machinery or equipment should be designed, tested and installed or constructed to be free from avoidable risks to health and safety when not misused. In addition, any substance for use at work should be free from avoidable risks to health and safety when properly used.[180]

In Australia, all x-ray equipment used in veterinary practices should comply with Australian Standards controlled by the statutory authority in each Australian states which controls the quality of x-ray machines.

In the UK, the manufactures and suppliers of x-ray machines must ensure that the machines do not produce unnecessary ionizing radiation and operate satisfactorily. The x-ray equipment whether new or second hand should have light beam diaphragms, electronic timers and warning signals when purchased.[54] These machines should be serviced at least once a year.[171,225]

The NHMRC Code o Practice (1982) for the Safe Use of Ionising Radiation[5] has not indicated the frequency of checking and proper maintenance of x-ray machines which may lead to veterinarians overlooking this aspect. However, to reduce the chance of increasing unnecessary radiation dose to persons involved in the x-ray examinations, the statutory authority should make it mandatory for testing of x-ray machines to be carried out on a regular basis. It is important to ensure that a second hand machine is serviced, repaired, overhauled and brought up to current safety standards before purchase.[159] Veterinarians may have experienced ill-health and even mortality because of exposure to ionizing radiation as a result of faulty x-ray machines and inadequate protective gear.[154.] While the survey carried out among Western Australian veterinary practitioners[224] confirmed that faulty exposure switches, blown globes and poor exposure of the x-ray machines were the main problems encountered by the majority of veterinarians in the study group, the survey among the zoo veterinarians did not request information pertaining the problems with their x-ray machines.

In Australia, when problems are encountered in an x-ray machine, the veterinarians including those who are in zoo practice should consult a licensed technician to repair and fulfill safety standards. The NHMRC Code of Practice (1982)[5] is deficient in as much as does not state that x-ray machines are not to be used for taking x-rays when there are major problems in the x-ray machine.

Some radiation leakage from the x-ray tube assembly always occurs during exposures[5] and the owner of the practice should consult the statutory authority when an x-ray tube assembly requires servicing. In some cheaper x-ray units it is not possible to replace the tube when it ceases to function and therefore it is wiser to purchase a machine that can be serviced and repaired.[159] Replacement of a tube must only be carried out by persons licensed under Radiation Safety Acts for the purpose of diagnostic x-ray servicing and such persons should have specialized training in radiation safety. If there is a problem with the x-ray tube, the repair or replacement should be carried out promptly.

The Radiological Council of Western Australia has already introduced a routine compliance testing for all medical and dental x-ray equipment. Testing would be a pre-requisite for registration and the frequency of testing would depend on the type of x-ray unit. If mandatory testing is introduced, the work would be carried out by organizations authorized by the Radiological Council of Western Australia in accordance with the test procedures issued by the Council. Veterinary x-ray equipment would have to be tested for compliance according to the requirements of the relevant compliance testing work book in each state and territory of Australia (Jacob c. Personal communication, 1999).

*Safety assessment of x-ray machines*

It is a requirement that the veterinary surgeon in charge of zoo or private veterinary practice should consult the statutory authority regarding appropriate safety assessments of their practices. Assessment should occur under the following circumstances: (a) Prior to the installation of the x-ray machine, (b) if a modification is made in the x-ray machine or location, (c) if the personnel monitor is faulty indicating that the doses received by any person exceeds or is likely to exceed the safe limit, (d) if any modifications are made in the building where the x-ray machine is installed, (e) if there is an increased workload in the practice, (f) or if an x-ray tube assembly requires servicing. The veterinary practitioner should inform the statutory authority if any person involved with ionizing radiation is over exposed.[5]

Inspection of x-ray machines in veterinary practices should be carried out on an annual basis to ensure quality assurance of radiological procedures. The veterinarian in charge of the premises should contact the Radiation Health Section of the Health Department if, and when, a problem arises with an x-ray machine. Inspection should be done only by the Regulatory Authorities who may quote from recommendations in NHMRC Code, and may require adherence to the Code as a condition of their licensing and registration procedures. (de Groot R. personal communication, 1999).

*Personnel involved in taking x-rays*

In Australia, it is a requirement that x-rays be taken only when necessary and without unnecessary exposure of x-ray beams to personnel. In order to minimize radiation dose to staff, all precautionary methods should be taken to avoid repeat radiographs. In the US, it is a requirement that all radiation procedures should be carried out with doses as low as can reasonably be achieved (ALARA Principle) a concept first proposed by the International Commission on Radiological Protection and presently followed in Australia.

The survey among the zoo veterinarians in Australia indicated that mainly veterinarians were taking x-rays in their practices (84%). However, 65% of practices had non-veterinary staff taking more than 15% of all x-rays. This confirms a study conducted among veterinary practitioners in Western Australia[224] which reported that 77% of veterinarians and non-veterinary staff in six practices were taking more than 50% of x-rays in the clinics. Even though the percentage of staff taking x-rays is low in both studies, there is still concern that if safety precautions are not being taken or the equipment is faulty, then these staff, most of whom are females, are getting unnecessarily exposed to radiation.

Even though, only an average of 10 x-rays per week were taken by the zoo practices in the study group, one practice took 30-40 x-rays per week whereas the study among the veterinary practitioners in Western Australia[224] reported that a majority of practices took an average of 13 x-rays per week with two practices taking 120 and 200 x-rays respectively per week. In both studies, the majority of practices required two x-rays per patient and 22% of practices in Western Australian study[224] averaged between three and six x-rays. Allowing for one dorso-ventral and one lateral view for diagnostic purposes, most situations would mean two x-rays per patient. However, it is likely that there are a number of causes for poor x-rays such as scatter radiation, lack of collimation, improper equipment , techniques and procedures. It is important to reduce the number of unnecessary radiographs by obtaining x-rays of diagnostic quality to ensure minimal exposure to all personnel.

*Women and radiation*

The study among zoo veterinarians in Australia noted that 40% of female veterinarians and a number of female staff of child-bearing age were taking x-rays while in the West Australian study,[224] among veterinary practitioners 66% of female staff of child bearing age took x-rays. The study also found that one female veterinarian and one associated personnel could have received radiation dose during pregnancy. However, the questionnaire did not request information on the stage of pregnancy for female veterinarians and staff taking x-rays where they could have possibly received radiation doses. In both, zoo and West Australian studies, it was not possible to determine the radiation exposure levels because all the veterinarians in these study groups were not wearing monitoring badges and those who wore, did not wear them all the time. The study by Wiggins et al.,(1989)[17] indicated that a large proportion of veterinarians in the study group did not wear film badges. According to the Radiation Safety Manual[226] film badges used for personal dosimetry are replaced by the thermoluminescent (TLD) badges. They are distributed by the

Australian Radiation Laboratory. The dosimeter (TLD) is a device which allows much faster evaluation than the film badge, with a lower threshold. TL dosimeters may be used in the form of a body badge similar to a film badge.[226]

The Radiation Safety Act amended in 1995[227] on the dose limits and maximum permissible exposure levels, states that the effective dose limit for radiation workers is 100 mSv averaged over a five year period with a maximum of up to 50 mSv in one year. The effective dose limits for persons other than radiation workers is 5 mSv over a year with an effective dose of 250 microsieverts per week. The external radiation exposure dose limits for a pregnant radiation worker is 2 mSv for the remainder of her pregnancy and for internal radiation exposure, 1/20$^{th}$ of the Annual Limit of Intake (ALI)[227]

In the UK, it is possible for all staff involved in x-ray procedures to avoid receiving a dose greater than 10 mSv per year. However, additional dose limits which apply to women of reproductive capacity, and to pregnant women, are observed.[171]

Radiation exposure places all veterinarians, especially women at risk. It has been noted that veterinary female professionals may experience an increased rate of spontaneous abortion when exposed to radiation.[158] Studies have revealed that exposure to ionizing radiation can cause increased rate of abortion and foetal deaths. Veterinarians and their associates should be aware of the potential reproductive hazards and take appropriate preventive measures.

*Protective gear used for radiology*

Personal protective gear such as gloves, aprons and shields suitable for hands and forearms made of lead impregnated rubber or plastic should be provided for staff involved in radiographic procedures, and to others not protected by fixed or mobile screens.[5]

The zoo survey showed that the Australian veterinarians used lead aprons (95%), personal monitor (90%) and lead gloves (85%). The frequency of use of lead aprons and lead gloves ranged from 10%-100% while the frequency of use of personal monitor was from 20%-100%. Thyroid shields were used by 65%, lead sleeves by 35% and protective glasses by 10% of participants. Some participants in the study group wore lead aprons, gloves, thyroid shields, lead sleeves and protective glasses part of the time. The survey also revealed that 75% of the non-veterinary staff in zoo practice used lead aprons, while lead gloves were used by 55%, personal monitor by 60% and lead sleeves by 20% while taking x-rays. The frequency of use of protective gear by the staff was 5-100%. The study among West Australian veterinarians[224] also showed that only 5% of participants used lead aprons and 21 practices used lead gloves. Both studies indicate that many veterinarians did not comply with the regulations on the use of protective gear during x-ray procedures. Use of thyroid shields and protective glasses is laudable and perhaps should be considered by others, although the NHMRC Code of Practice (1982)[5] does not specify the use of these protective gear. The study by Wiggins et al., (1989)[17] reported that, of the 375 veterinarians, 41% did not wear film badges while taking x-rays. Approximately 70% of the 222 veterinary practitioners who wore film badges knew the results of their film badge reading. Practice type, however, was predictive with large-animal practitioners being the least likely to wear film badges.

It was noted that more than 90% of participants in the study among zoo veterinarians were unaware of the lead equivalent thickness of the protective gear. This confirms the study among the veterinary practitioners in Western Australia[224] in which a majority of veterinarians did not have knowledge of lead equivalence for lead aprons, lead gloves and other protective gear used for radiography in their practices. It is not known whether the protective gear used in the practices provided satisfactory shielding against ionizing radiation for those taking x-rays and others participating in this exercise.

Veterinarians and staff may be exposed to radiation while holding an animal in the direct x-ray beam and therefore, they should avoid the primary beam. In Western Australia, approximately nine x-rays referred from veterinary practitioners had human hands, fingers and forearms on the films (Wyburn RS. Personal communication, 1997). Scattered radiation may not be a major problem because its intensity gets reduced as it passes through the lead gloves and lead aprons.[228] All radiation, primary or scattered, is reduced as it passes through the lead shield, but the scattered radiation is less of a problem because the intensity before entering the shield is about 0.1% of the primary beam at 1 m ( Jacob C. personal communication, 1999).

The protective devices used during radiography have to be examined both visually and radiographically to ensure their shielding efficiency. The zoo survey in Australia revealed that 30% of respondents never checked the effectiveness of their protective gear while forty percent did not respond. Sixty-five percent of zoo veterinarians failed to respond to the question on the methods used to check protective gear while only 25% used visual and radiographical methods to check their protective gear. The study among the veterinary practitioners in Western Australia[224] also revealed nearly 52% of respondents never checked their protective gear for its effectiveness. It is important that regular checks be carried out on all protective devices by examining visually and radiographically (eg. three monthly for a practice with a heavy x-ray workload) to ensure their shielding efficiency, as the devices become impaired by cracks due to sharp folds, penetrations caused by claws, or other damages. To avoid cracks and damages, aprons should be hung on appropriate hangers while not in use.[5] Inspections among veterinary practitioners in Western Australia have shown that shielding devices are often damaged or cracked and have lost the protective value.[224] It is therefore necessary that the protective gear is checked routinely and replaced with new shielding devices if the protective value is lost.[157]

Veterinarians and their associates in private and zoo practices should attend training courses and orientation sessions to become familiar with the importance of the use of all personal protective gear. This includes use of protective devices during radiography and handling the gear after use, as well as methods and frequency of checking to ensure shielding efficiency is not impaired from cracks and damages. The Act could be amended to specify the need for training courses.

*Restraint of animals for radiography*

Manual restraint is permissible only under exceptional circumstances and as far as possible animals should be restrained by tranquilisation or by anaesthesia. It is important to use protective devices during manual restraint and ancillary devices to support animals during radiography. Children and pregnant women should not be permitted to restraint animals while x-rays are taken and a notice to this effect should be displayed in the x-ray area. No one person should be allowed to restrain animals repeatedly for radiographic purposes.[5]

In Australia, use of cassette holders has been made mandatory for all horizontal beam radiography, although veterinarians have been reluctant to use cassette holders as it is easier to ask another staff member to hold the cassette.

The survey conducted among the zoo veterinarians in Australia showed that 65% of the veterinarians and 40% of nurses manually restrained up to 40% of their animal patients during radiography. Zoo keeping staff also assisted veterinarians in restraining animals for x-ray purposes. Restraining of animals manually by veterinarians, nurses and keeping staff in the zoo study in Australia is consistent with the West Australian study among the veterinary practitioners[224] which reported that owners of animals and staff, including veterinarians, nurses, stable hands and work experience students manually restrained animals for x-rays and that about one third of the 108 respondents manually restrained up to 100% of their patients for x-rays. This is a matter of concern because some veterinarians and staff in the study among the zoo veterinarians in Australia and the veterinary practitioners in the West Australian study did not use protective gear and badges and may have been exposed to high levels of ionizing radiation with the direct beam.

The ultimate responsibility for ensuring safety from exposure to ionizing radiation lies with the veterinarians in charge of the practice. The veterinarian is responsible for appointing radiation workers in the practice including veterinary surgeons and veterinary nurses who will be directly involved in taking x-rays, and others who may be exposed to ionizing radiation during radiographic and radio therapeutic procedures.[5]

*Availability of NHMRC Code of Practice (1982)*

The National Health and Medical Research Council (NHMRC) Code of Practice for the safe Use of Ionizing Radiation in Veterinary Radiology (1982)[5] is prepared by the National Health and Medical Research Council based on the recommendations of the International Commission on Radiological Protection. The Code is implemented by the appropriate statutory authority in each state and territory in Australia.

The NHMRC Code of Practice (1982)[5] is the best guide for veterinarians with regard to operating x-ray machines, use of protective gear and staff protection from ionizing radiation as the Code has incorporated certain requirements for compliance which includes the use of proper x-ray equipment with adequate checking and maintenance, installation of equipment in a suitable premises, use of appropriate protective devices and ancillary equipment, as well as providing all safety procedures and radiation monitoring. These measures ensure that exposure to persons involved in x-ray procedures are minimized.

Fifteen percent of the respondents in the study among zoo veterinarians in Australia did not have a copy of the 'Code of Practice' at their premises which indicates that these practices may not be familiar with, and do not refer to comply with, the guidelines laid down in the Code. A West Australian study among veterinary practitioners[224] revealed that 30% of the respondents did not have a copy of the Code in their veterinary facilities. A copy of the Code is usually given to all licensed applicants and it is vital that all zoo veterinary practices keep a copy of the NHMRC Code of Practice (1982)[5] for compliance. To minimize exposure to radiation by veterinarians and staff, the owner of the practice could draw up suitable guidelines for the practice based on the Code.

*Maintaining log book and radiation dose records*

Employers should maintain staff dose records and these records must be made available to employees on request and passed on to future employers. As required by the regulatory authority in Australia, the radiation dose records of all employees should be maintained by the employer till the death of an employee.[5]

Thirty percent of the participants in the study group failed to respond to the question on whether they maintained radiation dose records at their zoo veterinary practices and 45% did not maintain a log book to record radiation exposure factors and procedures. The survey revealed that only 10% of the veterinarians retained the radiation dose records for 5 years, while 20% retained the records for up to 20 years, and 35% indicated that the dose records were retained for a number of years, indefinitely or for an unknown period. This confirms the survey carried out among veterinary practitioners in Western Australia[224] which showed that 54% of participants did not respond to the question on maintaining radiation dose records. Those who failed to respond to the question in both studies, may not have any records in their premises. None of the veterinarians in the survey among zoo veterinarians have indicated that they maintained the dose records until the death of an employee and this means that the veterinary practices have not been complying with the Radiation Safety Acts in their states and territories of Australia.

*Methods of film processing*

The use of fixed temperature and fixed time for manual processing of films are recommended. When an automatic film processor is used, these parameters will be controlled. Improper techniques for processing films, will result in a poor quality radiographs and this could lead to taking additional x-rays resulting in an unnecessary increase in radiation.[5]

Both manual and automatic film processing have their advantages and disadvantages. Manual processing is cheaper to set up, has some degree of flexibility for the operator, is simple to maintain and rarely requires major maintenance. Automatic film processing is quicker than manual processing, takes longer to learn and the chemicals have to be maintained regularly. Even though, manual processing has certain disadvantages, when correctly practiced, it can provide veterinarians with excellent and inexpensive radiographs.[157]

The survey among the zoo veterinarians in Australia revealed that 55% of participants used manual method of film processing while 45% used automatic developers. A survey carried out in Western Australia[224] found that 73% of the 112 participants used manual processing of films while the remainder used automatic methods of film processing. Though, both manual and automatic methods of film processing are used in veterinary radiography, the choice rests with the veterinarian in charge of the practice, who should ensure correct handling.

It is important to emphasize the dangers involved while handling film processing chemicals. Film faults are a major problem in the dark room during manual processing which may lead to x-rays having to be repeated thereby causing unnecessary exposure to radiation. It is important that x-ray developer is of the highest standard.[157]

*Use of glutaraldehyde for film processing*

The procedures and practices laid down by the manufactures of developing solutions should match for the type of film used.[157] Fifteen percent of the participants in the study among zoo veterinarians in Australia did not know the type of chemical used for film processing while, 10% used gluataraldehyde for film processing. A study among the West Australian veterinary practitioners[224] also revealed that 25% of the participants used glutaraldehyde for film processing. The chemical components used in processing x-ray films are known for their hazardous nature. Even though, it has been known for a number of years that some people have severe adverse reactions to glutaraldehyde fumes, the effects of these fumes are not fully understood.[157]

Gluataraldehyde can cause adverse reactions such as watering of the eyes, rhinitis, breathlessness and dermatitis. While using glutaraldehyde for film processing, appropriate protective equipment, adequate ventilation and appropriate work practices are required to prevent any inhalation of, or skin contact with this chemical. Gluataraldehyde should only be used by trained staff and training should be provided on emergencies and first-aid procedures. Information such as a MSDS should be provided on possible health hazards of this chemical.[180]

Glutaraldehyde has been found to cause several side effects during film processing. The sources of exposure identified in the use of glutaraldehyde in film processing include manual preparation of processing chemicals, transfer of chemicals in and out of chemical tanks and processors, emission of vapours from open tanks and leaking mixers, exhaust from automatic processors, emptying of tanks, drying of x-ray films, cleaning of processors, rollers and tanks.[107,157] The Australian Code of Practice (1982)[5] should be strengthened to incorporate preventive guidelines for those involved in film-processing.

Concentrations of chemicals will change when a number of films are processed and when the solution is kept for a longer period. Therefore, the developing solutions need to be replaced regularly and the manufacturers of developing solution should provide guidelines on the frequency of change of this chemical.[5] Developing solutions used in processing films should be replaced at least once every 6 weeks as its performance is reduced mainly through oxidation. To maintain the full strength of the solution, it should be tightly covered.[157]

**Biological Hazards**

*Allergens*

Allergy to animals as a result of workplace exposure has not been described for specific animal-related occupations except for the animal workers working with laboratory animals and sensitive to animals which is recognized as a major occupational hazard. The workplace exposure to allergens of animal origins and ectoparasites conceivably increases potential for the development of allergic respiratory disease.

Zoo veterinarians in Australia spent an average of four hours per day in animal housing facilities while 20% of participants in the study group reported allergies due to exposure to different species such as felids, canids, equids, cevids, marsupials, meercats and bovids. Due to working with animals in animal enclosures, veterinarians experienced animal allergy such as sneezing, eye-nose-throat irritation, wheezing, skin irritation and headaches. This confirms the study carried out by Hill et al., (1998)[1] in the US which reported that zoo veterinarians experienced similar allergic reactions such as sneezing (26.5%) and eye-nose-throat irritation (25.8%). Australian zoo veterinarians reported the highest incidence of animal allergy to felines and birds. In the study among veterinary practitioners in Western Australia[8] one-sixth of the study group indicated that cat, dog, guinea pig, rabbit and deer hair contributed to allergies such as sneezing, hay fever, swollen face, swollen eyes and dermatitis which is confirmed in other studies.[10,45,104,219] Allergic reactions reported from coss-sectional studies include rhinitis, conjunctivitis, sneezing, wheezing, asthma and rarely anaphylaxis.[11,111,115-117] The swine veterinarians in Hafer et.al., (1996)[11] study reported that 95% of participants experienced respiratory problems due to working in swine housing facilities.

Animal allergy observed among zoo veterinarians in Australia when compared with most other values shows that a higher prevalence of animal allergy exists among zoo veterinarians. This may be due to a wide variety of species they treat and the number of hours they spent in animal housing facilities. It is necessary that veterinarians and non-veterinary personnel working in animal housing facilities should use adequate personal protective equipment and undertake necessary training to protect themselves and others from exposure to animal allergies.

Allergic reaction to latex gloves has also been reported by the zoo veterinarians (20%) in Australia. Earlier studies among practising veterinarians have found that some veterinarians are sensitive to latex gloves and powder within the gloves.[106] The swine veterinarians in

Hafer et al., (1996)[11] study and veterinarians in Langley et al., (1995)[10] study reported only five percent of participants experienced allergic or irritant reaction to latex. However, the study among zoo veterinarians in the US found that 12% of veterinarians showed skin reaction to latex gloves.[1] Frequent use of latex gloves by the veterinarians suggests that allergic condition is higher among zoo veterinary practitioners. It is recommended that veterinarians who are allergic to latex gloves should use non-latex or cotton lined gloves.

*Zoonotic Diseases*

Veterinarians have long been exposed to many serious zoonotic diseases. Specifically, veterinarians in the past were exposed to many potentially serious zoonotic diseases including rabies, glanders, brucellosis and anthrax. Rabies and glanders are exotic to Australia.[231] This study among zoo veterinarians in Australia showed that 40% have contracted an infection with ringworm, psittacosis, scabies and paronychial infection from lorikeet bite, herpes infection from a bite by a crab eating macaque. The zoo study in the US by Hill et.al., (1998)[1] also found that 30.2% of veterinarians acquired a zoonotic infection with ringworm and psittacosis being the most common. Of the 84 respondents in the US study, five participants were hospitalized for leptospirosis, campylobacteriosis, echinococcosis, herpes virus A1 and giardiasis. The frequency of zoonotic infection in veterinarians varied greatly from 13.2% to 64.5%.[10,11,59,229,230] The differences in the frequency of zoonotic infections in various studies may be due to veterinarians treating a range of animal species and the number of animals they treated. The study among veterinary practitioners in Western Australia[8] revealed that participants reported leptospirosis and cryptococcosis. The prevalence of zoonotic infection among zoo veterinarians in Australia appears consistent with those of US study by Hill et al., (1998),[1] North Carolina study by Langley et al., (1975),[10] study in Argentina by Alvares et al., (1990)[229] and study among veterinarians in Illinois by Schnurrenberger et al., (1975).[230]

In Australia, a high level of risk for veterinarians and staff from Q fever, ornithosis, ringworm, leptospirosis, and toxoplasmosis had been previously reported.[130] This compares with figures from the US where zoonotic diseases accounted for 12% of more than 200 reported claims over a three year period to the AVMA Professional Liability Group Insurance Trust.[3]

Of the five notifiable zoonotic infections reported at the national level in Australia, Brucellosis, leptospirosis and Q fever were nationally notifiable in 1999. There were 52 notifications of brucellosis in 1999 compared to the number of notifications in 1998 (48). Similarly, there were 318 notifications of leptospirosis in Austrlia in 1999, with 68% increase compared to 1998. Queensland had the highest notification rates for Q fever, leptospirosis and brucellosis. The increase in the number of leptosirosis in Queensland was due to an outbreak in the region. There were also 518 notifications of Q fever in 1999. These figures indicate that Q fever is the most common disease prevalent among veterinarians carrying out meat inspection. Even though, Q fever is the most important of all zoonotic diseases in Australia, its true prevalence is likely to be under-estimated. [146]

In the Western Australian study among veterinary practitioners,[8] the work-days lost per year due to human and zoonotic diseases were identified. While eight percent of veterinarians regarded zoonotic diseases such as Q fever, ornithosis, ring-worm, leptospirosis and toxoplasmosis as occupational hazards, only four percent reported having had a zoonotic disease. The study among veterinary practitioners in Westen Australia[8] also revealed that there were seven days lost in three cases due to zoonotic diseases accounting for only 10% of all occupational injury and disease. From the author's experience in a zoological garden, it is presumed that veterinarians working in zoological gardens in Australia are unable to avail leave from work due to heavy workload with an average of 59 hours of work per week and finding suitable replacements during their absence from work was difficult.

Seventy percent of participants in the study among veterinarians in the zoological gardens in Australia have not taken base-line serum level test at the start of their employment. One participant who was vaccinated against diseases such as hepatitis A, hepatitis B and rabies reported that the titres have increased for the diseases that the participant was vaccinated for. It is important to note that 30% of the respondents have not undertaken a base line serum level test and could contract zoonotic diseases while handling infected animals. The question on base line serum level test on an annual basis was not incorporated in our study. In the zoo study in the US,[1] eight of the zoo veterinarians had a positive tuberculosis skin test, but, only 46.2% were tested annually. A base line serum sample should be collected for all personnel including non-veterinary staff working with animals. The collection of serum sample should be based on the risk of infection prevalent in that environment and zoo veterinarians should undertake an annual skin testing for tuberculosis.

*Vaccination*

Zoo veterinarians in Australia received vaccination against tetanus (95%), rabies (65%) and polio (80%) which is consistent with the study among zoo veterinarians in the US.[1] Comparatively, zoo veterinarians in Australia had a higher percentage of vaccination against hepatitis B (85%) and typhoid (70%). Rabies is said to be common in the US and vampire bats and wild species of canines have been responsible for a number of incidents of rabies in the US. The study among zoo veterinarians in the US[1] reported that 13.7% of veterinarians had been scratched, bitten and exposed in some form to a known rabid animal including red pandas, bats, racoon, skunk, chimpanzee and fox.[1] It is commendable that 65% of Australian zoo veterinarians had been vaccinated against rabies. Veterinarians in Australia might be taking precautionary methods due to the outbreaks of rabies among bats in the recent past. A small percentage of zoo veterinarians in the US study[1] have been vaccinated for yellow fever and rocky mountain spotted fever while Australian zoo veterinarians have not been vaccinated for these diseases as these diseases do not prevail in Australia. Q fever affects mostly veterinarians and other associated personnel in the meat industry in Australia and perhaps this might be the cause for the zoo veterinarians in Australia to get immunized against Q fever.

Discussions with the Australian veterinarians and the authors experience in working in a zoo environment revealed that zoonotic diseases have not been reported among animals collected from the wild. When animals are to be collected from the wild by for zoo purposes, they have to be kept segregated under strict quarantine regulations and are vaccinated before they are used for breeding or exhibit purposes. The US study by Jong and McMullen (1995)[232] has recommended that if veterinarians have to collect animals in the wild, vaccinations against anthrax, cholera, yellow fever, typhoid, plague, Japanese encephalitis, hepatitis A and hepatitis B, rocky mountain spotted fever, tularemia and tick-borne encephalitis have to be considered.

**Chemical Hazards**

Many substances used in veterinary practice can cause hazardous effects which include mutagenicity, teratogenicity, carcinogenicity, acute toxicity, flammability, explosiveness, skin irritation, allergic reactions[1,59] and lung damage.[10] Hazardous chemicals commonly used in veterinary practices include disinfectants (ethylene oxide, hexachlorine, glutaraldehyde, formaldehyde), inhalent anaesthetic gases (nitrous oxide, halothane, isoflurane), injectable anaesthetic agents, pesticides (organophosphates and pyrethrins), antineoplastic drugs, analgesics (narcotics like pethidine and morphine), therapeutic agents (antibiotics), diethylstilbesterol (DES), non-DES hormones, solvents like xylene and heavy metals.[8] In the study by Hill et al., (1998),[1] 48.7% of zoo veterinarians reported an adverse exposure to inhalent anaesthetic agents, formaline, pesticides, disinfectants/ sterilants or antineoplastic drugs.

Veterinarians working in Australian zoos reported to have used a number of substances causing health problems. The use of chlorine bleach caused skin reactions, respiratory and other problems (5%), chlorohexidine caused skin reactions (10%) while iodine caused skin reaction (5%) and other chemicals in general caused various problems in 10% of participants. The study among veterinary practitioners in Western Australia[8] reported substances such as iodine, quaternary armonium compounds, chlorohexidine and glutaraldehyde have caused headaches, dermatitis and dyspnoea (20%) while glutaraldehyde and formaline also have caused health problems among veterinary personnel.

*Formaldehyde*

Formaldehyde commonly used by veterinary and health care personnel is irritant and toxic in nature. Formaldehyde is toxic if inhaled or swallowed. It is an irritant to the eyes, respiratory system and skin when contacted. Long exposure or higher doses can cause coughing or choking. Studies have reported that eye exposure to concentrated gas or liquid can cause serious damage to the eyes and it may cause cancer from repeated or prolonged exposure.

The study among Australian zoo veterinarians revealed that formaline was used by 70% of participants and exposure to formaline caused headaches, eye-nose-throat irritation, nausea, dizziness, sneezing and dyspnoea while, the study by Hill et al., (1998)[1] among zoo veterinarians in the US showed that 40.2% of respondents had ill-effects from formaline exposure. The nature of health hazards experienced included eye irritation (75.7%), respiratory irritation (61.3%) dermatitis (24.3%) headaches, dizziness, or nasal irritation (4.5%). Of the 275 respondents reported to have used formaldehyde or para-formaldehyde as sterilants or disinfectants on equipment had adverse reactions such as respiratory irritation (6.2%), skin irritation (4.4%), and other reactions (4.4%). The study among Australian zoo veterinarians reported that 50% of participants experienced formaline exposure which caused respiratory problems, skin disorders and other problems. The cross-sectional studies have identified formaline exposure could cause severe respiratory and skin problems to the veterinary practitioners and their associates. ATSDR Science Corner (1995)[233] has indicated that long-term repeated exposure for formaldehyde may cause cancer of the nasal passage, mouth lungs or bone marrow.

Anaesthetic gases

Anaesthetic agents used by veterinary and medical professional include volatile anaesthetics (isoflurane and halothane), injectable anaesthetics (ketamine, propofol and barbiturates) and local anaesthetics (lidocaine and procaine). Inhalant anaesthetics are preferred because they are highly effective and gets cleared quickly from the body.[234] Exposure to low levels of anaesthetic gas has been associated with a wide range of adverse health effects including decrease hepatic and renal function, central nerves system effects of headache, irritability, impaired cognitive function and adverse reproductive outcomes.[54,73,74,235] Exposure to anaesthetic gas by females have resulted in spontaneous abortions and congenital malformations.[53,54,70,80] It has also been reported in the zoo study in Australia that the veterinarians spent 10 hours per week on gaseous anaesthesia, while the study among the Western Australian veterinarians[8] and a study by Wiggins et al., (1989)[17] also reported participants spending ten or more hours per week on gaseous anaesthesia.

Isoflurane was the most common gaseous anaesthesia used by all the veterinarians in the zoo study in Australia and other gaseous anaesthetic agents used were halothane and savoflurane. Ninety-one percent of the zoo veterinarians in the study by Hill et al., (1998)[1] reported using inhalant anaesthetics. Isoflurane was used by 86.3% of zoo veterinarians in the US with less percentage using halothane and methoxyflurane. When compared, 83% of female veterinarians in the study by Wiggins et al., (1989)[17] and 88.1% veterinarians in North Carolina study by Langley et al., (1995)[10] reported to have used inhalant anaesthesia. In both studies,[10,17] isoflurane was the most commonly used inhalant anaesthetic by the veterinarians. These cross-sectional studies indicate that isoflurane has been the preferred anaesthetic agent used by veterinarians.

However, the study among veterinary practitioners in Western Australia[8] reported the use of both gaseous and injectable anaesthesia in veterinary practices with halothane and methoxyflurane being the most commonly used anaesthetic agents. Only a few participants used nitrous oxide and enflurane.[8] The discussion the author had with the field veterinarians in Western Australia revealed that, even though they preferred using isoflurane, veterinarians were compelled to use halothane in their practices as halothane was found to be less expensive. Veterinarians in the West Australian study[8] believed that exposure to halothane is much more toxic than other anaesthetic gases.

In the study among zoo veterinarians in Australia, gaseous anaestietic exposure was identified to be a major health hazard with 50% of participants reporting that they have experienced headaches, lethargy and nausea for isoflurane and halothane. The study by Hill et al., (1998)[1] among the zoo veterinarians in the US, also reported similar symptoms associated with the use of isoflurane and halothane with one case of respiratory irritation for isoflurane. Halothane has also been reported in the US studies as causing headache and nausea[212] and significant exposure to halothane has resulted in abortion and infertility among women.[74,212]

Ninety percent of zoo veterinarians in the Australian study group reported that their practices were equipped with a range of scavenger systems to extract waste anaesthetic gases and vapour while, 40% of veterinary practitioners in the West Australian study,[8] 53% of zoo veterinarians in the US study[1] and 38.1% of North Carolina veterinarians[10] used active scavenger systems. The study among zoo veterinarians in Australia reported that they used mostly older methods of scavenger systems in their practices, and the effectiveness of the scavenger systems could not be evaluated. Effective exhaust and disposal systems are essential in all areas where inhalation anesthesia is used. There are no set recommended safe limits for waste anaesthetic gas exposure in Australia, however, given the documented harmfulness associated with inhalant anaesthetic exposure, taking precautionary methods to minimize exposure levels to personnels below the recommended safe limit of 2 ppm set by the NIOSH is essential.[32,46,51,235,236]

*Pesticides*

Pesticide exposure in veterinary practices occurs primarily through cutaneous exposure to products such as flea dips, rinses and insect fumigant sprays. Secondary routes of exposure include inhalation of products such as sprays used in animal confinement facilities. Pesticides such as organophospates, carbamates and pyrethrins are used by veterinary practitioners directly on animals or applied to the area where the animals are confined and veterinarians are exposed to pesticides on a regular basis.

The study among zoo veterinarians in Australia revealed that 75% of the participants have been exposed to pesticides, but none of the participants indicated the type of pesticide used in their practices. In the North Carolina study,[10] of the 701 veterinarians, 92% of participants and 52% of veterinarians in the study by Wiggins et al., (1989)[17] reported having used pyrethrins, organophospates and carbamates. Eight percent of the zoo veterinarians in the US study[1] reported adverse reactions to pesticides compared with 11% of the

North Carolina veterinarians[10] and just 3% of the swine veterinarians.[11] In the study among West Australian veterinary practitioners[8] pesticides/ organophosphates (fenthion/malothian, asunthol) and various types of flea spray and rinses were used by 22% of the participants in the cohort which caused headaches, nausea and skin allergy. The above cross-sectional studies among veterinarians indicate that the zoo veterinarians in Australia have experienced higher incidence of adverse pesticide exposure.

Protective equipment used when handling chemicals

Zoo veterinarians and non-veterinary staff should protect themselves from exposure to hazardous substances such as formaline, antineoplastic drugs, pesticides and anaesthetic gases by using appropriate protective equipment including impervious clothing, gloves, aprons, safety foot wear, respirators, face shields or chemical splash goggles to prevent skin and eye contact. The type of protective gear used by the Australian zoo veterinarians when handling chemicals and antineoplastic drugs include gloves (60%), protective glasses (30%), aprons (10%), goggles (5%) and facemasks (5%). Even though, participants in the zoo study in Australia were well aware of the health effects and many of them were experiencing ill-effects from the use of chemicals and other hazardous substances in their work places, they did not adhere to the use of protective equipment. It is noteworthy that only one of the participants in the cohort used gloves, protective glasses, aprons and face mask while handling chemicals.

## Stress and trauma

The working environment of a zoo veterinarian is one of continuous hard physical and mental work with most practising veterinarians in the Australian zoo study indicating that they work 59 hrs per week. Mulvey and Langworthy (1987)[96] and Jeyaretnam et al., (2000)[8] also reported that most private veterinary practitioners work over 55 hours per week.

This study among zoo veterinarians in Australia reported that 60% of participants experienced occupational stress and trauma during their career due to stress associated with day to day management issues, mental stress, interference from other staff, lack of confidence in the treatment, insufficient wage paid for the veterinarian, inadequate staff, high work pressure, personality conflicts, potential exposure to zoonotic diseases, inter-departmental conflicts, poor staff management of the director, inadequate support and resources and incompetent managers with poor people management skills. Veterinarians also indicated that zoo staff being allowed to accuse, judge and make substantial allegations caused stress.

While there are some anecdotal accounts about stress, no studies on stress have been carried out among veterinarians in Australia. Veterinarians, especially practice principals, have an enormous responsibility in managing a veterinary practice. This includes activities such as ordering drugs and chemicals, overseeing the running of the hospital, medical and surgical management and generally being involved in community activities such as speaking at local meetings and schools. This combination of work and non-job responsibilities can cause considerable mental stress.[231] However, suicide rates for veterinarians are believed to be high. Studies carried out in the US show higher suicide rates among veterinarians when compared to the general population.[18,35] Occupational stress and easy access to drugs have been suggested as major contributors to the high mortality among health professionals.[30]

The study carried out among veterinary practitioners in Western Australia[8] reported that the responsibilities of a majority of veterinarians in the cohort included management of the practice, staff supervision, financial operation and public relations. Long working hours, heavy responsibilities, intra-professional jealousies, difficulties with neighbouring practices and inability to make decisions may lead to stress and depression for veterinarians. Author's experience confirms that such work-related problems and issues do exist among veterinarians in other countries including Sri Lanka. The Australian Veterinary Association has instituted programs to assist new graduates in practice and in Queensland, supports a 'hotline' for stressed veterinarians.[8] It could be noted that for pregnant women, maternal stress, pregnancy related fatigue and physical imbalance could increase the chances of work-related injury. Richardson (1993)[237] suggests that veterinarians in rural areas make less income than their urban counterparts however, whether this adds to stress remains a matter of conjecture.

**Major occupational health and safety issues**

The participants in the Australian zoo study were asked to list major occupational, health and safety issues in the practice and the physical hazards nominated included animal scratches and bites, injury from inadequately immobilized animal patients, injury associated with carrying, moving and positioning immobilized animals, trauma due to handling animals, injuries associated with sharps, needles, instruments and exposure to animal blood. Improper restraint of wild animals, incorrect use of instruments, inadequate ergonomically designed equipment and lifting and carrying of heavy objects and equipment as well as exposure to radiation.

Number of chemical hazards nominated included handling of dangerous substances such as etorphine and carfentanil, handling of certain drugs and immobilizing agents such as zylazine, ketamine, medeotomidine, exposure to anaesthetic agents and chemicals such as formaline and isoflurane vapour and disinfecting agents. Biological hazards identified were contracting zoonotic diseases, risk associated with frequent handling of faeces particularly of non-human primates, post-mortem exposure and lyssavirus in bats. Other occupational hazards identified included lack of facilities for manual restraining of animals, limited training for keeping staff, lack of communication between the veterinary department and occupational health and safety section, increasing amount of clerical and computer work and back and neck problems.

In the study by Hill et al., (1998)[1] carried out in the US did not incorporate any question on major occupational health and safety issues experienced by the zoo veterinarians. However, the West Australian survey among veterinary practitioners[8] revealed that 71% in the cohort suffered major physical injuries in their practices amounting to 162 over a 10- year period. The Western Australian study also found that zoonotic diseases such as toxoplasmosis, cryptococcosis, leptospirosis, psittacosis and chlamydiosis as health hazards. While eight percent of the veterinarians identified zoonotic diseases as a potential risk for them and their staff, only four percent stated that zoonotic infections have occurred. In addition, 94% of veterinary professionals in the Western Australian study group used radiology[8] in their practice and 24% believed that radiation exposure was a major occupational health and safety issue.[8]

The federal government sets and enforces national standards in protecting workers' health and safety throughout Australia. This is carried out by implementing national regulations of workers' health and safety through ratification of the 1981 International Labour Organization (ILO) Convention 155 on occupational health and safety.[49] An employer is expected to provide and maintain a healthy working culture environment and work processes to minimize the risk of employees being exposed to occupational hazards. Adequate training, proper machinery, protective gear and proper supervision are essential key elements in work places. The employer should consult and co-operate with health and safety representatives on issues pertaining to occupational, health, safety and welfare. Maintenance and transportation of machinery and handling, processing, storage, transportation and disposal of substances should be carried out without employees being exposed to occupational hazards.[238,239]

If and when an accident occurs, the employer shall notify the Occupational Health and Safety Commissioner with details of any injuries, illness and death that has occurred. A health and safety representative may request the employer to establish an occupational health and safety committee, if there are an excess of ten employees. The employer also has a duty of care when he/she employs contract workers and meeting this duty will reduce occupational hazards in work places.[239] It is also important that employees take reasonable care in ensuring their own safety and health at work and avoid affecting the safety and health of other employees.[239] Most veterinary practices in the zoological gardens and other veterinary practices in Australia do not have more than ten employees. However, it is important that veterinary practices continue to maintain proper occupational health and safety standards.

## Conclusion

Veterinarians experience a high risk of adverse work-place exposure. The veterinary profession is unique in nature differing in a number of ways from the medical and other health professions because animal patients vary in size, and behaviour, as well as in anatomical, physiological and other characteristics. In human medicine, the majority of patients co-operate with their physicians, whereas in veterinary practice, unco-operative and aggressive animal patients resist examination and treatment due to fear and excitement. In many instances, this results in trauma and other injuries being inflicted on veterinarians and non-veterinary staff. The use of physical and chemical methods of restraining could control fractious animals. It is advisable to use experienced staff including nurses, zoo keepers and teachnicians instead of using owners and inexperienced staff to restrain animals.

The majority of zoo veterinarians in the survey sustained needlestick injuries while injecting medicines, vaccines and while taking blood samples. Veterinarians sustained a number of physical injuries some of which necessitated hospitalization. Self-treating their injuries has been reported by the participants. Zoonotic diseases including ringworm, psittacosis, scabies and paronychial infection were reported by the veterinarians in the study group. They also reported that they have not taken base line serum level test at the commencement of their career at the zoo.

This study among Australian zoo veterinarians revealed that ionizing radiation is an occupational hazard to the veterinarians and their associated personnel. Even though, veterinarians are aware of the dangers caused by ionizing radiation, a number of veterinarians and non-veterinary staff did not use protective equipment while radiological procedures were carried out. Even though, it is clear that no radiation dose is free from risk, personal involved in radiographic procedures may be subjected to an unacceptable degree of risk, not only due to exposure to high doses, but low doses may also cause considerable harm over a long period.

Veterinarians are also exposed to disinfectants, a number of chemicals, animal hair, fur, hormones and a mixture of substances causing health hazards. Symptoms due to exposure to chemicals occur in different individuals at different levels of exposure, but little known work has been done to measure morbidity and mortality among zoo veterinarians and associates working with such chemicals. Studies have also found that prostaglandin exposure had caused abortion among female veterinarians. Therefore, it is important to limit the use of chemicals and to take necessary precautions to prevent or lessen the risk of exposure. Safety training for veterinarians and their associates is essential, as most accidents occur due to spills when workers are unfamiliar with chemicals. The MSDS should be provided within easy access.

This study among zoo veterinarians in Australia also revealed that protective equipment such as lead aprons, gloves, protective glasses and goggles or face masks were not used by a number of participants while handling chemicals, hazardous substances and anti-neoplastic drugs. Some participants did not use extractor fans for scavenging waste anaesthetic gas and vapour in their clinics. Use of extractor fans will remove not only waste anaesthetic gas and vapour from the respiratory valve, but also from the operating theatre, thus bringing the exposure concentration within acceptable limits. Currently there are no set standards for waste anaesthetic gas exposure in Australia and it is suggested that veterinarians should follow the safety standards set by NIOSH in the US.

It is suggested that zoo veterinarians have been affected by stress and suffer some impairment during their career due to a number of reasons including long and irregular hours of work, and to their environment. Adequate staffing, frequent in-service educational sessions, flexibility, regular discussions to share innovative ideas, organized and efficient work functions and environment may help to reduce stress-related illness among zoo veterinarians and their staff as well as control other occupational health hazards.

Veterinarians in private and zoo practice should have adequate knowledge of all occupational diseases and injuries, and should be aware of their legal responsibilities. If proper procedures are correctly followed and effectively managed, reduction of risk in work places can be achieved. It has been noted that veterinarians are at risk of injuries and this emphasizes the importance of providing the zoo veterinarians with proper induction programs at the beginning of their career followed with inservice training on a regular basis. The veterinary practitioners who manages zoo practices should have both technical and administrative training and experience to effectively train and manage staff to reduce work-related injuries. The work should be planned in accordance with legal obligations so that working hours and workloads are within safe limits.

## CHAPTER 8.

## DISCUSSION AND CONCLUSION

The veterinary profession encounters a range of exposure scenarios during their career with inflict injuries, some of them are very serious in nature. The profession differs in a number of ways from the medical and other health professions as animal patients are very unpredictable, unreliable, uncooperative and resist handling.

A review of the literature by Hill et al.,(1998)[1] on occupational hazards among zoo veterinarians in the US, Landercasper et al., (1988)[9] on trauma in veterinarians in Minnesota and Wisconsin, Langely et al., (1995).[108] on the health hazard among veterinarians in North Carolina together with the data obtained from the Insurance Claims for the Members of the American Veterinary Medical Association[2,3] reveals very little information available on work place hazards amongst veterinarians in the US.

The previous studies carried out in the US and a recent study in Western Australia on disease, injury and accidents among veterinarians[8] along with the information collected from other sources underpinned the planning of a survey and study on occupational hazards including radiological hazards amongst the veterinarians in the zoological gardens and wildlife parks in Australia.

The role of the veterinarians in the UK and the US are consistent with the role of Australian veterinarians. The study carried out in Western Australia[8] reported that veterinary practitioners treat a range of species including companion animals such as dogs, cats, birds and guinea pigs; domesticated animals such as cattle, horses, sheep, swine, goats, deer, rabbits and poultry; laboratory animals such as rat, mice, rabbits and guinea pigs; and sporting animals such as horses and dogs. A small percentage of veterinarians are involved in the treatment and care of wild animals in captivity including mammals, birds, aquarium animals and amphibians.

The first chapter of this thesis contains general introduction and development of thesis structure and the next four chapters are general reviews of published literature that focussed on physical, chemical, biological and radiological hazards occurring in veterinary practices in the zoos and wildlife parks. Because there was a lack of published data on the hazards to veterinarians in Australia, the little information that was available, along with the studies carried out among the veterinary practitioners in Western Australia[8] and the researcher's experience as a veterinarian became the basis of the research described in chapters six and seven.

In 2000, as a part of this research, a comprehensive survey on occupational hazards among veterinary practitioners in the zoological gardens and wildlife parks in Australia was carried out to determine the major disease, injury and accidents sustained by veterinary practitioners and their staff. A major part of the questionnaire focused on physical, chemical and biological hazards in zoo veterinary practice in Australia. Possible hazards due to radiation exposure were also raised in this study focusing on radiological hazards.

The study involved a self-administered comprehensive questionnaire on work-related physical including radiological, chemical and biological causes of disease, injury and accidents that was mailed to 27 potential study subjects in the zoological gardens and wildlife parks in Australia to obtain data on occupational exposures. The questionnaire was accompanied by a reply-paid envelope. After six weeks, a follow-up mailing of the questionnaire was sent to non-respondents. Another follow-up was carried out by telephone to encourage response and two more questionnaires were sent to those who claimed they had misplaced the survey form. Overall, 20 completed questionnaires from zoological gardens and wildlife parks were returned. This effectively meant that responses were obtained from 74% of all veterinary practitioners in the zoological gardens of Australia. Data on personal/practice information and other demographic aspects including work-related disease, injuries and accidents; potential hazardous exposures and use of protective equipment were obtained.

The survey reported numerous occupational hazards affecting the zoo veterinarians and their associates including physical trauma; exposure to waste anaesthetic gases and ionizing radiation, hazardous substances, pesticides, zoonotic diseases, allergies, skin problems and mental stress.

**Physical Hazards**

Physical trauma has been identified as a major cause of occupational injuries to veterinarians and staff in the zoo study in Australia. The study revealed that zoo veterinarians sustained major animal-related injuries including animal attacks, bites, scratches and lacerations, crushes, fractures, bruising, trauma during manual restraint, cuts with scalpel blades and knives during necropsy, back injuries due to heavy lifting, needle stick injuries and venomous snake bite.

In this study among zoo veterinary practitioners in Australia, 60% reported that they had sustained a physical injury in their practice.

However, this was over a five-year period. This is supported by data from one study among the zoo veterinarians in the US by Hill et al., (1998)[1] where 61.5% reported at least one major animal-related injury during their career. Another study by Langley et al., (1995)[10] also reported 68% veterinarians sustained physical injuries during their career necessitating hospitalization which is confirmed by the study by Landercasper et al., (1988)[9] that reported that 65% of veterinarians experienced an animal injury. The study among Western Australian veterinary practitioners[8] showed that 71% of veterinarians had sustained a physical injury in their veterinary practices. However, this was over their lifetime, not for one year. Constable and Harrington (1982)[59] in their study reported that the majority of veterinary staff sustained animal-related injury or illness in their career which were serious enough to require time off work.

The severity and nature of injuries sustained by zoo veterinarians in Australia included animal bites, crushes and scratches with some injuries requiring medical treatment. The zoo study in Australia also reported that 17.5% were hospitalized for animal-related injuries including fracture of the tibia while restraining an ostrich, fracture of the jaw and comatose condition, kick by a horse and a bite from Herpes B antibody positive primate. The studies among veterinarians in the US[9,10] and the Western Australian study[8] have indicated that dogs and cats were responsible for most of the injuries sustained. Various parts of the body including face, back, and neck were affected by animal injuries. Approximately six thousand to thirteen thousand animal bites are reported each year in Illinois, US. The animal species included were dogs (85-90%), cats (5-10%) and other animals (1-3%).[240]

Diagnosis and treatment of animal disease involves considerable risk of injury to veterinarians. In their study of trauma, Landercasper et al.,(1988)[9] reported physical hazards including exposure to radiation, extremes of temperature, electrocution, physical trauma inflicted by animals such as bites, kicks and crushes, scratches, needle stick injuries and cuts from scalpel blades, strains from lifting, slips from handling animals and automobile accidents. The study by Landercasper et al., (1988)[9] also revealed that veterinarians sustained cat bites (81%), cat scratches (72%), dog bites (92.3%), equine kicks (62.7%), equine bites (32.8%), bovine kicks (86.7%), and porcine bites (12.3%). The most severe injuries inflicted by animals were bites (34%), kicks (35%), crushes (11.7%), scratches (3.8%) and other injuries (14.9%). The most common injuries were in extremities followed by facial, ophthalmic and dental. Four percent of veterinarians reported a genital injury. Life threatening accidents also occurred necessitating laparotomy and craniotomy among veterinarians. There had been injuries to the small intestine and pancreas.

The West Australian study by Jeyaretnam et al, (2000)[8] reported that large animal practitioners were exposed to severe injuries in their practice including being struck by a horse on the face during treatment, a leg thrombosis from a kick by a mare, falling in a cattle race necessitating the removal of a torn knee cartilage, tibia and fibular injuries. In a study on large animals by Busch et al., (1989),[15] it was reported that injuries inflicted by dairy cows weighing over 636kg and bulls of different breeds weighing more than 1312 kg were very severe in nature. Because male veterinarians are more likely to treat large animals, nature of injuries sustained by male veterinarians was different from female veterinarians.

Animal-related injuries did not change with the sex of a veterinary practitioner. There was no statistically significant difference between the number of injuries by men versus women. Due to fatigue, and physical limitations, pregnant veterinarians and pregnant employees may be more susceptible to physical and traumatic injuries which may cause abortion or injure the foetus.

Thigpen and Dorn (1973)[2] in a study on "Non-fatal Accidents Involving Insured Veterinarians in the United States, 1967-1969", reported that veterinarians were bitten, scratched, and knocked down by animals. They were burnt by burst steam valves, slipped while reaching animal enclosures, injured their backs while lifting dogs or cattle and when delivering calves. Lacerations and puncture wounds were the most common injuries. Fractures including those of the face and teeth, were the second most common injury, followed by sprains-dislocations-torn ligaments and bruises-contusions-trauma-burns.

*Musculoskeletal injuries*

Musculoskeletal injuries have been common among veterinary practitioners as they strain their back from lifting or moving heavy animals. Veterinarians also run the risk from lifting heavy operating machinery while working in animal housing facilities. Studies in the US have confirmed that veterinarians have been suffering from back injuries sustained at their work places.[1,9,11] In the study among zoo veterinarians in Australia, 50% of veterinarians reported to have sustained back injuries within the past five years at the workplace with six work days lost. In their study, Moore et al., (1993)[12] report that ergonomic injuries are now a recognized physical hazard with repetitive task and manual handling overload through lifting and restraining animals contributing to many physical problems among veterinarians and their staff. Physical injuries may be associated with serious viral and bacterial infections.

The studies conducted in the US and in Australia[1,8,9,11] report the number of back injuries sustained by veterinarians. The AVMAGIT (1996)[2] reported 48% of veterinarians sustained back injuries while a study by Hafer et al.,(1996)[11] reported 31% and a study by Landercasper et al., (1988)[9] reported 8.9% of back injuries. The study by Hill et al., (1998)[1] among zoo veterinarians in the US reported 55% of veterinarians had back injuries over a five year period and Jeyaretnam et al., (2000)[8] reported that back injuries was one of the major causes for the 71% of injuries sustained by the West Australian veterinarians. The studies show that there is some consistency on the number of back injuries sustained by zoo veterinarians in the US and Australia.

*Needle Stick Injuries*

Needlestick injuries are wounds caused by needles that accidentally puncture the skin in people who work with hypodermic syringes and other needle equipment. Drugs, biologicals and any large animal preparations could have serious consequences if the veterinarians accidentally self inject themselves. Considerable variability of hazardous exposure exists within the veterinary profession. Veterinarians are subjected to accidental self-administration of drugs and vaccines. Exposure to microorganisms, vaccines, hormones and other pharmaceutical products present risk to veterinarians.

The study carried out among zoo veterinary practitioners in Australia identified that veterinarians had the highest incidence of needlestick injury amounting to 90%. More specifically, participants indicated that

70% were exposed to blood, 35% to vaccines and 35% to antibiotics one to sixteen times. The study by Hill et al., (1998)[1] among zoo veterinarians and the study by Hafer et al., (1996)[11] among swine veterinarians in the US revealed that needlesticks were the most frequent injuries reported with the majority of veterinarians reporting one or more needlestick injury including adverse reactions to injected agents, infections and severe lacerations. Vaccines (40%) were the most common exposure agents in the study by Hafer et al, (1996).[11] A British study by Constable and Harrington (1982)[59] showed that 45% of veterinarians self-injected themselves with vaccines, majority of which were serious enough to necessitate time-off work. A study among health professionals in London hospitals revealed that 75% of injuries were caused by needlestick or other sharp objects.[241]

The injuries caused by instruments such as needles and scalpels alone will not cause severe injuries. It is the biological or chemical agent accidentally introduced into the body that could cause severe problems. The studies among veterinarians both in zoological gardens and in private practice in Australia and in the US showed that veterinarians are at increased risk from accidentally injecting into themselves substances such as vaccines, antibiotics, anaesthetics, animal blood and immobilizing agents.

In a study carried out in the US[4] among all female veterinarians, 66% of participants reported needlestick injuries with one female veterinarian experiencing spontaneous abortion. Of these, 16.4% injury resulted in one side effect and 12.4% with mild and localized symptoms. Few veterinarians experienced severe symptoms causing side effects[4] A study by Wilkins and Bowman (1997)[242] showed a smaller percentage of female veterinarians compared to male veterinarians to have sustained needlestick injuries.

The study among zoo veterinarians in Australia reported self-treatment of animal-related injury was common. Almost three out of four veterinarians reported treating their own injuries. The survey among veterinarians in Western Australia[8] did not request information about self-treatment of injuries, however, it is likely that Australian veterinarians would have similar treatment regimes to their counter parts in the US.

The majority of large animal practitioners in the West Australian study[8] reported prostaglandin as causing respiratory problems and nausea. This hormone is potentially hazardous especially for pregnant veterinarians and accidental injection of prostaglandin can result in abortion. Ninety-two per cent of participants in a study by Wiggins et al.,(1989),[17] and 2.4% participants in North Carolina study by Langley et al., (1995)[10] reported to have been exposed to prostaglandin. However, they did not indicate if there had been any abortions or respiratory problems. Bowman and Wilkins (1991)[4] in their study reported that accidental self-injection of prostaglandin designed for the control of oestrus timing in cattle and horses and induction of parturition had resulted in a spontaneous abortion in a female veterinarian and it is evident that needlestick injury is a potential occupational reproductive hazard.

Needlestick injuries transmit infectious diseases, especially blood-borne viruses. In recent years, concern about HIV (Acquired Immune Deficiency Syndrome), hepatitis B, and hepatitis C has prompted concern. Hazardous fluids can be injected through the skin by accidental puncture from contaminated needles. The Laboratory Centre for Disease Control (CDC) Canada, has reported the first case of occupational transmisson of HIV that can be clearly linked to a needlestick injury. Two laboratory workers also have contracted HIV infection due to possible occupational transmisson.[141] There is potential for injection of hazardous drugs, but injection of infectious fluids, especially blood, is of greatest concern. Accidental injection even in small amounts of infectious fluid can effectively spread certain diseases. The hollow-bore needles used in syringes poses risk for needlestick. NIOSH has recommenced that the use of needles be eliminated where possible and effective alternative devices with safety features such as shields and sheaths to be used.[100]

*Necropsy Injuries*

The study among zoo veterinarians in Australia found that 30% of participants reported necropsy injury. This is similar to the study conducted by Hill et al., (1998)[1] in which 44% of zoo veterinarians experienced necropsy injury and the study by Hafer et al., (1996)[11] in which 36% of swine veterinarians reported such injuries. In all three studies sex and years in practice were not statistically correlated with necropsy injury rate. In the study by Wiggins et al., (1989),[17] 85% of participants indicated that they had performed necropsies while 36% indicated that they performed two necropsies or more per month, but the study did not indicate the nature of injuries sustained during necropsies.

The study carried out in among zoo veterinarians in Australia reported that the nature of necropsy injuries were from knife wound infections. Veterinarians could be exposed to cutaneous, percutaneous or mucous membrane exposure to chemicals and infectious agents. They may also be exposed to hazardous fluids even through small tears in the gloves, formaldehyde vapours and aerosols generated during the necropsy.

Motor vehicle accidents

Workers' compensation claims in Western Australia from 1991-1996 showed that five percent of claims are for motor vehicle accidents. The study among zoo veterinarians in Australia reported three minor motor vehicle accidents. Veterinarians working in zoological gardens do not require traveling long distances. The West Australian study among veterinary practitioners[8] showed that there were eight motor vehicle accidents including two major accidents in one year. Veterinarians drove greater distances than their counterparts in the US but, the injury rate was low compared to other studies carried out in the US. A study by Martin et al., (1983)[16] reported that 29% of veterinarians were involved in 416 motor vehicle accidents. The study by Thigpen and Dorn (1973)[2] revealed that motor vehicle accidents accounted for 10% of the 773 accidents. In Australia, the statistical evidence available on the number of veterinarians involved in motor vehicle accidents are not very accurate. However, few reports are available on workers' compensation claims for veterinarians and staff. One cannot totally compare recent results with data from the early 1973 study by Thigpen and Dorn (1973)[2] because many factors have been improved including car safety, wearing of seat belts, road quality, traffic controls and penalties.

Landercasper et al., (1988)[9] found that 30% of veterinarians in Minnesota and Wisconsin spent more than 20 working hours per week in their motor vehicles. Other studies carried out in the US [2,16,35] also showed that motor vehicle accidents are very common among veterinarians in rural areas. Also the mortality rate for veterinarians due to motor vehicle accidents in some studies were high. A study by Martin et al., (1983)[16] reported that 14 veterinarians were killed in work-related automobile accidents.

**Radiological Hazards**

Radiology is a commonly used diagnostic modality in veterinary medicine. All the participants in the survey among zoo veterinary practitioners used radiology in their practices and veterinarians believed that radiation exposure is a major occupational health and safety issue for the profession. The objective of the study was to identify the hazards associated in veterinary practices in Australia and to develop intervention strategies to reduce or prevent radiation exposure to veterinarians and their associates.

The questionnaire sent to the veterinarians in the zoological gardens included 15 questions on radiological hazards. The questionnaire focused on a number of areas of concern and addressed compliancy with the NHMRC Code of Practice for the Safe Use of Ionizing Radiation (1982).[5]

In the West Australian survey[8] almost all the participants in the cohort (94%) reported spending up to 28 hours per week taking x-rays with a mean of three hours per week, and 24% believed that radiation exposure is a major occupational health and safety issue for the profession. The results of the survey raised concern about exposure to ionizing radiation to veterinarians and their staff which led to another comprehensive survey on radiological hazards among West Australian veterinary practitioners[224] which reported that veterinarians were exposed to ionizing radiation and were not adhering to the NHMRC Code of practice (1982).[5] Both studies among veterinary practitioners in Western Australia led to this study on occupational hazards including radiological hazards among veterinarians working in the zoological gardens in Australia.

*x-ray machines*

The survey among zoo veterinarians in Australia showed that all the respondents used either portable, mobile or fixed x-ray machines in their practices and of these, fifty-four percent of the participants did not know the year of purchase of the x-ray machines. The survey showed that 21% of machines were 22-30 years old and 25% were less than 10 years old. The study among West Australian veterinarians[8] showed that 81% of participants used either portable, mobile or fixed x-ray machines in their practices and of these, 42% were second hand. These studies indicate that the use of old and second-hand machines are common in veterinary practices in Australia

The study among zoo veterinarians in Australia found that seven percent of x-ray machines were never serviced whereas the West Australian study[8] among veterinary practitioners showed that 25% of the x-ray machines had never been serviced. It is noteworthy to mention that the majority of zoo veterinarians in Australia have serviced their machines on a regular basis. The x-ray equipment used in veterinary practices should comply with the relevant Australian Standard and should be monitored and serviced at least once a year. All x-ray equipment should be fitted with electronic timers, warning signals and have light beam diaphragms. To provide a safe working environment, the Radiological Councils/statutory bodies of all states and territories in Australia should carry out compliance testing for all x-ray equipment on a regular basis. The radiation safety acts should be enforced to ensure veterinarians comply with the registration when purchasing new or second hand equipment and this will enable all machines to be checked prior to registration, repaired and overhauled to comply with safety standards.

*X-ray for dental purposes*

In Australia, registration for veterinary radiography requires that dental x-ray equipment should comply with Australian standard with 3201.5 of 1977, and veterinary premises must be registered if they perform dental x-ray. Veterinary dental radiography is covered under a standared veterinary operator licence. The study among veterinary practitioners in Western Australia[224] showed that a number of veterinary practices are using standard x-ray machines for dental purposes which indicates that a number of practices are not using dental x-ray equipment for taking these x-rays. The reasons for using standard radiographic equipment for dental x-rays instead of specialized equipment, could be the lesser number of practices carrying out dental x-rays in their practices, the cost involved in the purchase and maintenance of a separate x-ray unit for dental purposes, or possibly, ignorance on the availability of special x-ray machines. The use of non-dental x-ray equipment for dental purposes may result in staff being exposed to greater radiation doses. The use of standard x-ray equipment for dental radiography could also cause difficulty in the accuracy of positioning and image quality. This has the potential to reduce diagnostic value of the examination. It is important that the NHMRC Code of Practice (1982)[5] incorporate regulations that all veterinary practices taking dental x-rays be registered and that specialized dental x-ray machines be used.

*Collimation*

The x-ray machines should be equipped with a light beam collimator. The lack of proper collimation leads to exposure to primary and scatter radiation through repeated x-rays. The x-ray machine should have proper collimation for the restriction of exposure thereby collimating the primary beam to a smaller area, improving safety standards and image quality. Nine percent of the 104 respondents in the study among veterinary practitioners in Western Australia[224] reported that x-ray machines in their practice did not have a light beam collimator. The NHMRC Code of Practice (1982)[5] has not laid down detailed information on the risk when ionizing radiation leaks through the collimator causing scattered radiation to the operator and others who manually restrain animals.

Although, the study among veterinarians in zoo practice in Australia did not determine the safety assessment of x-ray machines in veterinary practices, the survey carried out among the veterinarians in Western Australia[224] reported that, of the 104 veterinary practices, 66% were assessed by the Radiation Health Section of Western Australia on an irregular basis. There were seven instances of safety checks. These included being checked two times in 12 years and three times in 16 years.

Discussions the author had with the four senior veterinarians in zoological gardens in Australia revealed that the radiation health section is unable to provide safety assessment on a regular basis due to inadequate number of staff members for compliance testing. However, there is a move to increase safety testing of x-ray equipment in the future. Compliance testing will have to be carried out on an annual basis. The veterinary surgeons in charge of zoo practices could request the statutory authority in their state to conduct safety assessments to ensure that the equipment is functioning properly, and persons involved with ionizing radiation are not exposed to it.

*Women and radiation*

The study among zoo veterinarians in Australia showed that eight female veterinarians took an average of 70% of x-rays in eight zoological gardens and female staff took an average of 29% of x-rays in ten practices. In this study, 91% of female veterinarians were of child-bearing age. One female veterinarian and a female staff took x-rays while pregnant. The West Australian study among veterinary practitioners [224] showed that 113 (77%) veterinarians and 387 non-veterinary staff of which 267 (69%) were females, either performed or assisted in taking x-rays. The study noted that 66% of female veterinarians could have received radiation doses during their pregnancy. However, the study among the zoo veterinarians and the West Australian study among veterinary practitioners did not request the stage of pregnancy. In these studies many participants involved in x-ray procedures did not use monitoring film badges and some wore film badges only part of the time.

Radiation exposure places women at risk and there had been an increased rate of abortion and foetal deaths due to exposure to radiation.[12,46] Therefore, it is important that veterinarians are well aware of the potential reproductive hazards prevailing in their work places, and take appropriate and adequate preventive measures.

*Protective shielding*

The table used for x-rays should have lead equivalence thickness of 1mm for the top and 0.5 mm for the sides. The questionnaire did not request the lead equivalence thickness for the top and sides of the x-ray table from the zoo veterinarians. In the West Australian survey,[224] majority of participants responded to most of the other questions, while only 31% and 15% responded to the lead equivalence of the top and sides of x-ray tables. This probably indicates that they did not know the lead equivalence of the x-ray table. The majority of the participants in the West Australian study have not complied with the NHMRC Code of Practice (1982)[5] recommendations and therefore, could be exposed to primary and scattered radiation. It is important that veterinarians in zoological gardens and private practice strictly adhere to the compliance of the NHMRC Code of Practice (1982).[5] Regulations on proper shielding of floors and doors of x-ray rooms in veterinary practices should be included in safety acts in all the states and territories in Australia to protect persons working close to the facility.

The survey among zoo veterinarians in Australia showed that veterinary practitioners and their associates have been wearing lead gloves, lead aprons, lead sleeves and personal monitor only part of the time during x-ray procedures and did not comply with the regulations on the use of protective gear during x-ray procedures. The protective devices used during radiography have to be examined both visually and radiographycally to ensure there shielding efficiency. However, the zoo study revealed that 82% of the participants did not know the lead equivalence thickness of lead aprons, lead gloves, thyroid shields and lead sleeves. The study also revealed that 82.3% of respondents never checked the effectiveness of their protective gear.

*Restraint of animals for radiography*

The survey among zoo veterinarians in Australia showed that 65% of veterinarians and 40% of veterinary nurses manually restrained their patients. Zoo keepers in the zoological gardens also assisted veterinarians in restraining animals for x-ray purposes.

The West Australian study among veterinary practitioners[224] also showed that veterinarians and their associated personnel manually restrained animals during radiography. Veterinarians who did not use protective gear and badges during radiography may have been exposed to high levels of ionizing radiation, and this is a matter of concern. The survey among zoo veterinarians in Australia did not request the use of ancillary equipment. The West Australian survey[224] identified that 33% of participants did not use special ancillary equipment such as sand bags, rice bags, air bags, bandages, ropes, lead sheets and foam to aid the restraint of animals.

Manual restraint is permissible only under exceptional circumstances. The NHMRC Code of Practice (1982)[5] has to be complied with during radiography and veterinarians and staff should restraint their animals by tranquillisation or anaesthesia. It is important to use protective and ancillary devices during x-ray procedures.

*X-ray therapy treatment*

Radiation doses for radiotherapy are very much higher than for diagnostic radiography and the potential hazard may be greater. If the NHMRC Code of Practice (1982)[5] is followed carefully and consistently, the dose limit will not be exceeded and the radiation risk will be low.[5]

The study among veterinary practitioners in Western Australia[224] found that x-ray therapy treatment has been performed in veterinary practices not registered to perform such treatment. X-ray therapy treatment is hazardous as the person taking x-rays is exposed to higher doses due to positioning him/herself close to the primary beam and the patient.

*Films and film processing*

The brands of films used by veterinarians in the West Australian survey[224] included Fuji (65%) Kodak (17%) and Konica (9%). The commonly used films for radiography included RX film (19%), Super HRG, HRG (17%) and Green (9%).

In the zoo study carried out in Australia, 55% of veterinarians used manual methods of film processing while in the West Australian study[224] 75% of veterinarians used manual methods of film processing. Improper techniques for processing films will result in poor quality radiographs and an increase in the use of ionizing radiation.

*Ventilation in the dark-room*

The survey among zoo veterinarians in Australia did not request the type of ventilation provided in the dark-room. However, in the study among veterinarians in Western Australia[224] 44% of respondents indicated that they did not have any type of ventilation in the dark-rooms. Others used extractor fans (41%), evaporative air-conditioners (5%), ordinary fans (4%), refrigerated air-conditioners (4%), and other methods of providing ventilation (6%). To prevent hazards in the dark-room, sufficient ventilation should be provided with an air-conditioner or an exhaust fan running continually. Neither the NHMRC Code of Practice (1982)[5] nor the Radiation Safety Act (1975)[7] in Western Australia mentioned any ventilation for dark-rooms. Installation of ventilation equipment in the dark-room including ducting, fan assemblies and filtration units should be made mandatory for the veterinary practices.

*Training in radiology*

The study among zoo veterinary practitioners in Australia and the survey carried out among the veterinary practitioners in the state of Western Australia[224] revealed that the majority of veterinarians in the cohort did not undergo a safety training or any other training in radiology subsequent to their undergraduate course. Non-veterinary staff in veterinary practices also did not undergo any training in radiology. Undergraduates from Murdoch University, Western Australia, are provided with approximately 50 hours of training in practical and clinical radiography and a small group in the fifth year are provided with extra hours of training for special assignments in radiology. The time limit may be insufficient to learn all aspects of radiography to cope with the increasing demands.

**Chemical Hazards**

Chemicals enter the body through skin absorption, ingestion or inhalation and could cause acute and/or chronic toxic effects. Chemicals which are corrosive when contracted could cause destruction to the site of contact and the most commonly affected parts of the body are skin, eyes and digestive systems. Skin irritants may cause reactions like eczema or dermatitis and severe respiratory irritants might cause shortness of breath, inflammation and oedema.[8]

Hazardous chemicals commonly handled by veterinarians and their personnel including therapeutic agents, barbiturates, anaesthetic gases, disinfectants, animal insecticides, formaldehyde, acetone and other solvents which may be accidentally inhaled, ingested or injected. Milligan et al., (1983)[46] report that chemicals used on animal patients by veterinarians include a number of anaesthetic gases, drugs, disinfectants and sterilants which could cause skin irritations, headache, neoplasia and even infertility and abortion among female veterinarians.

The study among zoo veterinarians in Australia showed that many chemicals and hazardous substances including formaldehyde, glutaraldehyde, chlorine bleach, immobilon, halothane, avisafe, dimethylsulfoxide, iodine, isoflurane, chlorohexidine, rabies vaccine, latex gloves powder and fibro glass resin were used in veterinary practices and these substances were reported to have caused health problems including headaches, lethargy, nausea, dizziness, sneezing, dermatitis, respiratory arrest and other respiratory problems and eye-nose-throat irritations.

The study carried out in Western Australia among veterinary practitioners[8] showed that many chemicals and hazardous substances caused headache, nose irritation, watering of the eye, dermatitis, respiratory problems, dyspnoea, nausea, skin disorders and other problems. The substances identified as hazardous included adrenaline, animal body fluids, antibiotics, benzylkonium chloride, bleach, cyclosporin, dark-room chemicals, detergents, disinfectants, euthanasia solutions, flea rinses, formaline, glutaraldehyde, hydrogen peroxide, insecticide, insulin, iodine, isoflurane, ivermectin, liquid nitrogen, methylated spirits, pentobabitone, potassium bromide, potassium hydroxide, prostaglandin, quaternary ammonium compounds, sodium hypochlorite, thiopentone, diazepam and xylazine.[8]

Exposure to any chemicals used in veterinary practice could have carcinogenic and/or teratogenic effects. Some of these chemicals cause headaches, nausea, respiratory problems, skin irritations as well as abortions and infertility in women. Well over 900 chemicals such as antibiotics, antineoplastic drugs, halothane and non-halothane anaesthetic gases have been found to be teratogenic or cause adverse reproductive effects.

*Anaesthetic gases*

Chronic exposure to anaesthetic gases has been associated with a number of adverse health problems. Australia has approximately one tenth the number of veterinarians in the US with similar type of veterinary practices and similar type of drugs.

The study among zoo veterinary practitioners in Australia reported that isoflurane was popularly used by all the veterinarians in the zoological gardens. Halothane was used by 15% as an additional anaesthetic agent presumably for anaesthetizing large animals. The study also found that zoo veterinarians have spent about ten and a half hours using mainly isoflurane as an anaesthetic agent. Discussions with the zoo veterinarians revealed that isoflurane has been used to anesthetize small animals and birds in zoo practice. Even though, veterinarians believe isoflurane to be the safest anaesthetic, 45% of veterinarians in the zoo study experienced nausea, dizziness, headache, sneezing and lethargy.

The study carried out among the West Australian Veterinarians[8] found that nitrousoxide, halothane, methoxyflurane and enflurane are the major gaseous anaesthetic agents used in veterinary practices. Seventy-seven (88%) respondents in the survey used gaseous anaesthesia and exposure to gaseous anaesthesia was identified as a major occupational hazard in veterinary practices. Halothane is the most commonly use anaesthetic agent in Australia. Halothane is comparatively cheaper than isoflurane and other commonly used anaesthetic agents. However, the use of anaesthetic agents may depend on individual practitioners preference, and prior experience with such agents. Halothane is also a common anaesthetic agent used in the US and the UK.

The study among veterinary practitioners in Western Australia[8] also revealed that small animal practitioners reported highest rate of exposure to anaesthetic gases which confirms studies carried out in the US. Many participants also identified exposure to inhalation-anaesthesia as a major occupational health hazard. The study revealed that 22% of veterinarians in the survey identified halothane exposure as having caused headaches and nausea. Therefore, by extrapolation, this could mean that thousands of Australian veterinarians including zoo veterinarians and their staff have the potential to be exposed to halothane and methoxyflurane or similar anaesthetic agents used in veterinary practices in Australia.

A number of studies on waste anaesthetic gas and vapour exposure on reproductive outcomes amongst veterinarians showed that females working with anaesthetic agents had miscarriages, abortions and congenital birth defects. When inhaled, gaseous anaesthetic agents cause respiratory diseases. Exposure of pregnant female staff to gaseous anaesthesia may cause birth defects.[17,53,55,212]

As far back as in 1974, an increased risk of spontaneous abortion has been reported among female anaesthesiologists.[206] Corbet et al., (1974)[243] in their survey found that nurse anaesthetists who were exposed to anaesthetic gases during their pregnancy experienced very high incidences of birth defects including hemangiomas, heart defects, hypospadias, pyloric stenosis, pectus excavatum, microcephaly (imperfect development of the cranium) and mental retardation. This has been confirmed by a number of epidemiological studies in the US and the UK. Gross and Smith (1993)[244] in their study reported that there have been increased rates of abortion and birth defects not only in female veterinarians, but also in the wives of male personnel exposed to waste anaesthetic gases. A study by Guirgis et al., (1990)[245] reported that exposure to waste anaesthetic gases significantly increased the ratio for spontaneous abortion among exposed females and spouses of exposed male workers and for congenital abnormality in offspring of exposed females and spouses of exposed male workers. The results of this study found a positive association between exposure to anaeshetic gases and abortion which was surprising because scavenger systems were used during the study period.[245]

In the study among the veterinarians working in the zoological gardens in Australia, 90% of veterinarians reported that their clinics were equipped with a range of extractor fans. However, 75% of the participants indicated that they always used the scavenging system while some veterinary practitioners used the scavenging system sometimes or never used the scavenging system. According to the survey among veterinary practitioners in Western Australia,[8] over 55% of the respondents did not answer the question on the number of scavenging units installed in their practices, although, they answered other related questions. This indicates that those practices either did not have scavenging units or they were not aware of the types of units available. The study among zoo veterinarians showed that veterinarians were able to protect themselves from waste anaesthetic gas exposure due to effective use of scavenger systems more than the private veterinary practitioners.

In the US, waste anaesthetic gas exposure must be decreased by effective scavenging equipment to a level of 2 ppm as recommended by the NIOSH, 1994.[246] However, there is no set recommended safe limits in Australia. Veterinary practices where gaseous anaesthesia is used, should be well ventilated and have adequate scavenging systems to extract waste anaesthetic gases. The study by Potts and Craft (1988)[72] indicated that the use of scavenging systems such as ceiling exhaust fans brought about a 38-fold reduction in the exposure levels in surgical rooms. Such measures could result in controlling waste anaesthetic gas exposure and reduce gas concentration from non-scavenged and poorly maintained anaesthetic machines. Passive venting to the outside, suction-drawn venting and the use of charcoal to absorb waste gases, are other methods of scavenging.[247]

*Pesticides*

Pesticides are designed and used because of their toxicity, therefore, they are potentially harmful for the veterinarians and others who are associated with them. Veterinarians use a number of pesticides for the control of pests in their patients.

The study among zoo veterinary practitioners in Australia found that 75% of veterinarians have been exposed to pesticides. A study carried out in Western Australia among veterinary practitioners identified fenthion/malothian and asuntol to have caused headaches, nausea and skin allergies among veterinarians[8] The study among zoo veterinarians in the US[1] indicated that 85% of veterinarians used pesticides and of these, 8% experienced adverse reaction to pyrethroid, carbamates and organophospates exposures resulting in skin, respiratory reactions and nausea. In a North Carolina study by Langley et al., (1995),[10] 11.4% veterinarians and in a study by Hafer et al., (1996)[11] 3.3% of swine veterinarians reported an adverse reaction to pesticides.

According to the Health Profile for Safe Handling of Pesticides, there are about 10,000 registered commercial pest control chemical agents in Australia. The commonly used pesticides in veterinary practices include organophosphates, carbamates, and pyrethrins. Studies confirm the use of similar pesticides in the US. A study by Langley et al., (1995)[10] showed, that large animal practitioners used less pyrethrins and carbamates than other practitioners. Centres for Disease Control in the US (1988)[58] reported that, in a study on the use of pesticides by 24 pet groomers, 50% developed symptoms when flea-dip products were used. Litchie and Hartle (1984)[210] in their study reported that fenthion caused health hazard to workers in an animal hospital in Georgia. Veterinarians should ensure that the handling of pesticides in their practices is consistent with the labelling of those products.

*Dermatitis and allergies*

In this study among Australian zoo veterinarians, a number of chemicals were identified to have caused skin disorders, respiratory and other problems. The study reported that formaline exposure caused respiratory and other problems in 50% of participants while chlorine caused skin reactions, respiratory and other related problems in 25%, and avisafe caused dermatitis in 10% of zoo veterinarians. The other agents caused skin and respiratory problems include rabies vaccine, dimethylsulfoxide (DMSO), fibre glass resin, immobilon, chlorohexidine, glutaraldehyde and iodine.

The majority of participants in the study among veterinary practitioners in Western Australia[8] indicated that a number of substances including glutaraldehyde, formaldehyde, benzylkonium chloride, chlorohexidine, surgical spirits, cleaning agents, iodine, betadine, hibitane and malathion have caused dermatitis.[8] There are different types of dermatitis including acute and chronic contact eczematous dermatitis, granulomatous dermatoses, neoplastic dermatoses, folliculitis and acniform dermatoses, ulcerative lesions, pigmentary disturbances, alopecia, discoloration of skin, hair and nails. Studies have shown that veterinarians have developed dermatitis when exposed to veterinary drugs, bovine tuberculin, disinfectant and antibiotics such as procaine.[222,223]

Animal studies have shown that formaldehyde has been found to be mutagenic and teratogenic and considered to be a potential carcinogen in humans.[64] Even though, increased risk of upper respiratory tract and lymphopoietic cancers due to exposure to formaldehyde have been cited in the literature, human epidemiological data are not conclusive. A study by Loomis (1979)[65] reports that formaldehyde which is often used by veterinarians as a tissue sterilant and/or as a preservative for pathological specimens in the laboratories had caused adverse health effects such as dermatitis and irritation of the eyes and respiratory tract. Henrick and Lane (1977)[93] in their study report that sensitization to formaldehyde can also occur and may lead to asthma.

A number of studies have shown that veterinarians have greater prevalence of asthma than control subjects. Both asthma and infectious and/or obstructive respiratory diseases were common among veterinarians. A study by Lutsky et al., (1985) [98] report that the prevalence of these diseases increased with the length of occupational exposure with veterinarians being allergic to both the animals they treat and some of the therapeutic agents they use.

Occupational allergic respiratory disease is on the increase amongst veterinarians because of their close and frequent contact with animals. This study among zoo veterinary practitioners in Australia found 47% of participants experienced allergic reactions to animals due to working in enclosed animal housing facilities. The nature of allergies sustained were sneezing, wheezing, coughing, phlegm production, skin irritation, headaches, eye-nose-throat irritations and other symptoms. Also in this study, 17.6% of zoo veterinarians reported to have experienced animal allergies due to contact with a number of species including marsupials, equids, cervids, felids such as cheetahs and tigers and bovids such as greater kudus and gazelles.

The study among Western Australian veterinarians[8] also indicated that the veterinarians have been subjected to skin allergy, sneezing, hay fever, nausea, asthma, swollen face and eyes when exposed to dogs, cats, guinea pigs, rabbits and deer hair, and this has been confirmed by several other studies.[1,10] Studies have found that there is 20% chance of showing allergic symptoms to at least one animal such as cats or dogs. A survey by Langley et al., (1995)[10] revealed, that 20.3% of veterinarians in his study were allergic to at least one animal species. The study among veterinary practitioners in Western Australia[8] did not request specific information about the animal species to veterinarians were allergic. Langley et al., (1995)[10] in their study reported that veterinarians were allergic to animals including cats (16.6%), dogs (7.4%), horses (5.3%), rabbits (5.3%), cows

(2.1%), hogs (1.1%) and other (2.9%). Female staff were more likely to be allergic to cats (22.5% versus 13.8%) and rabbits (6.3% versus 2.7%).

A study by Falk et al., (1985)[62] on the prevalence of skin and respiratory disorders in veterinary surgeons revealed that, of the 34 participants, ten had periodic eczema on their hands and fingers while 19 had continuous eczema on their hands, fingers and arms and three had eczema on the face and neck. Birthing of calves and lambs exacerbated the skin conditions in some cases. Eight participants who were in contact with cows, horses, dogs, or cats suffered from rhinitis and conjunctivitis.[62]

Allergic symptoms such as rhinitis, conjunctivitis, cough, sneezing, urticaria, asthma, and anaphylaxis are due to sensitivity to antigens derived from animal origins. Asthma and respiratory diseases are linked to the length of work place exposure. Asthmatic attacks and infectious and/or obstructive respiratory diseases were found to be common among veterinarians. The prevalence of this condition increased with the length of exposure to allergic substances.

**Drug abuse and suicide**

Veterinary practitioners indicated the potential hazards for drugs they stock, some of which can be used by drug abusers. These drugs included pethidine, ketamine, barbiturates and analgesics. In the Western Australian study among veterinarians, four veterinary practices reported one drug related incident each and three reported two incidents each. The incidents reported were abuse with methadone by two veterinarians, pethidine abuse and pethidine addiction and subsequent death.[8] Veterinarians and associates as well as health professionals and pharmacists have easy access to a variety of drugs, therefore, there is great potential for abuse. It could be noted that although some veterinarians are aware of some of the commonly abused prescription drugs, others may not know all of the prescription drugs of abuse. Muscle relaxants which act on the central nerves systems are abused frequently due to their sedative effects. Certain drugs when used with alcohol result in prolonging the effect of either alcohol or the drug or both.

Substance abuse is considered to be a major occupational hazard among physicians and other health professionals and veterinarians are at risk from similar occupational hazards. There is little information available about the actual amount of substance abuse in veterinarians. One report has shown that a veterinary assistant died of hepatic failure after sniffing methoxyflurane as a euphoriant.[248] The level of drug abuse among Australian veterinarians due to work-related stress is not known, but it is estimated to be high. It has been noted that veterinarians are subjected to occupational stress caused by long and irregular hours of work, fatigue at the end of a long work-day, heavy work-load and professional isolation.

The discussions the author had with the senior veterinarians in the zoological gardens in Australia revealed, that drug abuse and suicide are not prevalent among zoo veterinarians, however, this is an emerging problem in the general population. It is presumed that there have been some suicides among veterinarinarian within the past 10 years by deliberately injecting barbiturates. There is a need for more detailed research on drug abuse and suicide among veterinarians.

**Stress and trauma**

Stress and trauma levels are considered very high among veterinary practitioners in Australia. The study carried out among zoo veterinarians in Australia found 60% of participants experienced a range of occupational stress and trauma due to improper management, lack of cooperation from staff in other sections of the zoo, high work load as well as criticizing and ridiculing by staff.

A study among veterinarians in New Zealand[34] found that a number of suicides were reported among younger veterinarians. The study also reported that of the 48.5% respondents, 25% felt depressed and 16% considered suicide. Veterinary Association Chief Executive in New Zealand, Murray Gibb said that, "the results have proved that fears of a widespread problem were well founded. The average veterinarians are experiencing high-levels of stress. The new veterinarians are particularly vulnerable and they are plunged into practice without an internship. They have all the challenges of proving themselves professionally competent in the real world, and having to take full responsibility for the client's animals. On top of that, they will have a student debt, they may be working long hours and living away from their usual support systems." The Association and the Veterinary Council have taken immediate measures to address the problems and the veterinarians have access to a free phone line staffed by Work-Place support that could be called at any time by those experiencing difficulties or who are concerned about a collegue. Special programmes, networking and mentoring schemes have been organized for new graduates.[34]

Work-related stress seriously impacts on the health of Australian veterinarians including those who practice in rural areas who it is believed, may experience more stress than urban veterinarians because of financial problems and isolation. The formal discussions the author had with Registrar of the Veteinary Surgeons Board, Western Australia revealed that in order to deal with this situation, the Australian Veterinary Association has instituted programmes to assist new graduates in practice and in Queensland, the Association supports a "hotline" for veterinarians experiencing workplace stress. In addition,special programmes and mentoring schemes have been undertaken to help those veterinarians who are affected by drug abuse and stress.

**Biological Hazards**

Zoonoses

Veterinarians and their associated personnel confront varieties of microbial hazards, including bacteria or viruses, due to infections obtained from animal contact and the nature of their work. The most common zoonotic diseases prevalent in Australia include toxoplasmosis, Q fever, leptospirosis, cat scratch fever, psittacosis and dermatophytosis. Other zoonotic diseases commonly prevalent in veterinarians throughout the world include anthrax, brucellosis, cat scratch fever, ornithosis, rabies, ringworm, salmonellosis, pasteurellosis and tuberculosis.

Zoonotic diseases where there is a high level of risk for veterinarian, especially those in large animal practice or public health, include brucellosis, tuberculosis, leptospirosis, salmonellosis, Q fever, cryptococcosis and listeriosis.[46] Q fever is one of the major zoonotic disease to which Australian veterinarians and associates in rural practice are exposed. Australia is free from rabies exposure and hence bites from animals do not pose zoonotic risk for this disease. However, Lyssavirus is of concern. Because of its eradication, brucellosis is no longer a problem for Australian veterinarians, however, pig-borne brucellosis is still of concern.

In this study among Australian zoo veterinarians, 40% reported to have contacted ring-worm, psittacosis, scabies and paronychial infection. The zoo study reported that only 29.4% of respondents have undertaken a base line serum level test at the start of their employment. It was noted that 70% of respondents have not taken this test. Veterinarians have to treat a range of animals in a zoo environment and tend to contract a number of zoonotic infections, and therefore, it is important that they undertake the serum test.

Zoo veterinarians in the US[1] reported to have been vaccinated against many diseases. The percentage of zoo veterinarians vaccinated in two different studies in the US and in Australia are shown in Table 27.

**Table 27. Percentage of zoo veterinarians vaccinated for specific diseases in the US and in Australia**

| Type of vaccination | US (%)[1] | Australia(%) |
|---|---|---|
| Tetanus | 94.2 | 94.0 |
| Rabies | 77.3 | 65.0 |
| Polio | 62.5 | 82.0 |
| Hepatitis B | 25.3 | 88.0 |
| Yellow fever | 23.8 | - |
| Q fever | - | 17.6 |
| Typhoid | 19.1 | 65.0 |
| Cholera | - | 11.8 |
| Measles | 46.9 | 88.0 |

Among the veterinary practitioners in Western Australia, 20% of veterinarians indicated that zoonotic diseases are a health hazard in their practices, but only three percent reported having had a zoonotic disease. In Australia, there is a high level of risk for veterinarians and staff from ring-worm, Q fever, ornithosis, leptospirosis and toxoplasmosis.[8] A study by Schnurrenberger et al., (1978)[249] in Illinois found, 42.7% of veterinarians experienced a zoonotic infection. Langley et al., (1995)[10] in a study in North Carolina found that, of the 701 respondents, 35% reported one zoonotic infection during their career. Zoonotic diseases cause not only diseases with serious physical and mental health consequences but also loss of income to veterinary practitioners and their associates.

Veterinary practitioners have been exposed to zoonotic diseases due to accidental contact or injection with vaccines against, for example, rabies and brucellosis. Other vaccines which have been reported as having zoonotic potential are those used to prevent newcastle disease, ovine-ecthyma, infectious bursal disease and combinations of feline-panleukopenia-calicivirus-rhino tracheitis-pneumonitis.[12]

Allergies

Repeated exposure to strong and toxic allergens can result in an allergic condition when the defence system in the body becomes exhausted. Allergic symptoms can also appear whenever the body becomes imbalanced due to serious physical trauma, subsequent to a major surgery, from anaesthetic exposure, vaccinations against diseases and emotional stresses. Symptoms can become worse at certain seasons of the year when there is high pollen concentration in the environment or when symptoms are acute at certain periods due to greater amount of allergen exposure.

This study among zoo veterinarians in Australia showed that the participants have spent four hours per day in an animal housing facility and 50% of participants reported allergic reaction to animals. The respondents also reported allergic reactions to a number of species including marsupials, equids, cervids, felids and canids. The nature of allergic reactions reported by zoo veterinarians in Australia has been confirmed by a study by Teilen et al., (1996)[219] which reported veterinarians experienced a three-fold increase in chronic cough and phlegm production while working in swine facilities for over 20 hours per week and large animal practitioners experienced two-fold increase in chronic cough, chronic phlegm production and asthmatic attacks. The study by Langley et al., (1995)[10] showed that female veterinarians experienced higher rates of allergies than the males did.

The Western Australian survey among veterinary practitioners[8] revealed that 17% of veterinarians in the cohort had allergic reactions to animal such as cats, dogs, deer hair, dog semen and rabbit fur. The study by Hill et al.,(1998)[1] among zoo veterinarians in the US also showed that 20.3% of veterinarians were allergic to at least one animal species including cats, dogs, horses, rabbits, cows and pigs. Cross sectional studies on veterinarians and other animal handlers[10,11,111,115-118,120,121] reported prevalence of allergy to animals ranging from 7-44%. The frequency of animal allergy in the US[1] co-relates with the values at the higher end of this range suggesting a higher prevalence of animal allergy to zoo veterinarians than veterinarians and animal handlers in cross-sectional studies. The study among zoo veterinarians in Australia suggests that prevalence of animal allergy is higher than the values mentioned in previous studies.

## Conclusion

An initial overview of occupational injury among zoo veterinarians in Australia and among veterinary practitioners appears to show a low number of occupational hazards. But reviews, studies and author's experience as a veterinarian and working in a zoo environment for several years, as well as being the chairman of a safety committee and member of an ethics committee revealed that veterinarians in zoo and private practice experience a high risk of adverse work place exposures resulting in injuries, some of which are serious enough to require hospitalization and days off work.

The study among zoo veterinarians in Australia showed that 60% of respondents sustained one to three physical injuries at their practices over a five-year period. The common injuries included crushes, bites, scratches, needlesticks, knife wounds and scalpel blade cuts requiring sutures and treatment. The study also revealed that veterinarians in the cohort were hospitalized for animal-related injuries. Self-treatment of injuries has been common among zoo veterinarians. The injuries sustained by fifty percent of participants were strains and back injuries from lifting and moving animals and heavy objects. The injuries sustained by zoo veterinarians in Australia confirms other studies carried out in the US, the UK and in Western Australia. Three accidents involving motor vehicles were reported by zoo veterinarians in Australia. However, the study among veterinary practitioners in Western Australia[8] showed that there were eight motor vehicle accidents including two major accidents.

In the study among zoo veterinarians in Australia, all veterinary practices spent 10 hours per week with gaseous anaesthesia. The most common gaseous anaesthetic agent was isoflurane. Other agents used were halothane and sevoflurane. It is noteworthy to mention that halothane which is considered much more toxic than other anaesthetic agents was not used extensively by zoo veterinarians. Gaseous anaesthetic exposure was identified as an occupational health hazard for the zoo veterinarians. Participants in this study group experienced headache, nausea and lethargy due to the use of isoflurane. There are no set recommended safe limits for waste anaesthetic gas exposure in Australia, however, waste anaesthetic gas exposure should be reduced below the recommended safe limit of 2 ppm set by the US NIOSH.

Veterinarians in West Australian study identified prostaglandin used for oestrus timing and induction of parturition in animals as causing respiratory problems, nausea and fatal bronchospasms in asthmatics. The zoo study carried out in Australia could not ascertain the number of veterinarians exposed to prostaglandin.

The study among zoo veterinarians in Australia also identified 71% of veterinarians have been exposed to pesticides but none of the participants indicated the type of pesticide that they used. In the Western Australian study among veterinary practitioners, pesticides/organophosphates (Fenthion/ malathion, asunthol) and a number of flea spray and rinses have been used by veterinarians. Chemicals including dark-room chemicals, formaldehyde, chlorine, chlorohexidine, iodine and other chemicals have caused health problems such as skin reactions, respiratory and other problems among zoo veterinarians and veterinary practitioners in Australia. A number of flea rinses which are currently marketed are non-toxic and safe to be used for flea control.

The study among zoo veterinarians in Australia found that exposure to allergens from animal origin contributed to allergic conditions in the cohort. Zoo veterinarians on an average spent four and a half hours in an animal housing facility per day. Due to working in such environment, veterinarians experienced allergic reactions to animals such as sneezing, wheezing, phlegm production, skin irritation, eyes-nose-throat irritation and other problems. Precautionary methods have to be taken to reduce unnecessary exposure to chemicals and allergens in the work place.

Zoonotic infections are transmitted to veterinarians through animal contacts, injuries and accidental self-injection of animal vaccines. Forty percent of participants in the zoo study in Australia reported that they contacted zoonotic infections from animals. Eight percent of veterinarians in the West Australian study group indicated zoonotic diseases as a potential risk for them and their staff while only four percent sustained zoonotic infection.

All the participants in this zoo study in Australia used radiology in their practice. The study also revealed that there is a potential risk for veterinarians and staff from exposures to ionizing radiation. Even though veterinarians believed radiation exposure is a major occupational health and safety issue for the profession, they have not taken adequate precautionary methods including the use of protective gear to minimize exposure from ionizing radiation. The Code of Practice for the Safe Use of Ionizing Radiation[5] and the relevant acts and the amended radiation safety acts on "Dose Limits and Maximum Permissible Exposure Levels" should be adhered. Professionals involved in x-ray procedures should be properly trained and attend in-service training courses in radiology to update their knowledge on modern techniques on x-ray procedures, and compliance with radiation safety.

This study also identified that zoo veterinarians experienced stress and trauma at the work place which confirms the finding of other studies carried out among West Australian veterinarians and veterinary practitioners in the US, the UK and New Zealand.

The risk presented in this review could be considered a representative of the occupational hazards associated with the veterinary profession in a zoo environment and it is evident that the incidence of occupational injury to our veterinarians is very significant.

# CHAPTER 9.

# STRATEGIES AND RECOMMENDATIONS FOR MINIMISING HAZARDS IN ZOO AND OTHER VETERINARY PRACTICES

## Introduction

The Health and Safety Executive has defined the safety culture as "the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determines the commitment to, and the style and proficiency of, an organization's health and safety management."[250] Although, a number of organizations have put in place strategies for preventing occupational hazards in their work places, only some institutions have been successful in health and safety management.

Each state and territory in Australia is responsible for managing occupational, health and safety within its borders. General duty of care is common to all the occupational health and safety acts in all states and territories. Every individual in a work place is responsible for the duty of care of themselves, colleagues and visitors to the organization, in accordance with the occupational health and safety regulations. The duty of care provisions highlights the need for other legislative requirements including the development of policies, education and training. The legislation can only provide the minimum requirements necessary to establish a safe and healthy working environment. But, establishing and maintaining safety in the work place takes more than fulfilling legal requirements. The Australian Health and Safety at Work sets out recommendations for promoting 'health, safety and well-being' of people in thei workplaces.[239] The legal responsibilities of employers in relation to routine management of the work place will have to be adhered. The employer will have to concentrate on some of the more obvious areas of concern and use them to promote a greater awareness of health and safety issues.

The veterinary surgeons are solely responsible for the safety of themselves, their associated personnel and all those who enter the veterinary premises. All employees including locums, casual, temporary and contract workers, should know the nature and the range of hazardous exposures such as physical, chemical and biological causes of disease, injury and accidents prevalent in veterinary practices. Employers must take adequate measures to reduce their employees' exposure to any hazards in the work place. In order to create a safe and healthy work environment, safety policies and practices have to be documented and implemented.

Typically, veterinarians employed in zoological gardens have to attend to the care and treatment of a diverse collection of animals including endangered species. Treatment of wild species is different from the normal domesticated animals that the veterinarians are somewhat familiar with. Veterinarians who attend to wildlife health investigations and treatment have to be ideally qualified as problem solvers and decision makers. Wildlife veterinarians have a lot to offer to improve the health of a wide collection of exotic and native species held in zoos and wildlife parks. A zoo veterinarian may have to develop the necessary expertise and the gear to handle these clinical challenges and have to gain the specialist knowledge over the years.

In zoological gardens, the treatment and some surgical procedures are mostly undertaken in the animal housing facilities for larger animals. The veterinarian has to deploy the associated personnel such as zoo keepers and animal handlers to assist in such procedures. To successfully maintain the health and well being of animals in captivity, they have to be closely monitored and treated. Sometimes physical or chemical restraint has to be applied to undertake treatment. Restraining can be stressful and dangerous and could impair the immune system and increase animals' susceptibility to disease. Veterinarians working in a zoo environment with large and/or dangerous animals should have sufficient knowledge of an escape route before working with such animals.

This chapter focuses on the strategies to prevent or reduce those hazardous exposures most commonly encountered in veterinary practices along with suggestions for implementation of safety procedures.

**Physical Hazards**

Physical trauma is considered to be a major cause of physical injury to veterinarians and their staff. Physical hazards that may affect veterinary personnel include ionizing radiation, noise, vibration and physical trauma. Hazards for males and females are generally the same except where the female is pregnant. Some adverse effects could result from exposures that occur prior to fertilization. The size and rapid growth pattern of the foetus make it more susceptible to dangerous substances even in small amounts.[46] Landercasper et al.,(1988)[9] reported that veterinarians were exposed to numerous hazards because they encounter large and uncooperative animal patients. In a zoo environment, veterinarians have to care and treat a range of wild animals in captivity. The most frequent injuries to which veterinarians and their associates are exposed include bites, scratches and crushes. Veterinarians are also exposed to other hazards including acute trauma such as fractures, lacerations, fall injuries, wound infections and their complications as well as psychological trauma.

Ergonomic injuries due to heavy lifting, overexertion or awkward postures might pose work-related musculoskeletel disorders such as tendonitis, back injuries, other sprains or strains. Needlestick injuries, necropsy injuries, hearing loss, heat and cold injuries and equipment injuries are also of concern. Zoo veterinarians in Australia experience a greater number of needle stick injuries that requires medical treatment including adverse reaction to injected agents, infections and severe lacerations. Both West Australian study among veterinary practitioners[8] and the study among zoo veterinarians in Australia reported that veterinarians and staff have sustained numerous needlestick injuries. The practice incidence of needle recapping among veterinary personnel is unknown, but given the extent of the problems associated with needlestick injuries among veterinarians including zoo veterinarians, there is a strong reason for concern and further study.

Adequate restraint of animals during diagnosis and treatment requires a physical method of restraint. To avoid injury from animal patients, proper methods should be undertaken in restraining animals using anaesthetics. Sedatives and tranquilisers do not always afford full protection. Large animals which are partially sedated could cause serious injuries to veterinarians and their associates. If wild and semi-wild animals are to be restrained, immobilizing agents could be injected from a distance with darts or with specially designed guns.

Staff and clients/owners in private veterinary practices should be provided with guidelines and instructions and warned of the possible physical hazards associated with handling and treatment of animal patients. Clients probably should not hold their own animals because of possible litigation if injured by their animal, even if they volunteer to hold their own pets. Nevertheless, this is often impractical because as often occurs after hours, and there is no-one else to restrain the animal.

The increase in the number of women taking up to veterinary medicine and the increased participation of women working as associated personnel and technical staff has changed the pattern of work-related hazards among female veterinarians and female staff. The health of female veterinarians is attracting concerns as great number of women enter the profession.

As mentioned in Chapter two of this thesis, claims for compensation by veterinarians and their staff in Western Australia from 1991 to 1996 show that the largest claims (36%) were from animal bites while 8% were from being attacked by an animal and 15% from muscular stress.[251]

Hearing loss has not been widely reported in the veterinary profession, although, 3% of zoo veterinarians in the study by Hill et al., (1998)[1] and 22% of swine veterinarians in the study by Hafer et al., (1996)[11] in the US have reported hearing losses. It is unlikely that equipment will cause hearing loss, however in a zoological environment animals such as elephants, lions, certain species of primates including gorillas and gibbons might cause noise hazard and could be a problem to the staff and neighbouring residents. Similar problems do exist due to barking dogs held for treatment in private veterinary clinics and hospitals. Barking has been estimated often to cause sound pressures over 85 dB and even up to 105 dB. If occurring over an eight hour period, this would be above the threshold defined in current Australian legislation and might result in legal action. According to Seibert (2000),[252] the noise levels in animal facilities typically range from 95 dB to 115 dB. A weighted upper end of this range is considered hazardous and a person should not be exposed to such hazard for a long time. If the noise level cannot be reduced by any method, personal hearing protection will have to be used. Varieties of ear muffs and disposable foam earplugs could be used to reduce noise levels by at least 20 dB and this could reduce the risk of long-term damage. Noise hazard areas must be identified by means of a poster, placard or sign.[252] The hearing protection that has to be used must be of high quality, and meet the Australian standards.

To minimize hazardous exposures in zoo and private veterinary practices, it is important for the veterinarian to become knowledgeable about occupational hazards. Veterinary practice should be a safe and healthy place to work, and the veterinarians have to develop a healthy and safe program for their practices. Employees in the practice in their first week of employment should be provided with an induction program that involves safety training. There should be a continuing commitment to, and reinforcement of, occupational health and safety training for all personnel in the practice. It is also important to provide written and verbal instructions on the procedures to be followed in an animal hospital. Correct procedures for lifting animals and using appropriate equipment will reduce back injuries to veterinarians and their personnel. Evidence, however, shows that back problems are related not so much to how physically heavy or light the work is, but how the lifting of heavy objects is done.

The high rate of physical injuries occurring when handing animals highlights the hazardous nature of some procedures which are in existence. Solution to a safety problem sometimes requires detailed knowledge and experience. Designing and developing a healthy and safe program will protect the veterinarians and their associates from adverse occupational exposures.

***Recommendations:***

- ***Adequate guidelines and instructions should be provided about the potential for physical hazards.***

- ***Safety training and induction programs should be provided to all employees associated with restraint and treatment of animals.***

- ***Personal protective equipment such as aprons, gloves, masks, footwear, protective glasses, long-sleeves shirts, lab coats, leather gloves and face shields should be used while handling and treating animals.***

- ***Veterinarians with cuts or abrasions on their hands should always wear double gloves.***

- ***Suitable hearing devices such as ear plugs or ear muffs should be used in noise hazard areas where the noise level is above 80dB(A) to prevent damage to the inner ear and subsequent hearing loss.***

- ***Manual handling of animals should be avoided as much as possible and the task may be redesigned.***

- *Animals should be restrained at all times either by physical method by muzzling or have someone to hold the animal.*

- *Adhere to correct techniques for lifting animals, equipment and heavy objects to avoid musculoskeletal injuries. Always lift heavy animals or objects without bending from the waist to avoid ergonomic injury or request for assistance.*

- *Avoid use of step stools or ladders while treating un-anaesthetized animal patient.*

- *Zoo veterinarians should keep protective gear such as gloves, goggles, jumpsuits, head gear, hearing protection and boots within hand's reach.*

- *Veterinarians in zoo practice should check where an animal is before entering an enclosure. Animal enclosures should use lock-out procedures, and design cage and gate locks so that the key cannot be removed unless the lock is closed.*

- *Zoo veterinarians should assist curators and others during emergency drills and in formulating procedures to be followed during an animal escape as well as on the use of anti-venom for snake-bites.*

- *If an injury occurs, appropriate first-aid procedures should be applied.*

- ***Take steps to inform workers' compensation insurance if the injury requires compensation.***

**Chemical Hazards**

Veterinarians in zoo practice and in private practice experience ill-effects due to exposure to chemicals. Recognition of hazards in any occupational activity involves characterization of work place by identifying hazardous chemicals and the workers potentially exposed to these hazards. The chemical exposure may either be immediate or occurs over a long period of time or both. There are several concepts in place to classify the health effects of chemicals. A single acute exposure with high dose of carbon disulphide can result in unconsciousness, however repeated chronic daily exposure for years at slower doses can result in damaging the systems such as central nervous systems, heart, liver and the kidneys. Chemicals are marketed into workplaces with variety of trade names and the information provided by the manufacturers is inadequate. According to the Occupational Safety and health Regulations, in Australia, manufacturers or importers are required to provide a MSDS for chemical products to the workplaces, although, risk of adverse effects of exposure to new chemicals and new technologies are still relatively unknown.

The information on the use of chemicals and their side-effects should be known before they are used in veterinary practice including zoo practice. The type of occupational hazards and the magnitude of exposure may not be fully understood by those who experience problems due to chemicals. Present data are inadequate to measure all the risks associated with chemical exposure. On the interest of the workers, Australian Council of Trade Unions adopted a health and safety policy on chemicals in 1983. The policy recognises the risks to health and safety posed by chemicals used at work and take appropriate action to reduce the risks of chemicals in both veterinary and zoo practices. Commonly used hazardous chemicals/substances by zoo veterinarians and their associates include formaline, isoflurane, halothane, nitrous oxide, antineoplastic drugs, ultrapotent narcotic analgesics, immobilizing agents, ethylene oxide, zylene, glutaraldehyde, and pesticides.

Chemicals that are being used in zoo and private veterinary practices should be checked, identified and labelled on arrival. The location and construction of buildings for storing chemicals have to be carefully planned to prevent harmful exposure of persons to the effects of chemicals. Chemicals should be kept in tightly covered containers and handled with caution. A policy for handling these materials has to be developed and displayed in appropriate places. The use of adequate protective gear including protective eye wear and mask must be worn while handling chemicals. Skin contact with chemicals should be avoided.

Employers must identify and maintain a record of all hazardous chemicals used in their work places and provide MSDS which contain instructions, warnings and guidelines to employees. Chemicals must be handled according to the manufacturer's instructions. The manufacturers and distributors of those chemicals must provide the principal veterinarian/ purchaser with 'material safety data sheets' containing physical and chemical data, safety data instructions, handling instructions, storage conditions and advice on protective apparel for each hazardous chemical supplied. This advice should be followed when storing, using and disposing of each chemical.

Employees are often exposed to hazardous chemicals on a regular basis and therefore, it is important that veterinarians, veterinary technicians and other associates are properly trained on chemical safety and prevention, first-aid and emergency procedures, use of personal protective equipment such as hoods, gloves and eye wear as well as safe work practices. Veterinarians including those who are in zoo practice must have a broad knowledge and be well informed of the physical and health risks involved when handling these hazardous substances.

Formaldehyde/formaline is commonly used in veterinary practices. To avoid exposure to formaline, it is advisable to have the following information appear on bottles of Formaline/formaldehyde - "Formaldehyde (10% formaline) - toxic in terms of its acute lethal effects by oral route, inhalational toxicity, irritating to the eyes, respiratory system, and skin. It may cause sensitisation by inhalation or skin contact. Risk of serious damage to the eyes. Prolonged or repeated exposure increases the risk of cancer." The Short Term Exposure Level (STEL) for formaline is 2.0 ppm. The Permissible Exposure Limit (PEL), based on an eight hour day, is 0.75 ppm. The level at which Environmental Health and Safety is required to take action to lower the exposure levels is 0.5 ppm. All areas utilizing formaline have to be tested on a regular basis and maintain Action Level below 0.5 ppm.[253] It is imperative that knowledge, awareness, and good practice habits be reinforced constantly to prevent chemical exposures and injuries to veterinarians and their associates.

There is much to be learnt about proper and safe handling of anti-neoplastic agents and it is advisable that careful approach with good technique is made while handling antineoplastic drugs in veterinary practices. An accidental spill of this drug on the skin will have to be washed with soap and carefully rinsed with water. If it splashes into the eyes, an eye-wash is recommended. If necessary, the physician should be consulted immediately.

***Recommendations:***

- ***A policy for handling chemicals should be developed and implemented.***

- ***As a protective measure substitution of an agent with less hazardous substances, must be utilized to limit exposure.***

- ***Training on chemicals safety, emergency procedures and work safe practices should be provided.***

- ***MSDS should be maintained according to the Australian standard.***

- ***A record of all hazardous chemicals used should be maintained.***

- ***Chemicals should be labelled, carefully stored and handled with caution as indicated in the manufacturer's instruction manual.***

- ***Adequate personal protective equipment in the form of gloves and mittens to protect the hands, safety foot wear to protect the feet, coats or overalls to protect the body, spectacles, goggles or face shields*** *to protect eyes and the face and respirators for respiratory protection should be used while handling hazardous chemicals. This requirement should be documented on the chemicals Materials Safety Data Sheet.*

- *Personnel handling chemotherapy treatment should use double latex gloves which is specifically designed for this purpose.*

- *While mixing chemicals, it should be ensured that the area is well ventilated well in advance of mixing the chemicals.*

- *Air monitoring of exposure levels to hazardous chemicals should be regularly performed, for example, weekly monitoring.*

- *When formaldehyde is used, gloves, lab coats, and protective eyewear should be worn at all times. Use in a hood is advisable, but, when not possible, it is important to minimize the use or use in a well-ventilated area.*

- *It is advisable to change double set of latex gloves every fifteen minutes and wear respiratory protection and gowns when handling antineoplastics.*

- *Skin splashes must be washed off in running water. Any chemical spill into the eyes should be flushed*

***with water for at least 5 minutes and then a doctor should be consulted. It is advisable to have a list of specialist doctors with contact numbers readily available where chemicals are stored.***

**Anaesthetic gases**

Anaesthetic gases produce complete insensitivity or unconsciousness when breathed or injected. They are used in human hospitals, veterinary hospitals and clinics and animal research facilities. Animal patients are exposed to anaesthetic gases very briefly, but those who work and others who are exposed on a regular basis are at risk of waste anaesthetic gas exposure and from unused fresh gases. The health effects due to inhaling anaesthetic gases may be acute or chronic. Short-term exposures can cause symptoms such as drowsiness, irritability and nausea. Chronic effects include reproductive problems, birth defects, liver and kidney problems, immune suppression, central nervous system disorders and cancer. No trace level exposure can be determined to be safe and it is wise keep exposure levels as low as possible.[254]

Common sources of anaesthetic gas pollution in veterinary practices include poor maintenance, excessive flow and careless work practices. The majority of veterinarians are unaware of the concentrations of and exposure to waste anaesthetic gases in their practices.

According to NIOSH (1977),[69] an estimated 50,000 veterinarians and their staff are exposed to waste anaesthetic gases. After reviewing the human and animal data on reproductive and embryofoetal effects of halogenated anaesthetic agents, NIOSH is of the view that a safe level of occupational exposure to halogenated anaesthetic agents cannot be established. Currently, no permissible exposure limits have been set by Occupational Health and Safety Authority for waste gases used in veterinary hospitals because the NIOSH has been unable to identify a safe level of exposure. Therefore NIOSH recommends that exposure be reduced to the greatest extent possible. Exposure concentrations of anaesthetic gases should not exceed 25 ppm (time-weighted average over the time exposed) for nitrous oxide and 2 ppm (based on a 1-hour sample) for halogenated agents such as isoflurane, methoxyflurane and halothane (NIOSH, 1977).[69] "The exposure standards working group recommends a time-weighted average exposure standard of 0.5 ppm for enflurane based on the similarity in toxicology and application between enflurane and halothane. The working group of the American Conference of Government Industrial Hygienists (ACGIH,1986)[255] also recognizes that occupational exposure to enflurane can be kept below this level if active scavenging equipment is used and maintained properly."

The study among the zoo veterinarians in US[1] reported the use of inhalant anaesthetics by a majority of participants with some participants experiencing an adverse reaction. Females were more likely to experience adverse reactions including headache, nausea, sleepiness with isoflurane and halothane and sleepiness and dizziness with nitrous oxide. The study among the veterinary practitioners in Western Australia[8] showed that 88% of the participants used inhalant anaesthetia. Halothane and methoxyflurane were used by majority of participants. Other gaseous anaesthetic agents used were nitrous oxide and enflurane. Study among veterinarians in zoological gardens in Australia revealed that all the participants used inhalant anaesthesia. Australian zoo veterinarians and the West Australian veterinary practitioners identified exposure to gaseous anaesthetia as a major health hazard. Halothane has been reported in the US as causing similar effects[212] and significant exposure to halothane has also resulted in abortion and infertility among women.

The study by Currier (1994)[256] among 25 hospitals in Iowa in 1989 identified major problems with the anaesthetic equipment including failure to conduct a daily preoperational check out procedure to detect deficiencies in the equipment, operator dependence on monitors and alarms used in combination with anaesthetic gas delivery system.[256]

Each anaesthetic machine needs to be checked for leaks and serviced on a regular basis to ensure the welfare of all staff in the practice. The machine should be examined and calibrated by qualified technicians, and a checklist should be used to ensure that correct maintenance is carried out. The recommendations by the manufacturer of the machine should be strictly followed. Staff members who operate the machine should be conversant with all aspects of anaesthetic agents used in the practice, storage of liquid agents, refilling and handling in an emergency situation. Periodical checks of exposure levels to anaesthetics are not mandatory in Australia. It is not compulsory in the US where Occupational Health and Safety standards have been developed specifically for veterinary practice. Exposure to anaesthetic gases could cause harm and exposure should be minimized.

Veterinary medical clinics and hospitals in Australia should be periodically monitored for anaesthetic gas exposure and institute appropriate control measures. Precautionary measures should be taken to protect veterinary practitioners and their associates from waste anaesthetic gas exposure as this can cause adverse effects on a person's biological system. Pregnant veterinarians and staff in zoo veterinary practice should aim to minimize the exposure to waste anaesthetic gases by using scavenging systems, periodically testing anaesthetic machine for gas leaks and by not emptying or filling vaporizers. By introducing a proper management program, the exposure to waste anaesthetic gas, not mobilised by animal patients, could be minimized.[32,53,55] An approved scavenging system to extract all excess gases and transport them to a safe area usually outside the building, will effectively reduce the waste anaesthetic gas exposure in the workplace. The scavenging systems include active scavenging systems, passive exhaust systems and absorption systems. It is also important to provide ventilation in all work areas to minimise anaesthetic gas exposure.

Exposure to waste anaesthetic gases may be controlled by effective anaesthetic gas scavenging systems that remove excess anesthetic gas at the point of origin; effective general or dilution ventilation; good work practices on the part of the veterinarian and associated personnel including the proper use of controls; proper maintenance of equipment to prevent leaks; and periodic personnel exposure and environmental monitoring to determine the effectiveness of the overall waste anaesthetic gas control system.[253] Veterinarians also utilised passive systems of disposing gases by simple tubes leading from the respiratory valve of the anaesthetic circuit to the outside of the operating theatre.[212] Monitoring of waste anaesthetic gases is possible through air sampling, dosimeter badges and portable infrared analysers, but monitoring is costly and, therefore, not routinely practiced.[32,53,55]

*Recommendations:*

- *Anaesthetic machines must be serviced regularly and maintained by qualified personnel to ensure proper functioning of the equipment.*

- *On-going preventive maintenance of anaesthetic machine includes daily leak testing and an effective engineering control system.*

- *Adequate general ventilation must be provided for the dilution of anaesthetic gas in areas where anaesthetic machines are used.*

- *Sufficient effective exhaust and disposal systems are essential in all areas where inhalation anaesthesia is used.*

- *Scavenging system should be made mandatory for anaesthetic and operating rooms.*

- *Start the gas flow only after induction and perform surgical procedures with the endotracheal tube cuff properly inflated.*

- *Monitor anaesthetic gas exposure on a regular basis and institute appropriate control measures. Monitoring can be accomplished by using dosimeter badges, portable infrared analyzers and safety practices.*

- ***Proper management program for waste anaesthetic gas exposure should be implemented.***

- ***Flush the patient with oxygen before disconnecting the tube and use an oxygen flow rate appropriate to the animal's size.***

- ***Periodic personnel exposure and environmental monitoring to determine the effectiveness of the overall waste anaesthetic gas control system will help in the reduction of waste anaesthetic gas exposure to veterinarians and others in the vicinity.***

- ***Pregnant veterinarians and female staff of child bearing age should minimize their exposure to waste anaesthetic gas by always using scavenging systems, by periodically testing anaesthetic machine gas leaks and by not emptying or filling vaporizers.***

**Pesticides**

In the past, biological control methods such as dung beetle to combat bush flies, gambusia to combat proliferation of mosquito larvae were used when human health was threatened by living pests. Since physical and biological methods were insufficient to control a variety of pests, toxic chemical agents were introduced as an intergrated approach on pest management. Pesticides are designed and used because of their toxicity and there is potential harm for the applicator and the community. Agricultural scientists have estimated that without the use of pesticides, even the production of some crops and livestock could be reduced.

Pesticide exposure in veterinary practice occurs primarily through cutaneous exposure to pet grooming products such as flea dips and insect-repellant wipes. Secondary routes of exposure include inhalation of products such as insect fumigants sprayed in animal confinement areas. Veterinarians are exposed to pesticides when they have to control pests in their patients.

In Australia, there are a number of commercial pest control companies and numerous pesticide constituents are being used. Each product poses its own characteristics degree of risk. In the past, there has been considerable amount of documentation pertaining to the use of dichloro-diphenyl-trichloroethane (DDT) because of its potential effects to form a long-standing residue in human and food chain and classified as an organo-chloride. In a National survey conducted by the Environmental Protection Agency, Washington, US, from 1971 to 1977,[253] the health status of persons exposed to pesticides was continually monitored on a cohort basis with a similar non-pesticide cohort group. The findings showed high serum level of organochloride, increased accidental trauma, dermatitis and skin cancer, hypertension and sclerotic cardio vascular disease among those who were exposed to pesticides.

There are currently about 3800 pesticide products registered for use in the State of New South Wales in Australia by the National Registration Authority for Agricultural and Veterinary Chemicals. These chemicals are used extensively in both urban and rural areas almost in all the states of Australia. Pesticide is a substance or mixture of substance represented, imported, manufactured, supplied and used directly or indirectly for control of pests. Pesticides such as pyrethrins and carbamates could cause skin problems and fenthion used for flea/ticks control has caused human illness in several veterinary clinics and grooming facilities. Veterinarians in zoo and private practice should take precautions to prevent the toxicologic and legal problems that can result from improper use of injudicious dispensing of insecticides.

The use of insecticides such as aldrin, dieldrin and heptachlor has been banned in Australia since 1994. This brings Australia into line with New Zealand which has not allowed registration of any organo chlorines since 1991.

***Recommendations:***

- ***Carefully identify the pest and consider appropriate control measures.***

- ***Pesticides should be used only where they are absolutely justified.***

- ***Replacement of harmful pesticides with less toxic pesticides is recommended.***

- ***It is the legal responsibility of the person concerned to ensure that the pesticide is correctly used according to the instructions on the pesticide product label.***

- ***Use of personal protective equipment such as gloves and aprons may prevent the development of pesticide exposure symptoms.***

**Biological Hazards**

There is a close link between human beings and animals and most pathogenic and non-pathogenic organisms move freely between humans and animals. There are well over 150 pathogenic organisms have chosen humans and one or more species of animals as a suitable media for their existence and proliferation. Emerging zoonoses are defined as zoontic diseases caused either by apparently new agents or by previously known micro-organisms, appearing in places or in which the diseases were previously unknown.[125]

Biological hazards are caused by living organisms found in the work environment. Some infections may cause an allergic response, endotoxins and micotoxins can cause acute chronic respiratory symptoms. Biological hazards can be classified (a) by mode of transmission through blood borne, zoonoses, vector-borne, and by droplet spread; (b) by aetiological agent such as bacteria, rickettsiae and fungi; (c) by occupational groups at risk including veterinarians in private and zoo practice, farmers, health workers, forestry workers, veterinary staff and zoo keepers. Veterinary surgeons are particularly at risk for contracting leptospirosis and cat-scratch disease while bird handlers may contract psittacosis and ornithosis and health workers may contract hepatitis and HIV.[257] Infectious animal diseases are also one of the major causes for morbidity and mortality among veterinarians.

Zoonoses with teratogenic and abortifacient effects include brucellosis, tuberculosis, cryptococcosis, listeriosis, lymphocytic choriomeningitis, Q fever, toxoplasmosis and Venezuelan equine encephalitis. For example, cats are the definitive host of the disease toxoplasmosis while humans can be the intermediate hosts with subclinical infection. The oocysts are shed by the cat for two weeks after infection and then become infective after they sporulate in 1-5 days. After sporulation, the oocysts can survive in soil for up to one year. Humans can get infected by ingestion of oocysts through cat faeces, undercooked meat, inhalation or by handling an infected cat. Listeriosis is a bacterial disease of ruminants, occasionally produces abortion in sheep and cows. Listeria monocytogenes is widespread in the environment and most often causes disease among human by ingestion of infected milk of contaminated dust.[258]

Veterinarians in zoological gardens have been exposed to scratches and bites to rabid animals. In the US, it has been reported that veterinarians were exposed to rabies from animals including red pandas, bats, raccoon, skunk, chimpanzee and fox. Fox, jackal and feral dogs are reservoirs of rabies contracted by humans in South East Asian and several other countries.

***Recommendations:***

- ***Veterinarians and their associated personnel should be vaccinated against pre-exposure vaccinations such as rabies, tetanus, hepatits and other illnesses.***

- ***Immunocompromised individuals may benefit by frequent monitoring of serum samples.***

- ***A base line serum sample should be collected and preserved for all personnel including veterinarians and others working with animals.***

- ***Periodic tests for tuberculosis and other diseases as well as annual testing for parasitic diseases should be undertaken.***

- ***Veterinarians should wear protective clothing and equipment whenever appropriate to reduce risk from zoonotic and other infections.***

- ***Veterinarians working in zoos and in private practice will have to undertake annual serum testing if there is an outbreak of zoonotic disease in the animal collection.***

**Allergy**

Veterinarians have very close contact with animals due to their occupation. They sustain workplace exposure to allergens of animal origin such as hair, dander, urinary protein from the faecal material and urine, blood proteins and ecto-parasites conceivably increases the potential for the development of occupational allergic respiratory disease. In sensitized persons, exposure to allergic agents may contribute to allergic symptom such as allergic rhinitis, conjunctivitis or asthma. Allergic alveolitis is characterized by acute respiratory symptoms such as cough, fever, headache, chills and muscle pain which may lead to chronic lung fibrosis.[66]

Occupational allergic rhinitis is caused by exposure to allergens and those who work near animals such as veterinarians, researchers and farm workers may have episodic symptoms when exposed to certain animals. The symptoms can be short-term or continual and some workers experience seasonal symptoms. Other significant occupational allergens that may cause allergic rhinitis is the inhalation of powder from latex gloves.[259] Allergy to animals as a result of workplace exposure has not been widely described for specific animal-based occupation, except for laboratory animal workers where hypersensitivity to laboratory animals represents a recognized occupational disease.[98]

Symptoms of allergy may be severe as to necessitate changing jobs.[115] Agrup et al., (1986) in their study reported that 17% laboratory technicians stopped work because of animal allergy related symptoms.[115] Studies among swine and poultry workers reported that adverse reproductive effects of working in animal confinement buildings included acute irritation of the respiratory tract, prevalence of chronic respiratory symptoms and small decrements in lung function.[260-262]

A study by Backstrom and Jolie (1994)[123] on respiratory ailments among veterinary students visiting a swine farm reported that 38.6% of participants had allergic reactions at the farm while 49% fell ill within seven days of the visit. Most common allergic symptoms reported were cough, nasal, throat and sinus irritation as well as headache.

A study on occupational allergy to animals by Seward (1999)[122] found that the overall prevalence of allergic respiratory symptoms in exposed workers was 23% with 4-9% developing asthma. Duration and intensity of exposure was related to the development of the symptoms. Environmental control of antigens, general environmental hygiene, training and medical surveillance of workers are important elements of allergy preventive program.

One third of the zoo veterinarians in the Australian study group suffered an allergic reaction to an animal or contracted an animal transmitted disease including ringworm and psittacosis. Many animal allergies are contracted with proteins usually those found in animal dander or urine and veterinarians working in the zoo run the risk of developing latex allergy.

Given the documented harmfulness of the environment of livestock confinement facilities, it is important to use respiratory protective devices and other protective equipment to avoid allergic conditions. The use of gloves, gowns, lab coats and masks will decrease exposure to animal allergens and hopefully prevent development of symptoms. Once a worker develops symptoms from allergens, not only wearing personal protective equipment, but also taking prophylactic medication is necessary to alleviate symptoms.[111]

Veterinarians in zoological gardens in Australia, the US, the UK, Canada and in other developed and developing countries have been exposed to specific allergens including certain animal species, pollen, chemicals and environmental pollution. If specific allergic triggers are unknown, it is difficult to recommend appropriate preventive measures. The medical practitioner should know the allergen that is sensitive in order to perform allergen immunotherapy (desensitization treatment). Skin allergy testing, radioallergosorbent test (RAST) is the most commonly used method of determining allergy to a particular substance which indirectly measures the quantity of specific IgE to a particular antigen.[259]

*Recommendations:*

- *Training should be provided to educate workers about animal allergies and the steps to be taken for risk-reduction.*

- *Individual veterinarians and staff with family history of allergies should take appropriate precautions.*

- *Skin allergy testing such as radioallergosorbent test (RAST) should be undertaken to measure the quantity of specific IgE to a particular antigen.*

- *Environmental control of antigens, general environmental hygiene, training and medical surveillance of workers are necessary to prevent allergy among workers.*

- *The animal enclosures and areas should be kept clean and the workers should take care to control exposures during cleaning.*

- *Perform animal manipulation within ventilated hoods or safety cabinets when possible.*

- *Veterinarians and animal handlers should use respiratory protective devices and other protective gear to avoid allergic conditions. To decrease exposure to animal allergens and prevent development of symptoms, it is necessary to use* *gloves, gowns, lab coats and respirators with faceshields.*

- *Reduce skin contact with animal products such as dander, serum and urine by using appropriate protective gear.*

- *Better designed ventilation and air flow system can reduce much of the dust and dander from the area where animal is housed.*

- *Allergic diseases can be prevented by environmental control of antigens.*

- *Prophylactic medication has to be taken to alleviate allergic symptoms.*

- *Provide health monitoring and appropriate counseling and medical follow-up for workers who have become sensitized or have developed allergy symptoms.*

- *Individuals with systemic reactions should consider hyposensitisation therapy and carry with them anaphylaxis medication when working outdoors.*

**Pregnant veterinarians and staff**

Scientists must become more cognizant of the occupational hazards to pregnant females in the field of veterinary medicine. Veterinary medicine poses the same hazards to female practitioners as to their male associates, with the additional hazards associated with women's reproductive role. The studies regarding occupational hazards to female veterinarians and their associated personnel are limited, and most of the information has been extrapolated from studies on workers in related professions and from animal studies.

There is an increase in the number of women seeking veterinary profession and in Australia both male and female veterinarians are almost equally represented in the veterinary practices and zoological gardens. Studies have found that in the US, most veterinary practices have been employing at least one woman of child-bearing age. Occupational health hazards are of concern for pregnant veterinarians or those who are trying to conceive.

Scattered radiation poses hazards to male and female veterinarians and others who are in the x-ray room when radiographic procedures are undertaken. Radiation can affect egg cells and spermatogenesis, and it is of particular concern to both male and female veterinarians trying to conceive. The embryo is most susceptible to radiation-induced damage at 8-10 days post-conception. Usually, women at their early stage of pregnancy may not be aware that they are pregnant. However, women trying to conceive should be aware of the risk of radiation exposure and take appropriate precautionary measures to save their pregnancy. Studies have revealed that the human embryo and foetus are very sensitive to radiation throughout gestation resulting in mutation and birth defects increasing the risk of childhood leukemia.[48] Ionizing radiation is a known carcinogen at high exposures and has been associated with cancer and possibly increased rates of spontaneous abortion and congenital anomaly at lower levels of occupational exposure.[54,169,171]

It is important to avoid radiation exposure during pregnancy by following the guidelines and using adequate shielding from ionising radiation. The current International Commission for Radiological Protection (ICRP) recommendations on occupational exposure during pregnancy (ICRP60-1990) are that the conceptus should be protected by applying a supplementary equivalent dose limit to the surface of the abdomen of 2 mSv for the remainder of the pregnancy.

In accordance with guidelines suggested by the American College of Veterinary Radiology, pregnant students/staff wear a complete wrap-around lead apron to protect all parts of their trunk and an additional film badge worn at the waist level underneath the apron. The badge worn at the waist level, should measure maximum possible exposure to the foetus. The exposure limit should not exceed 50 millirems per month. The maximum dosage to the foetus during the entire gestation period should not exceed 500 millirems as defined by the National Council on Radiation Protection and Measurements, but there is no established zero risk level of radiation.[48] Every person who take x-rays and involved in other radiological procedures should keep track of personal exposures even before pregnancy, to derive an average exposure rate. In order to minimize the reproductive hazards by scatter radiation, safety measures including decreasing the time of exposure by using calibrated equipment and faster screen-type films, chemical and mechanical restraints, wearing of protective clothing and dosimetry badges including foetal badges for pregnant women at the mothers' waists under the apron should be considered.[48]

Veterinarians experience injuries from lifting and moving heavy objects and due to working with unpredictable and dangerous animals. Pregnant veterinarians and employees may be more susceptible to physical injury due to fatique and physical limitations specifically during pregnancy. An injury may cause an increased chance of miscarriage or injure the foetus.

Infectious diseases such as toxoplasmosis and listeriosis appear to be of main concern for pregnant women. If a female of a child bearing age is initially seronegative for toxoplasmosis and then acquire an infection during the pregnancy period, the foetus can be infected via the placenta. Treatment during pregnancy reduces the likelihood of transmission of this disease to the foetus. However, congenital infection can result in abortion or premature birth, blindness, deafness, retardation, encephalitis and other defects. Listeriosis which is a bacterial disease of ruminants, causes abortion, neonatal septicaemia or meningitis. Large animal female practitioners are at risk due to preponderance of cases in ruminants.[48]

Women are especially at risk from abortion or infertility, if they are chronically exposed to high level of gaseous anaesthetic agents such as halothane.[54,169,171] The size and the rapid growth of the foetus make it more susceptible when exposed to dangerous substances even in small quantities.[46] Leakage from anaesthetic equipment and waste anathetic gas exposure poses a special risk to the pregnant veterinarians and associated personnel. A number of studies have reported an increased risk of abortion and birth defects in anesthesiologists and nurse anaesthetists. There can be increased frequency of birth defects in children of male anaesthesiologists chronically exposed to anaesthetic gases. The first trimester of pregnancy appears to be the most critical time of exposure. The NIOSH[69] has recommended that exposure to halothane and methoxyflurane should be limited 2 ppm and Nitrous oxide to 25 ppm. There are no set limit currently for isoflurane levels.[48] Studies carried out in Australia among veterinarians in private practice and in zoological gardens reported that isoflurane is less toxic. There are no set recommended safe limits for waste anaesthetic gas exposure in Australia and veterinarian in Australia should follow the recommendations set by NIOSH.[5] It is important that women of child-bearing capacity are informed of the possible reproductive effects and encouraged to reduce exposures while they are planning to become pregnant.

Some drugs commonly used in veterinary practice pose a particular risk to pregnant women. Antineoplastic drugs used for cancer treatment, damages the rapidly dividing cells in the early stage of pregnancy and poses a significant risk to the foetus if the mother is exposed through the skin or by inhalation. These drugs include alkylating agents such as chlorambucil, cisplatin, cyclophosphamide, antibiotics actinomycin D, antimetabolites methotrexate, mitotic inhibitors vincristine, and other drugs including hydroxyurea, and L-asparaginase. Pregnant women should ensure avoiding handling these drugs. All individuals should reduce exposures as much as possible as some of these drugs are excreated unchanged in patient vomitus.[48]

Statistically significant association between foetal loss and occupational exposure to antineoplastic agents in the first trimester was observed in the matched case control study. The studied pregnancies were identified through Finnish National Registers of healthcare personnel, hospital discharges and through multi-clinic data. The study found that the drugs associated with foetal loss to be cyclophosphamide, doxorubicin (Adriamycin), and Vincristine.[68] Antineoplastic treatments have been undertaken in animal treatments in Australia. In recent years, chemotherapy has been used successfully in the treatment of certain small animal tumours. By extrapolation from studies in humans and experimental animals, and partly through trial and error, therapeutic protocols have been devised. It is now possible to treat a variety of tumours with good efficacy and minimal adverse effects. A great deal is more known about canine than feline chemotherapy. A West Australian study among veterinary practitioners found only two practices undertaking chemotherapy treatment.[8]

Prostaglandins are used frequently by large animal practitioners for reproductive manipulation in cattle and other large animals. Prostaglandin may present a significant risk to pregnant women. A spontaneous abortion was reported in a pregnant woman due to an accidental self-injection of a dose of prostaglandin. Prostaglandins cause smooth muscle contraction and can induce labor at any stage of pregnancy. This drug can be absorbed through the skin and personnel involved should wear protective clothing.

***Recommendations:***

- ***Workplaces where anaesthetic gases are used should install proper scavenging systems to collect waste anaesthetic gases so that pregnant veterinarians and staff are not unduly exposed. The waste anaesthetic gas must be disposed of safely.***

- ***Preventive measures for anaesthetic gas include starting gas flow after induction using snug-fitting endotracheal tubes and masks, inflating endotracheal tube cuffs properly, emptying breathing bags into the scavenge system, and air monitoring programs.***

- *Pregnant veterinarians and female staff of child bearing age should minimize their exposure to waste anaesthetic gas by always using scavenging systems and periodically testing anaesthetic machine gas for leaks.*

- *It is mandatory that during pregnancy the conceptus should be protected by applying a supplementary equivalent dose limit of 2 mSv to the abdomen.*

- *In accordance with guidelines suggested by the American College of Radiology, pregnant student/staff wear a complete wrap-around lead apron to protect all parts of their trunk and an additional foetal monitoring dosimeter worn at the waist level underneath the apron. The dosimeter worn at the waist level, which should measure the maximum possible exposure to the foetus, should not exceed 50 millirems per month. The maximum possible dosage to the foetus during the entire gestation period should not exceed 500 millirems.*

- *Anti-neoplastic drugs should be used carefully by pregnant women and as far as possible avoid handling such drugs. Use gloves specially made for chemotherapy administration when handling these drugs.*

## Radiological Hazards

Radiography in veterinary hospitals, as in human hospitals is a vital tool in the diagnosis of disorders and treatment of patients. Short duration, infrequent exposure to radiation is accepted as insignificant. While high doses of radiation exposure can cause skin changes, cell damage, gastro intestinal and bone marrow disorders and can be fatal.[252]

Veterinarians in zoo and private practice unfortunately have had a poor record in the attention they have paid to the radiological protection procedures adopted in their practices. Over the years, a number of investigators have warned about the hazards in veterinary radiology. There is evidence to show that many veterinarians do not take sufficient precautions from the harmful effects of x-rays.

Veterinary practitioners have to act as radiographers and radiologists and take x-rays to diagnose and treat wild animals in captivity and domesticated animals. As a radiographer, the veterinarian must attempt to produce films of highest quality and as a radiologist, critically examine the standard of the radiographs produced before attempting to interpret them. This will enable the veterinarian to make allowances for any technical faults and should help prevent the need to take repeat x-rays.

Radiography is an exacting art which benefits from meticulous attention to detail. With care and precision at every stage good quality films can be constantly produced. This will enable the radiologists to obtain sufficient information from the film which will contribute to the diagnosis and prognosis of the patient's condition and proper treatment.

Exposure to high levels of radiation can cause clinical damage to human tissues and has the potential for the delayed induction of malignancies. Exposure to ionizing radiation from diagnostic radiographic machines may also be higher in animal hospitals than in human hospitals and laboratories for a number of reasons including using older radiographic equipment, manual restraint of an animal during radiographic procedures and lack of specialist staff. Use of proper equipment and correct procedures can reduce exposure times. The Code of Practice for the Safe Use of Ionizing Radiation in Veterinary Radiology (1982), and the radiation safety acts in the state of Western Australia including Radiation Safety Act (1975), Radiation Safety (General Regulations - 1983), Section 36 of the Radiation Safety Act (1991), Radiation Safety Act (Amended in 1995) and Radiation Safety Acts in other states and territories in Australia are framed to protect persons against the detrimental effects of ionizing radiation and to create safe practices for radiation workers, other employees and general public in veterinary practices. Even though, radiological hazards are documented and several preventive guidelines are framed, veterinary practices do not comply with the regulations. The main objective of this preventive guideline, is to recommend the use of sound judgment when radiological procedures are undertaken and to avoid exposure to radiation. All regulations, acts and codes framed to protect personnel from radiation exposures should be followed.

Much is known about the properties of x-rays, and the ways to protect veterinarians and their employees. Modern facilities have sufficient safeguards integrated in the design, but, there still exists the possibility of injury if these tools are misused. However, most of the machines in the veterinary practices are old and second hand. The collimator of an x-ray machine should collimate the primary beam to a restricted area (NHMRC 1982)[224] During one radiation safety inspection, the inspector found that a light beam collimator was not functioning properly and the fault in the collimator had greatly increased the radiation dose for the animal and the potential for increased exposure by persons restraining the animal (Jacob C. personal communication, 1999). Primary beam radiation could cause risk during manual restraint if adequate collimation is not carried out and radiation may pass through the top of non-lead-lined tables to the floor thus causing scattered radiation or irradiating feet of people restraining animals.[161]

Licensing of operators

Veterinary Surgeon who operates radiographic equipment, even occasionally, must hold an appropriate operator licence for irradiating apparatus. The license is issued only to a veterinarian and not to a veterinary practice. The licence cannot be transferred from one person to another and all the operators at the practice should possess individual licence. In the state of Victoria, an applicant for a licence should hold a current registration issued by the veterinary board. The licencee must comply with the NHMRC Code of Practice for the Safe Use of Ionising Radiation in Veterinary Radiology (1982).[5] All radiation safety equipment which should include protective gloves and aprons, positioning devices and cassette holders, must be used during radiography (Health Radiation Safety Regulations, 1994). Similar licensing conditions to operate radiographic equipment apply to other states in Australia.

Registration of premises and equipment

In the state of Western Australia, The Radiation Safety Act (1975)[6] controls all uses of radiation. The Act covers the use of a range of ionizing and non-ionizing radiation and requires equipment and substances and the premises in which they are used to be registered. Persons using radiation must be licensed or be acting under the direction of a licensed person. To obtain a licence for the purpose of veterinary radiography, an applicant must be a qualified veterinarian and have passed a radiation safety examination. The registration is valid for one year from the date of issue. A registered label is issued by the department which must be affixed to the specific x-ray unit to which it relates.[224]

A Radiation Safety Officer (RSO) should be appointed in writing by the registrant and will be responsible for maintaining radiation safety, however, the ultimate responsibility rests with the registrant, usually the veterinarian in charge of the practice. Both the radiation safety officer and the veterinarian should ensure that the equipment complies with the relevant regulations and standards and is used only by approved persons. In addition, all persons involved in radiographic examinations should be individually monitored for their personal radiation dose.

In Australia, the registration of veterinary x-ray equipment is subject to the following general conditions: Radiation shielding must be provided in the doors, walls, floors and ceilings of the room in which the x-ray equipment is installed. The operators must provide shielding apparatus to ensure that no one receives a radiation dose more than the relevant radiation protection limit. The registrant must ensure that personal radiation monitoring devises such as Thermoluminescence

Dosimetry (TLD) are provided as required by the Regulations. The registrant is responsible for the maintenance of radiation safety (Health (Radiation Safety) Regulation 1994). The Health (Radiation Safety) Regulation, (1994) has also laid down further conditions of registration related to the x-ray unit. "The registered person in relation to the x-ray unit to ensure that: (a) Sheet lead of at least one millimeter (1 mm) thickness is provided under the cassette to fully intercept the primary beam to reduce the amount of scattered radiation. (b) Casette holders or other mechanical means are employed when the cassette is unable to be placed on a table and the primary beam is angulated or horizontal. (c) Film cassettes must not be held directly in the hand, even if lead rubber gloves are used. (d) Devices for immobilising and restraining animals, such as slings and sandbags, as outlined in the Code, are provided. (e) Whenever possible, animals should be anaesthetized or sedated during radiography so that they can be positioned more easily. (f) The x-ray unit is only operated by a person holding an appropriate operator licence. (g) Any person required to be present during radiographic procedures and not shielded by protective screens are provided with lead aprons and gloves. It should be noted that lead aprons and gloves are not designed to shield operators from the primary x-ray beam. (h) The facilities and radiation safety practices of the Code are met".[263]

Veterinary surgeon in charge of the practice should have sufficient professional or technical training to implement radiation safety in the premises. Veterinarians being generalists do not have wide training and experience in radiology and strive continually to update their skills. It is stated in the Code of Practice, that the professionals involved in radiographic procedures should be properly instructed on radiological procedures.

Radiography should be carried out if and when there is a clinical justification for the use of radiology, the exposure level should be kept to a bare minimum, and the dose limit should not be exceeded. Exposure to radiation may entail some risks and the risk is proportional to the number of doses received. International Commission on Radiological Protection (ICRP) has, for many years, recommended that all exposures to radiation be justified as producing a net benefit and that exposure should be As Low As Reasonably Achievable (ALARA). The ICRP has recommended a dose limit of 20 millisivert (mSv) average dose over five year time period for radiation workers with a limit of 50 mSv in any one year.

***Recommendations:***

- ***The premises where radiography is undertaken and the x-ray equipment have to be registered as required by the statutory authority.***

- ***The veterinary Surgeon operating a radiographic equipment must hold an appropriate licence issued by the authority which is not transferable to any other person.***

- ***The responsibility for ensuring safety from exposure to ionizing radiation lies with the veterinarian in charge of the practice.***

- ***Veterinarian in charge of the practice should ensure that the x-ray equipment complies with the relevant regulations and standards and is used only by approved persons.***

- *Appropriate radiation shielding must be provided in the doors, walls, floors and ceilings of the room in which the x-ray equipment is installed.*

- *The veterinarian should nominate the Radiation Safety Officer (RSO) from his staff who could be a veterinarian ora nurse.*

- *According to the Radiation Safety (Qualifications) Regulations 1980 in Western Australia, a person nominated to be the RSO should possess an approved qualification in radiation safety to carry out safety duties. Similar practice is being carried out in other states in Australia.*

- *It is advisable that persons pregnant women and women of child-bearing age, should not be permitted in the x-ray room.*

- *Exposure to ionizing radiation should be kept at the very lowest practical level by reducing the time spent in the radiation area.*

- *Radiography should not be carried out unless there is clinical justification.*

- *The collimator of an x-ray machine should collimate the primary beam to a restricted area.*

- ***Exposure level should be kept to a bare minimum using the ALARA principle (As Low As Reasonably Achievable).***

Radiographic facility

Diagnostic x-ray machines are installed mostly in small rooms in veterinary practices in Australia. Radiography is being under taken within a defined x-ray room or area and sometimes outside a defined area when a mobile or portable x-ray machine is used. The radiographic room should be adequate in size to ensure that everyone present during radiographic procedures can remain behind a protective screen or outside the useful beam and at least 2 mm from the beam axis during exposures. X-ray personnel should be behind a lead shield or screen, or outside the room during exposures.

The x-ray room should be provided with walls and doors for personnel protection. Single brick wall is sufficient to provide shielding. People in rooms adjoining the x-ray room should be protected if there is any risk from the primary beam. If the x-ray equipment is installed in an upstairs room built with wooden floors, personnel working in the room below the x-ray room should be protected from primary and scattered radiation.

Warning signs should be displayed at the entrance of the x-ray room when the radiography is in progress and access to the x-ray room has to be restricted.

***Recommendations:***

- ***The radiographic room should be adequate in size and provide sufficient protection for those who are involved in the x-ray procedures.***

- ***The walls and doors of the x-ray room should have sufficient protective barrier so that those in the adjacent areas will not receive ionising radiation.***

- ***Safety signs containing the words 'Caution-radiation area' and written safe operating procedures and safety policies should be displayed at the appropriate areas.***

Radiographic equipment

There has been a significant increase in the use of radiographic equipment by the veterinarians during the past three decades. All radiographic equipment are manufactured specifically for the health care industry and used by qualified radiographic personnel. Veterinary surgeon often with limited radiographic knowledge and experience who owns a radiographic facility can find it extremely difficult to find the most suitable x-ray machine for his practice.

X-ray equipment must be checked and serviced on a regular basis by a qualified technician, and maintained in accordance with the manufacturer's direction. The x-ray equipment must produce a consistent output of radiation so that under and over exposures are avoided. A complete radiation safety program must include a regular evaluation of the radiographic equipment and the procedures followed during the use of the x-ray equipment. The equipment should be fitted with a light beam diaphragm and checked regularly for accuracy.

When an x-ray tube fails and replacement becomes necessary, the replacement must only be carried out by a licensed service person. All x-ray equipment should be fitted with a means of adjusting the useful beam to the minimum size necessary for the examination being undertaken. This is best achieved by using a light beam diaphragm. The light beam collimator limiting the useful beam must be constructed so that when in combination with the tube housing, it complies with the leakage limits. The illuminance of the light beam is not less than 100 lux, above the ambient level, at a distance of one metre from the light source. The tube head should be supported so that it remains stationary when placed in a position for radiography. A device must be provided to stop the exposure after a preset time. Interchangeable cones are a poor alternative and should not be used if animals have to be manually restrained during radiography.

During purchase of an x-ray equipment, veterinarian should ensure that the machine is demonstrated and ready back up services and emergency repairs are provided by the supplier. Veterinarian in charge of radiographic equipment must be vigilant in the maintenance of safety measures. Operation of radiographic equipment presents a number of risks and is being regulated by the state governments. Also veterinarians have to be familiar with the contents of the instruction manual of the x-ray equipment and a copy of the instruction manual should be available in the practice. It is important to ensure that the radiographic equipment functions properly for the safety of the veterinarians and their associates.

*Recommendations:*

- *The registered person of a veterinary x-ray unit must ensure that all licensed employees operating the x-ray machine are aware of safe working practices.*

- *To provide a safe working environment, the Radiological Councils/statutory bodies of all states and territories in Australia should carry out compliance testing for all x-ray equipment on a regular basis.*

- *The radiation safety acts should be enforced to ensure veterinarians comply with the registration when purchasing new or second hand equipment and this will enable all machines to be checked prior to registration, repaired and overhauled to comply with safety standards.*

- *X-ray equipment should be checked and serviced regularly by a qualified technician.*

- *The onus is on the registered person to ensure that testing of radiographic equipment is carried out by a licensed person at regular intervals.*

- *Replacement of any part of the x-ray equipment should be carried out by a licensed contractor.*

- *A radiation safety program including regular evaluation of the x-ray equipment and procedures to*

***be followed during radiography should be developed and implemented.***

- ***X-ray equipment should be fitted with a light beam diaphragm.***

- ***A copy of the instruction manual should be available in the premises and located close to the x-ray equipment.***

- ***It is important to reduce number of unnecessary radiographs by obtaining x-rays of diagnostic quality.***

- ***Exercise caution in purchasing old and used equipment.***

Ancillary equipment used for radiography

In accordance with the Code of Practice, special devices should be used for radiography to avoid restraining animals by hand. Positioning aids will make patient restraint easier and safer, and should be used whenever possible. Positioning devices such as adhesive tapes, slings, sandbags, positioning troughs, radiolucent pads, cassette holders, mouth gags and suction cups could be used when radiographing anaesthetised animals. Birds and small mammals may be retrained by placing them inside a short length of plastic tubing or piping with suitable ventilation. As far as possible, animals should be anaesthetized or sedated during radiography so that they can be positioned more easily.

The x-ray table should have a lead equivalence of 1 mm for the top and 0.5 mm for the sides. If the table is not provided with the required lead top, a 1 mm thick sheet of lead could be spread on the examination table under the cassette or film to reduce scatter radiation. This will protect the feet of the person who may need to stand closer to the table.

Cassette holders or any other mechanical means are used when the cassette is unable to be placed on a table and the primary beam is angulated or kept horizontal, especially in a field radiographic procedure. Suitable cassette holders, fitted with long handle if required, could be used during horizontal radiography. Use of cassette holders for all horizontal beam radiography will help reduce exposure to ionising radiation.

***Recommendations:***

- ***Restraining animals by hand should be avoided and positioning devices such a adhesive tapes, slings, sandbags, cassette holders, positioning troughs, mouth gags and suction cups should be used for this purpose.***

- ***Whenever practicable, animals should be anaesthetized, or at least sedated prior to radiography to reduce personnel exposure during animal restraint or while positioning the animal.***

- ***The x-ray table should have 1 mm lead on the top and 0.5 mm on the sides of the table or lead lined to avoid scatter radiation.***

- ***The use of cassette holders should be mandatory for all horizontal beam radiography.***

Personnel shielding devices

Appropriate protective equipment such as lead body aprons, lead gloves and sheets of lead rubber suitable for hand and forearm drapes must be available for all persons likely to be in the controlled area during radiography. The double sided aprons are more efficient than single sided ones because they protect persons against scatter radiation from behind and front of the body. As recommended by the NHMRC Code of Practice (1982),[5] protective devices should have a lead equivalent thickness throughout of not less than 0.25 mm and of not less than 0.5 mm when energies above 100 kV peak are used. When the operator is unable to comply with the use of protective equipment, a protective barrier must be provided if required.

It is a prerequisite that the selection, purchase, maintenance and use of any personal protective equipment should comply with the relevant Australian standard as indicated in the Australian Standard for Health and Safety at Work (AS 1470-1986). It is important to understand that such protective clothing is only intended to give protection from scattered radiation and will not provide shielding against the primary beam.

If aprons have to be transported during mobile work, they should be carefully rolled and not folded. Lead gloves and sleeves should be dried after use and stored singly and flat or else over upright supports as stacking may cause cracks around the base of the fingers. Any protective device with cracks should be discarded.

As stated in the NHMRC Code of Practice (1982),[5] lead protective devices should be examined both visually and radiographically on a regular basis (eg. 3-monthly for practices with a heavy x-ray work load) to ensure that their shielding efficiency has not become impaired by cracks due to sharp folds, penetrations which could be caused by claws or other damages. It is also wise to keep a record of all checks carried out on the protective clothing.

***Recommendations:***

- ***Adequate instruction and training should be provided on the correct use and maintenance of protective equipment.***

- ***Protective apparel including lead gloves and lead aprons should be used to avoid radiographic exposure.***

- ***Protective devices should have a lead equivalent thickness of less than 0.5 mm when over 100KV energies are used.***

- ***Protective gear such as lead gloves and thyroid collars should be checked annually for effectiveness. As stated in the NHMRC Code of Practice (1982)[5] protective devices used during radiography should be checked visually and radiographically to ensure their shielding efficiency has not been impaired.***

- ***Keep personnel away from exposure to the primary beam as lead apron and gloves are designed for the scatter radiation only.***

- ***A record of all checks carried out on protective gear should be maintained and damaged items should be discarded.***

Radiation injury

Radiation injury may occur when a person is exposed to a single large dose of radiation or a number of exposures over a short period of time or to several exposures over a long period of time. Exposure to radiation has a potential for the delayed induction of malignancies. If the provision of the Code of Practice is applied consistently, the dose limits will not be exceeded and the risk of injury will be reduced.

Primary radiation may leak out of the tube head if the lead casing has been damaged and causes risk when small animal is manually restrained for radiography. It is also a risk during any form of manual restraint if inadequate collimation is carried out as it may pass through the top of non-lead lined tables to the floor irradiating feet or producing scattered radiation. A light beam diaphragm controls the size of the primary beam. Restricting the size of the primary beam not only limits the volume of the patient that is irradiated but also limits the scattered radiation that is produced. Optimal use of light beam diaphragm reduces personnel exposure and helps to improve radiographic contrast.

Exposure of personnel can also be minimised by using fast-film screen combinations, avoiding repeat exposures, ensuring that the distance between the patient and the radiographer is as large as possible and using proper lead shielding. It is also necessary that x-rays should not be taken until the animal is restrained and positioned.

A registered person of an x-ray unit who believes that an equivalent dose received by any person has or may have exceeded one millisievert must prepare a written report with relevant details to the occurrence and forward to the department within five working days.

Rotation of radiographic duties among all qualified staff will reduce exposure levels. To produce good quality films, training programs, in-service training and new employee training are important. Conscientious and continually maintain precautions are important to avoid radiation exposure of the practitioner.

***Recommendations:***

- ***It is important to ensure that radiation exposure dose does not greatly exceed those normally received from natural background radiation.***

- ***To reduce exposure level to personnel:***
    - ***attend training and in-service workshops***
    - ***maintain safety precautions***
    - ***use suitable and adequate protective clothing***
    - ***use fast-film screen combination for exposure reduction***
    - ***avoid repeat exposures***
    - ***collimate the primary beam***
    - ***use adequate lead shielding***
    - ***rotate radiographic duties***

- ***animal should be restrained and positioned***
- ***reduce exposure time***
- ***replace hand-holding cassettes with film holders***
- ***increase the distance from the radiation source***
- ***protect staff from scattered radiation.***

- ***If a person has received or may have exceeded one millisievert of radiation dose, the registrant should forward a detailed written report to the department.***

-

Radiation doses

In Australia, it is requirement by the statutory authority in each state and territory that radiation dose records of all employees should be maintained accurately and the records should contain all doses received during the present and previous period of employment. The dose records should be available for inspection by the individual worker and the statutory authority.

When a person is first designated as a radiation worker, the employer should request from the previous employer a copy of the radiation dose record of that employee.

It is important that body dosemeters are worn while taking x-rays in order to give accurate record of the dose received. A record indicating the type of dosemeter used, dosemeter readings, recommendations of the supplier should be maintained in the practice.

The registrant should ensure that the personal monitoring device or the records of the employees are not tampered intentionally or interfered with by other personnel. These radiation monitoring records should be kept carefully in the premises to allow each worker's annual effective dose to be assessed whenever necessary.

***Recommendations:***

- ***It is mandatory to maintain radiation dose records of all employees exposed to ionising radiation and these records must be made available to all employees on request and passed on to future employers. In Australia, the dose records of employees should be maintained in practices and held until the death of an employee.***

- ***Dosemeters should be worn to gauge accurate dose received due to exposure.***

- ***When not in use, dosemeters should be stored away from x-ray machine.***

- ***A person must not intentionally tamper with or interfere with a personal monitoring device or the personal monitoring records of any person.***

- ***Radiation monitoring records must be kept to allow each worker's annual effective dose to be assessed and must be available for inspection.***

Persons involved in x-ray procedures

Trained and qualified personnel should carry out radiography in veterinary practices. The persons who perform radiography are exposed to ionising radiation due to their direct involvement. Veterinarians, veterinary nurses, zoo keepers and the members of the public including owners of animals, observers, receptionists and family members of the staff are likely to be exposed to ionising radiation.

According to the radiation protection limits prescribed for radiation workers in the Health (Radiation Safety) Regulations, 1994, the exposure to the worker should not be over twenty millisieverts per year to the whole body averaged over a period of five consecutive years, with no more than 50 millisieverts in any one year. The members of the public who are in the vicinity will also have to adhere

to the radiation dose protection limits. The radiation dose should not exceed one millisievert to the whole body in any one year, averaged over a period of five consecutive years. The members of the public will have to wear lead aprons when required to be near the x-ray unit, wear lead aprons and gloves when using cassette holder, never hold cassette holder by hand and x-ray unit must not be held in position by hand.

According to AAHA, any person under 18 years of age or who are pregnant are not allowed in the x-ray room during radiography. Also, owners should not be allowed to hold their pets or be in the x-ray room during x-ray procedures.

***Recommendations:***

- ***The veterinarian in charge of a radiographic equipment must be vigilant in the maintenance of safety measures. Slackness by responsible persons quickly leads to the total neglect of precautions.***

- ***Only trained and qualified personnel should carry out radiography.***

- ***Keep personnel away from exposure to the primary beam as aprons and gloves are designed for scattered radiation only.***

- ***Primary beam should be collimated to the specific area and should not irradiate people outside that range.***

- ***Persons other than those who are not involved with radiography should not be in the vicinity.***

- ***Use minimum personnel for the x-ray procedure.***

- ***Have all personnel wear monitoring devices.***

- ***As recommended by the AAHA, it is advisable that persons under 18 years of age or pregnant, and owners of animals should not be allowed in the x-ray room.***

X-ray equipment used for dental and fluoroscopy purposes

Veterinary dental radiography is covered under a standard veterinary operator licence. It should be noted that the x-ray units which are purpose built for dental radiography must not be used for other types of veterinary radiography.

Dental x-ray equipment will have to comply with the Australian Standard. The use of dental x-ray equipment is recommended to avoid persons involved in taking dental x-rays being exposed to a greater radiation dose. According to the NHMRC Code of Practice (1982)[5] veterinary premises should be registered to perform dental x-ray treatment.

Fluoroscopy units are not to be used for veterinary work and approval for specific purposes should be obtained subject to additional training requirements.

***Recommendations:***

- ***Use of dental x-ray equipment of Australian standard for x-ray purposes should be made mandatory.***
- ***Veterinary premises should be registered to perform dental x-ray treatment.***

X-ray therapy treatment

In comparison to diagnostic x-ray machines, radiotherapy machines work at higher energies and may produce electromagnetic radiation. Exposure to such energies may cause more harmful effects than diagnostic x-ray machines.

The drugs used for the treatment of cancer are potentially mutagenic and teratogenic in nature. Therefore, it is important that strict handling protocols and preventive methods are used during chemotherapy treatment. During x-ray therapy treatment adequate shielding has to be provided and protective guidelines have to be followed.

X-ray therapy treatment being hazardous in nature, veterinary premises should be registered to perform x-ray therapy treatment.

***Recommendations:***

- ***Registration of veterinary premises for x-ray therapy treatment should be made mandatory.***
- ***Adequate shielding should be provided during x-ray therapy treatment.***
- ***Treatment should be done in a competent and safe manner.***

Dark-room chemicals

Dark-room activities including handling chemicals have to be carried out with caution. It is important to wear plastic aprons and gloves while handling chemicals. Masks are recommended for personnel with respiratory problems.

The dark-room should be well ventilated before mixing the chemicals used in developing x-rays as x-ray film processing requires the use of chemicals many of which are irritant to both skin and the respiratory system. The air emissions are of major concern as asthmatics are often very sensitive. If any skin splashes occur it must be washed off in running water. In case of a spill in the eyes, it is important to flush with water immediately and continue for a few minutes.

The dark-room should have a lockable door and should be in a position to unlock from either side. It is necessary that the film and chemicals are within their dated shelf life and all chemicals are replenished and renewed as recommended by the manufacturer. While emptying, it is important that the tank is properly cleaned and flushed into the drain. The cold water should run for at least fifteen minutes. Separate containers for fixer and developer are recommended.

***Recommendations:***

- ***Dark-room chemicals should be handled with caution. While emptying dark-room chemicals, the tank should be cleaned thoroughly and the chemicals should be disposed carefully.***

- ***Installation of ventilation equipment in the dark-room including ducting, fan assemblies and filtration units should be made mandatory for the veterinary practices.***

- ***Film and chemicals should be within their dated shelf life.***

- ***Developing solutions used for film processing should be changed regularly.***

- ***Protective apparel should be worn during mixing and handling chemicals.***

- ***While mixing chemicals, ensure to keep the area well ventilated.***

- ***Have a separate container for the developer and fixer.***

- ***During an emergency, a staff member in practice should be able to provide first-aid and medical treatment advice.***

Training in radiography

Training in all aspects of radiography is highly desirable for those who are involved in radiography. If the professional staff feel that their undergraduate course needs refreshing or inadequate, they should attend a course in radiography. Training in practical radiography will help veterinarians involved in radiographic procedures to adopt safe practices that will minimise the radiation risk to all persons involved. It is important to increase the laboratory hours for veterinary radiography of the undergraduates and this includes examination of film quality processing and exposure charts. It is also advisable to increase the number of hours on clinical training in radiology.

Regulation 12 of the NRPB, UK (1988)[171] reports that adequate information, instruction and training should be provided to employees engaged in radiological procedures. Each practice should identify the staff who will operate the x-ray machine and those permitted into the controlled area. The level of training will depend on the degree of involvement. Any person operating an x-ray machine should be fully aware of the radiation protection aspects and of the radiographic techniques.

***Recommendations:***

- ***All those who perform radiography should undergo training in practical radiography.***

- ***In-service training, refresher courses and orientation sessions for new employees are essential.***

- ***Training in practical radiography for owners of veterinary practices should be made mandatory.***

## Conclusion

In this thesis, the occupational hazards of the veterinary practice including zoo veterinary practice are inventoried and the risks associated with physical trauma, exposure to ionizing radiation, infectious agents, and chemicals have been assessed. The study conducted among zoo veterinarians in Australia reported that veterinarians have received numerous occupational injuries and illnesses. The nature of injuries reported included needlesticks, musculoskeletel injuries, necropsy injuries, radiation exposure, chemical hazards, allergies and zoonotic infections. Needlesticks were the most frequently reported injuries with one or more sticks. A preferable safety method of handling needles is the one- hand scoop method that involves scooping up the needle cap with the needle in one hand and securing the needle cap with the other hand. Training and education of veterinarians and associated staff in handling needles, proper use of needles and syringe disposal and the use of needlestick prevention devices will help to reduce such injuries. There is potential risk for veterinarians from exposure to waste anaesthetic gas and vapour even at low levels. Installation of effective ventilation systems and increased attention to equipment maintenance including leak detection and careful anaesthetic practice will reduce exposure to waste anaesthetic gases. It is important that female veterinarians are informed of the risk of spontaneous abortion and adequate scavenging methods have to be instituted in veterinary practices if they are not already in use.

Veterinarians in zoo practice have to deal with wild and semi-wild animals which are unreliable and unpredictable. Veterinarians also experience mental stress and trauma due to insufficient skills in managing the veterinary practice, inadequate skills and knowledge in the treatment and care of animals held in captivity. The science of wild animal care and treatment differs very much from domestic animal species. The psychological well-being of captive animals and physical care are of great concern for the veterinarians treating animals in zoological gardens.

Several studies in Australia and overseas including two comprehensive studies carried out among veterinary practitioners in Western Australia revealed that veterinarians have contracted zoonoses and sustained injuries inflicted by animals. Some physical injuries are associated with zoonotic infections. Such diseases include rabies, tetanus, pasteurellosis and anaerobic infections. Veterinarians are also exposed to chemical hazards and ionizing radiation during their career. The Code of Practice for the Safe Use of Ionising Radiation (1982), and the Radiation Safety Acts should be adhered, and professionals involved in x-ray procedures should be properly trained on radiology to update their knowledge on modern techniques on x-ray procedures and compliance on radiation safety.

The employers in both zoological gardens and private practice should assess the workplace for the prevalence of hazards and provide employees with appropriate protective gear for the specific areas of concern. Many pieces of veterinary equipment can cause injury to veterinarians if not used properly. Injury control strategies and risk prevention begin with an understanding of the types of accidents and mechanisms involved in animal-related injuries. An active programme of safety awareness, featuring specific training for veterinary personnel in the proper techniques of lifting heavy objects and operating dangerous equipment should be given priority in veterinary practice. Veterinarians employed in the treatment of wild animals have to be provided with specialised training in all safety aspects and at least a basic training in the care and treatment of wild animals. The training could be in the form of induction and in-service programs. Proper training and education to support these programs are essential in providing veterinarians and their staff with a safe and healthy working environment.

The outcome of this study has enabled the author to provide preventive strategies against physical including radiological, chemical and biological hazards which are prevalent among zoo and practising veterinarians. Judicious use of preventive gear affords considerable amount of protection against physical including radiological, chemical and biological hazards. Immunisation against selected infections, avoiding direct injury from animals, proper restraining methods including immobilization from a distance with darts or with specially designed guns, protection from radiation exposure and other suggested preventive guidelines should be adhered. Only through the application of knowledge and practical procedures, the veterinary premises can become a safe and healthy working environment. The institutions should have a successful health and safety management as well as implement occupational safety and health policies and strategies which have been suggested in this chapter to provide work-place safety to the veterinarians and other staff in the practice.

## ABBREVIATIONS

| | | |
|---|---|---|
| AAHA | - | American Animal Hospital Association |
| ABS | - | Australian Bureau of Statistics |
| ALARA | - | Australian |
| ALI | - | Annual Limit of Intake |
| ATSDR | - | Science corner |
| AVMA | - | American Veterinary Medical Association |
| AVMAGIT | - | American Veterinary Medical Association Group Insurance Trust |
| AVMAPLT | - | American Veterinary Medical Association Professional Liability Trust |
| BLS | - | Bureau of Labor Statistics |
| BSE | - | Bovine Spongiform Encephalopathy (Mad Cow Disease) |
| CDC | - | Centres for Disease Control |
| CJD | - | Creutzfeldt-Jakob Disease |
| dB | - | Decibels |
| DES | - | Diethylstilbesterol |
| DNA | - | Dioxyribonnucleic acid (p. 98) |
| HIV | - | Human immunodeficiency virus |
| HRG | - | film |
| ICRP | - | International Commission for Radiological Protection |
| IgE | - | Immunoglobulin |
| ILO | - | International Labor Organisation |
| kV | - | Kilovoltage |
| LBD | - | Light Beam Diaphragm |
| mA | - | Milliamperage |
| MeV | - | Mega elecron Volts |
| mm | - | Millimetre |
| MSDS | - | Material Safety Data Sheets |
| mSv | - | microsieverts |
| MVA | - | Motor Vehicle Accidents |
| NHMRC | - | National Health and Medical Research Council |
| NIOSH | - | National Institute of Occupational Safety and Health |
| NOSHC | - | National Occupational Safety and Health Commission |
| NRPB | - | National Radiological Protection Board |
| nvCJD | - | New varient Creutzfeldt-Jakob Disease |
| PEL | - | Permissible Exposure Limit |
| ppm | - | Part per minute |
| RAST | - | Radioallergosorbent test |
| RSO | - | Radiation Safety Officer |
| STEL | - | Short Term Exposure Level |
| TLD | - | Thermoluminescent Dosimeter |

## GLOSSARY

**Abortifacient:** It is a drug or device which causes an abortion within the first one or two weeks of a human's life.

**Acute:** sudden, severe, and severe; **not Chronic.**

**Allergy:** acquired state of immunological hyper-sensitivity in humans and animals to allergens (substances foreign to the body) induced by exposure through injection, inhalation, ingestion or skin contact.

**Anaesthetic:** an agent that produces anaesthesia, or insensibility to pain.

**Antigen:** any substance abele to provoke an immune response in the human body.

**Atopy:** a pruritic (itchy) skin disease of animals that is caused by an allergy to substances in the environment that are contacted through the air, either by absorption through the respiratory tract or contact through the skin.

**Bacteria:** one-celled organisms, some of which are capable of causing infection.

**Bovine spongiform encephalopathy (BSE):** a fatal, slow developing disease of cattle affecting the nervous system, sometimes referred to as Mad Cow disease or Creutzfeldt-Jakob disease. The disease in human called new variant Creutzfeldt-Jakob disease (nvCJD).

**Carcinogen:** a cancer causing substance.

**Carcinogenicity:** the ability of a substance to cause cancer.

**Chemotheraphy:** treatment of disease by the use of chemical agents; usually refers to drugs used in treating cancer.

**Chronic:** of long duration; recurring; not **acute.**

**Congenital:** existing at birth.

**Contact dermatitis:** a skin reaction that occurs as a result of exposure to an irritant.

**Cytotoxic:** harmful to cells and cell division.

**Disease:** malfunctioning of the body or any part of the body resulting from any number of influences, including genetic errors, toxins, **infections**, nutritional deficiencies, and environmental factors.

**DNA:** deoxyribonucleic acid, the basic genetic material in humans.

**Epidemiology:** the study of the distributionand determinants of disease in population.

**Fungus:** any of a group of parasitic lower organisms, including molds and yeasts, that can infect tissue in the human body.

**Gas-scavenging**: removing excess anaesthetic gases from the operating theatre.

**Hormone:** one of a large class of chemicals that are secreted by glands and some organs. Hormones travel throughout the body and regulate the activities of systems, tissues, organs, and **glands**. They play an important role in regulating functions such as growth, reproduction, digestion, and fighting **infection**.

**Hypersensitivity:** abnormally heightened sensitivity to a foreign agent, small doses of which produce a violent reaction in a patient.

**Immunocompromised:** have the immune response attenuated.

**Infection:** invasion of the body by agents that cause disease or tissue damage.

**Inflammation:** a by-product of the immune response, a reaction of tissue to injury or infection, characterized by redness, pain, swelling heat, and sometimes impaired function.

**Metabolism:** the physical and chemical processes of an organism that are necessary to maintain life.

**Mutagenicity:** the property of a physical, chemical or biological agent to induce mutation in living cells, leading to inherited differences (muttion).

**Neoplasm:** a tumour or cancer – new growth.

**Pathogen:** any disease-causing agent, such as a virus or bacterium.

**Radiotherapy:** treatment o disease by radium, x-rays or radioactive isotopes.

**Sensitisation:** a condition in which the response to a second and subsequent stimuli is greater than to the original stimulus; the immune process by which individuals become hypersensitive to such substances as pollen, animal dander.

**Symptom**: an abnormal function, sensation, or appearance experienced by an individual.

**Teratogenicity:** the ability of a substance or condition to cause deviations from normal growth and development between conception and birth, resulting in abnormal individuals.

**Toxin:** a poison produced by an organism, such as the substance released by certain bacteria that causes tetanus.

**Virus:** a simple pathogenic microorganism that invades living cells and uses cellular mechanisms to create multiple copies of itself.

**X-ray:** a form of radiation similar to light but capable of penetrating many solids and of ionizing gases; an image made by using x-rays.

**Zoonoses:** Zoonotic diseases are those that can be passed from animal to animal

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27th June 2000

**Human Research Ethics Committee**

Mr Joseph Jeyaretnam
20 Newell Way
Noranda WA

Dear Mr Jeyaretnam

**Code:** 00-93
**Project Title:** *Occupational hazards in veterinary practice including zoo veterinary practice in Australia and strategies and recommendations for minimising hazards*

This project was reviewed by the members of the Human Research Ethics Committee.

I am pleased to advise that the project complies with the provisions contained in the University's policy for the conduct of ethical research, and has been given ethics clearance.

Please note that your research proposal must be approved by the Research Students and Scholarships Committee before you commence any data collection. The Graduate School will inform you in writing as soon as your research proposal has been accepted.

Period of approval: From 27th June 2000 To 31st December 2002

With best wishes for success in your work.

Yours sincerely

[redacted]

ROD CROTHERS
Executive Officer

**Attachment: Conditions of Approval**

cc. Associate Professor M Nedved, Supervisor
Mrs K Leckie, Executive Officer, Graduate School
Mrs A Stevenson, Administrative Officer, HDC

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16 October, 2000

Dear Colleague

I have been a practising veterinarian for over 18 years. Some time ago, as a M.Sc student by research, I carried out a survey on occupational health and safety in veterinary practices in Western Australia and received 81% response from veterinarians.

As a result of this study, another survey of radiological hazards in veterinary practices was carried out by me, which also had an excellent response from veterinarians.

Both the surveys identified a number of occupational hazards in veterinary practice including radiology.

Currently, I am a Ph.D. student undertaking a further research on occupational hazards of the zoo veterinarians under the supervision of Associate Prof. Dr. Milos Nedved and Prof. Dr. Andrew Thompson.

I would kindly request you to complete the questionnaire and return it in the reply-paid envelope that is enclosed. The information obtained will be kept confidential and be used to develop preventive programs for use in veterinary practices.

Thanking you for your valuable contribution towards this research, which has been designed to improve safety in your practices.

[redacted]

Dr. Joseph Jeyaretnam
B.V.Sc., B.Sc..A.H.,
M.Sc.A.H., M.Sc.O.H.S.
Ph.D.Student

**Supervisors** [redacted]

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# SURVEY OF

# DISEASE, INJURY AND ACCIDENTS

# (HEALTH AND SAFETY HAZARDS)

# OF THE ZOO VETERINARIAN

# IN AUSTRALIA

**JOSEPH S A JEYARETNAM**
B.V.Sc., B.Sc. A.H., M.Sc. A.H., M.Sc. O.H.S.

This study is conducted by Mr Joseph Jeyaretnam, Ph.D. student of the Edith Cowan University, Mount Lawley Campus, Western Australia with the assistance from Dr Milos Nedved, Associate Professor of Occupational Health and Safety at Edith Cowan University and Dr Andrew Thomson, Professor, Division of Veterinary and Biomedical Sciences, Murdoch University, Western Australia.

## PURPOSE

This study is being carried out to investigate and document the occupational health and safety issues of the zoo veterinarians. Your response to this questionnaire is essential for this study.

## CONFIDENTIALITY

Strict confidentiality is assured by using a coded numbering system.

## FEEDBACK

When this study is complete, the results will be used to publish strategies and recommendations for minimising hazards in veterinary practice.

**If you have any queries or concerns, please contact Joseph Jeyaretnam on 08-9276 5586 or 041 342 2366 (mobile)**

**CONFIDENTIAL**

**EDITH COWAN UNIVERSITY**
**MOUNT LAWLEY CAMPUS**
**WESTERN AUSTRALIA**

**JOSEPH JEYARETNAM**

**CODE NO:..................**

# SURVEY OF DISEASE, INJURY AND ACCIDENTS (HEALTH AND SAFETY HAZARDS) OF THE ZOO VETERINARIAN IN AUSTRALIA

**(To complete this questionnaire, please circle the number corresponding to the response you wish to give and/or write the response on the given lines)**

## A DEMOGRAPHICS

1. (a) SURNAME:.........................................................................................

   (b) OTHER NAMES.................................................................................

   (c) AGE:......................(YEARS)

   (d) SEX: 1. Male 2. Female

2. (a) Name of the zoo:.................................................................................

   (b) Location:...........................................................................................

   (c) Avg. hours/week the veterinary facility open: ......................................

3. What is your position in the practice? (eg. Chief Veterinarian, Additional Veterinarian, Assistant Veterinarian, Locum, Temporary, Casual, Contract, Other)

   ..........................................................................................................

4. How many years have you been practising as a zoo veterinarian?

   ..........................years.

5. Indicate the number of staff employed in the Veterinary unit and their role.

| STAFF | FULL-TIME | PART-TIME | CASUAL | LOCUM | CONTRACT |
|---|---|---|---|---|---|
| Vet.Surgeon | | | | | |
| Vet.Nurse | | | | | |
| Zoo Keeper | | | | | |
| Clerical | | | | | |
| Other | | | | | |
| Total | | | | | |

6. What percentage of your yearly caseload is made up of the following animals? (Total caseload = 100%)

| TYPE OF ANIMAL | PERCENTAGE CASELOAD |
|---|---|
| Australian Fauna | |
| Birds | |
| Hoofstock | |
| Carnivore | |
| Primates | |
| Other (specify) | |
| | 100% |

## B PHYSICAL INJURIES INCLUDING RADIATION

7. (a) Indicate the number of major animal related injuries that you have had in the past five years?

0 1 2 3 4 5 6 7 8 9 10+

(b) Please indicate the major animal-related injury sustained by you during the past five years and whether medical treatment was required.

| INJURY | ANIMAL(S) | MEDICAL TREATMENT (Yes/No) |
|---|---|---|
| Animal bite | | |
| | | |
| | | |
| Scratch | | |
| | | |
| | | |
| Kick | | |
| | | |
| | | |
| Trample | | |
| | | |
| | | |
| Horn wound | | |
| | | |
| | | |
| Knocked over | | |
| | | |
| | | |
| Other (specify) | | |
| | | |
| | | |

8. Have you self-treated animal-related injuries?

1. Yes 2. No

9. (a) Have you been hospitalised for an animal-related injury?

1. Yes    2. No

(b) What is the nature of injury? Please explain.

..............................................................................................................

..............................................................................................................

10. (a) Have you sustained an injury or infection when performing necropsies?

1. Yes    2. No

(b) What type of injury did you receive? (Circle all that apply)

1. Knife wound    3. Chemical exposure
2. Infection .    4.Other (specify)....................................

11. (a) Have you sustained a needle-stick injury while injecting medicines, vaccines or taking blood samples.

1. Yes    2. No

(b) How many times have you experienced needle-stick injury in the past five years?

0    1-3    4-6    7-9    10-12    13-15    16+

(c) What type of agents were you exposed to as a result of needle-stick? (Circle all that apply)

1. Animal blood    4. Antibiotics
2. Vaccines    5. Anaesthetics
3. Hormones    6. Other (specify)...............................

(d) Have you experienced an adverse effect from a needle-stick that required medical treatment?

1. Yes    2. No

12. Have you experienced back injury due to lifting or moving animals or heavy objects?

1. Yes    2. No

13. Indicate the number of work-days lost resulting from back injuries within the past five years.

.......................................days

14. Have you sustained an injury as a result of falling at work?

1. Yes    2. No

15. Please circle the number corresponding to the response and write the response on the given lines.

(a) Indicate the type of x-ray machine/(s) used in your clinic?

| **MACHINES** | | **YEAR OF PURCHASE** |
|---|---|---|
| Portable | 1. | ...................... |
| Mobile | 2. | ...................... |
| Fixed | 3. | ...................... |

(b) Have your machine/(s) been serviced since purchase?

| **MACHINE** | **YES** | **NO** |
|---|---|---|
| Portable | 1 | 2 |
| Mobile | 1 | 2 |
| Fixed | 1 | 2 |

16. Do you perform radiographic examinations?

1. Yes 2. No

17. How many x-rays on average do you take per week?
..........................................

18. Indicate the average number of x-rays taken for each patient diagnosed?
........................................

19. Please list the percentage of x-rays taken by you and other staff in the unit? (approximate if records not available)

Vet:.........% Male staff:..........% Female staff..........%

20. (a) What protective gear do you use for radiology work? How frequently are they being used and what is the lead equivalent (if known) for each of the items listed?

| **PROTECTIVE GEAR** | | **FREQUENCY OF USING THESE WHEN TAKING X-RAYS** | **LEAD EQUIVALENT** |
|---|---|---|---|
| Lead gloves | 1 | ......................... | ............ |
| Lead aprons | 2 | ......................... | ............ |
| Protective glasses | 3 | ......................... | ............ |
| Thyroid shield | 4 | ......................... | ............ |
| Personal monitor | 5 | ......................... | ............ |
| Lead sleeves | 6 | ......................... | ............ |
| Other ( Specify) | 7 | ......................... | ............ |

(b) What protective gear do your staff use during radiography and how frequently are they being used?

| **PROTECTIVE GEAR** | | **FREQUENCY OF USING THESE WHEN TAKING X-RAYS** |
|---|---|---|
| Lead gloves | 1 | ........................ |
| Lead aprons | 2 | ........................ |
| Protective glasses | 3 | ........................ |
| Thyroid shield | 4 | ........................ |
| Personal monitor | 5 | ........................ |
| Lead sleeves | 6 | ........................ |
| Other ( Specify) | 7 | ........................ |

21. (a) How often is the protective gear checked for leaks/damages?

| | |
|---|---|
| Monthly | 1 |
| Quarterly | 2 |
| Six monthly | 3 |
| Annually | 4 |
| Other (Specify) | 5 ................................................................ |

(b) How do you check them?..........................................................

22. How frequently do you and your staff use the following while taking x-rays? (Please circle)

| | **Never 0%** | **Rarely 1-30%** | **Sometimes 30-70%** | **Mostly 70-90%** | **Always 100%** |
|---|---|---|---|---|---|
| (a) sedative/tranquilliser | 1 | 2 | 3 | 4 | 5 |
| (b) general anaesthesia | 1 | 2 | 3 | 4 | 5 |
| (c) manual restraint by staff | 1 | 2 | 3 | 4 | 5 |
| (d) manual restraint by owners of animal patient | 1 | 2 | 3 | 4 | 5 |

23. (a) What percentage of animals are manually restrained for x-ray purposes at your clinic?

.......................................%

(b) Who is usually responsible for restraining the animals for x-rays?

..................................................................................................

(c ) Have you or your staff been bitten, kicked or scratched while restraining animals?

| | | |
|---|---|---|
| Vet. Surgeon | 1.Yes | 2. No |
| Staff | 1. Yes | 2. No |

24. If you are a female veterinarian, have you been involved in x-ray examinations during pregnancy where you could have received a radiation dose?

1. Yes 2. No

25. Have any pregnant staff members been involved in x-ray examinations during pregnancy where they could have received a radiation dose?

1. Yes 2. No

26. Do you have a copy of the Code of Practice for the Safe Use of Ionising Radiation in veterinary radiology, 1983? NHMRC (National Health and Medical Research Council) Code.

1. Yes 2. No

27. (a) Do you maintain a log of the procedures and exposure factors (kVp, mA, exposure time, FFD etc.) of all radiography undertaken?

1. Yes 2. No

(b) For how long do you hold the radiation dose records of the veterinarian and the staff?

Vet.:................years/months Staff:................years/months

28. What method of film processing do you use?

Manual 1
Automatic 2

29. Do you use glutaraldehyde in processing x-ray films?

1. Yes 2. No

## C ALLERGIES

30. (a) How many hours per day do you spend in an enclosed animal housing facility?
.................................... hours

(b) Have you experienced any of the following as a result of working in an animal enclosure? (Circle all that apply)

1. Sneezing
2. Wheezing
3. Cough
4. Phlegm
4. Skin irritation/dermatitis
5. Eye, nose, throat irritation
6. Other (specify).................................
7. None

31. (a) Do you have any animal allergies?

1. Yes 2. No

(b) What species are you allergic to?

..........................................................................................

32. (a) Have you experienced adverse reaction when applying topical medication to animals?

1. Yes 2. No

(b) List the agents and the type of reactions experienced.

…………………………………………………………………………………………
…………………………………………………………………………………………

33. Have you developed a skin reaction while using latex gloves?

1. Yes 2. No

## D BIOLOGICAL HAZARDS

34. Have you ever acquired an infection or disease due to handling of zoo animals?

1. Yes 2. No

35. Review the list below and circle all that apply:

| | INFECTION | WAS INFECTION LOCALISED OR SYSTEMIC(Yes/No) | HOSPITALISED (Yes/No) | NO OF WORK DAYS LOST |
|---|---|---|---|---|
| 1 | Ringworm | | | |
| 2 | Any other fungal infection | | | |
| 3 | Toxoplasmosis | | | |
| 4 | Psittacosis | | | |
| 5 | Cryptosporidium | | | |
| 6 | Salmonella | | | |
| 7 | Shigella | | | |
| 8 | Tuberculosis | | | |
| 9 | Hepatitis A,B,other | | | |
| 10 | Campylobacter | | | |
| 11 | Scabies | | | |
| 12 | Strongyloides | | | |
| 13 | Hookworms or Pinworms | | | |
| 14 | Erysipeloid | | | |
| 15 | Staphylococcosis | | | |
| 16 | Amoebiasis | | | |
| 17 | Q fever | | | |
| 18 | Leptospirosis | | | |
| 19 | Influenza | | | |
| 20 | Giardia | | | |
| 21 | Other | | | |

36. (a) Have you undertaken a baseline serum level test at the start of your employment as a zoo veterinarian?

1. Yes 2. No

(b) Has there been any change in the baseline serum test since working as a zoo veterinarian?

1. Yes 2. No

(c) If yes, in what way?

..............................................................................................................

## E CHEMICAL HAZARDS

37. Name the chemicals and other substances that cause headache, nausea or other problems in your practice.

| SUBSTANCES CAUSING PROBLEM | PROBLEM CAUSED (eg. Dermatitis) |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |

38. Do you use anti-neoplastic drugs?

1. Yes 2. No

39. What type of protective equipment do you wear when handling chemicals and anti-neoplastic drugs?

1. Gloves
2. Protective glasses
3. Goggles
4. Aprons
5.Other (specify)......................
6. None

40. Have you had an accidental exposure to anti-neoplastic drugs?

1. Yes 2 No

41. Which inhalant anaesthetic agents do you use? ( circle all that apply)

1. Nitrous oxide
2. Enflurane
3. Halothane
4. Isoflurane
5. Methoxyflurane
6.Other (specify)......................

42. Indicate the number of hours per week spent on gaseous anaesthesia?

..........................hours per week

43. Do you have in place a protocol/protection when using dangerous substances such as etorphine (immobilon)

1. Yes    2. No

44. (a) Describe the system you have for extracting/scavenging waste anaesthetic gases and vapour. (e.g. Nitrous oxide, Halothane, Methoxyflurane etc.)

..........................................................................................................

(b) No of scavenging units:..........................................

(c) How often do you use the scavenging system?

1. Always    2. Sometimes    3. Never

45. Do you get exposed to pesticides when working with animals?

1. Yes    2. No

46. Have you experienced an adverse reaction when using pesticides on animals? If so, circle all that apply.

| **PESTICIDE** | **SKIN DISORDER** | **RESPIRATORY PROBLEM** | **OTHER PROBLEMS** |
|---|---|---|---|
| Organophosphates | 1 | 1 | 1 |
| Carbamates | 2 | 2 | 2 |
| Pyrethrins | 3 | 3 | 3 |
| Other | 4 | 4 | 4 |

47. Have you experienced an adverse reaction when using disinfectants/ sterilants? If so, circle all that apply.

| **DISINFECTANTS/ STERILANTS** | **SKIN DIOSORDERS** | **RESPIRATORY PROBLEM** | **OTHER PROBLEMS** |
|---|---|---|---|
| Formalin | 1 | 1 | 1 |
| Quarternary ammonium compounds | 2 | 2 | 2 |
| Chlorine bleach | 3 | 3 | 3 |
| Iodine | 4 | 4 | 4 |
| Chlorohexidine | 5 | 5 | 5 |
| Glutaraldehyde | 6 | 6 | 6 |
| Ethylene oxide | 7 | 7 | 7 |
| Phenolics | 8 | 8 | 8 |
| Other | 9 | 9 | 9 |

48. (a) Has exposure levels of hazardous chemical agents been conducted at your work place by air monitoring?

1. Yes  2. No

(b) Name the hazardous agents that were monitored.

..........................................................................................................
..........................................................................................................

49. Have you been vaccinated against any of the following diseases? (Circle all that apply)

1.Tetanus  4.Measles
2.Hepatitis B  5.Polio
3.Typhoid  6.Other...........................................

50. Have you undergone tuberculin skin test since working as the zoo veterinarian?

1. Yes  2. No

51. Do you have a policy on handling venomous reptiles?

1. Yes  2. No

52. When undertaking varied tasks, what percentage of time do you wear appropriate personal protective equipment?

1. 90 – 100%  3. 40 – 59%
2. 60 – 79%  4. 0%

53. Name the type and number of work related motor vehicle accidents you have had while you have been a zoo veterinarian.

| Type of Accident | No of times |
|---|---|
| Minor | |
| Major | |
| Fatal | |

54. While working with dangerous and unpredictable animals, do you practice safe contact methods either under instruction of a trained/experienced elephant keeper or through protected contact? eg. elephant

1. Yes  2. No

55. What major incidents/accidents have occurred in your practice while you were a zoo veterinarian? eg. fracture, animal bite

..........................................................................................................
..........................................................................................................
..........................................................................................................

56. (a) Have you experienced occupational stress and trauma during your veterinary career?

1. Yes 2. No

(b) What are the causes for such stress and trauma?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

57. What drug related incidents have occurred in the zoo veterinary facility? eg. addiction

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

58. What do you believe are the major occupational health and safety issues confronting your practice?

…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

## Appendix 3

## Formal discussions with veterinarians in Sri Lanka on occupational hazards

Formal discussions were held with the veterinary practitioners in Sri Lanka to gather information on occupational hazards affecting the profession in a developing country. These discussions were held subsequent to the literature searches, the study and the survey among zoo veterinarians across Australia. Two veterinary practitioners from the zoological gardens and ten veterinarians in state and private practice participated in three separate discussions.

During the past few decades, there had been an increase in women entering the only veterinary faculty in the university of Peradeniya, Sri Lanka. The discussions revealed that the veterinarians are challenged by an imposing group of occupational hazards including physical injuries, biological and chemical exposures. Animals most often involved and the mechanism of injuries included kicks, goring and head butting by cattle and ungulates in captivity; bites and scratches from monkeys, dogs and cats; knocks, trampling and crushes by elephants, rhinoceros, cattle and buffaloes; and horn wounds from cattle and goats. Most of the injuries inflicted by the animals necessitated medical treatment. One participant indicated that he self-treated most of the injuries received from animals.

The participants in the discussions cited the injuries and infections experienced from knife wounds while performing necropsies and accidental needlestick as well as scalpel injuries from sudden patient movement. It was also revealed that each participant had sustained more than 16 needlestick injuries within a five year period between 1997 and 2002 some of which necessitated medical treatment.

During discussions, most of the participants indicated that they were not vaccinated against infectious diseases which are common in Sri Lanka even though, they were exposed to rabies while treating domesticated canine and bovine species. However, subsequent to rabies exposure, some veterinarians have undergone a series of vaccination against rabies.

Majority of the participants have experienced dermatitis and skin problems due to the use of chemicals and other exposures. In the course of the conversation, some participants indicated that the veterinarians perform artificial insemination and pregnancy diagnosis in cattle and goats on a regular basis by rectal examination without adequate protection and the use of gloves. Two participants reported that they experienced allergic conditions from direct contact with amniotic fluid during dystokia.

During discussions it was reported that even though the veterinary faculty in Sri Lanka provides some strategies on work-related disease, injury and accidents for the veterinary undergraduates, these strategies were not strictly followed by practising veterinarians. The nature of injuries have been common among veterinary practitioners both in developed and developing countries, however, the occupational health and safety legislations and other measures prevalent in the developed countries have enabled the veterinary professionals to adopt some measures of prevention in the control of occupational hazards. The discussions I had with the veterinarians in Sri Lanka brought awareness on occupational hazards and the importance of preventive strategies for minimizing hazards.