Radiation exposure in the perioperative environment — are we safe ?

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Radiation exposure in the perioperative environment – are we safe?

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DECLARATION

I certify that, except that where due acknowledgement has been made within this work, this dissertation comprises my own original work. This material has not been submitted to any other university for any award for any other degree or diploma.

Signature Redacted

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ABSTRACT

Like most things in today's world, health technology has undergone many changes over the past few decades. Medical and technological advances have changed many health practices. The subject of this study is perioperative personnels' knowledge and understanding of radiation in the perioperative environment. The concern of this study is whether perioperative personnel who are exposed to radiation during their daily work routines are adapting their work practices in line with this changing technology, specifically regarding radiation in the Operating Suite.

A focus group study was undertaken to determine the knowledge and understanding of radiation exposure and safety held by perioperative personnel during their daily work routines within the Operating Suite. The personnel studied came from diverse backgrounds with varying education levels and experiences. They consisted of preoperative nurses, theatre assistants, surgeons and anaesthetists. A total of 23 personnel from the population of 82 participated in four homogeneous focus groups.

The discussions were tape-recorded and copies of the transcripts and preliminary analysis were returned to participants for correction, comment and verification. Following the processes of data collection and ongoing data analysis five intra and inter related categories were identified. These were the dangers of radiation exposure; the lack of knowledge and education on radiation exposure and safety; the radiation environment; protective devices and apparel; and, the radiographer's role and responsibilities. The study identified self-determined deficits in the knowledge and understanding of radiation exposure and safe radiation practices by the participants.

The results demonstrate that, at this point in time, safe radiation practices by perioperative personnel are not optimised within this environment. The

recommendations - education on radiation exposure and safety, the appropriate quantity and quality of protective apparel, attention given to signage and warning systems, the roles and responsibilities of radiographers identified and enacted upon; and, future research involving the monitoring of perioperative personnel to determine whether safe exposure levels were not exceeded - could indeed provide a safer perioperative environment.

It has also been recommended that policies and procedures and an education package covering the use of radiation within the perioperative environment are required.

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GLOSSARY AND ABBREVIATIONS

Absorption. Transference of energy from a x-ray beam to the atoms or molecules of the matter through which it passes.

Attenuation. Any process that decreases the intensity of the primary photon beam directed toward some destination.

Backscatter. Photons that have interacted with the atoms of an object and as a result are deflected backward (toward the x-ray tube).

Bucky slot shielding device. A protective device of at least 0.25mm lead equivalents that automatically covers the Bucky slot opening in the side of the x-ray tube during a fluroscopic examination when a Bucky tray is positioned at the foot end of the table. This device protects the radiographer and radiologist from radiation exposure at the gonadal level.

C-arm fluroscope. A portable device for producing real-time (motion) images of a patient. The opposite ends of the C-shaped support arm hold the x-ray tube and the image intensifier.

Clear lead. Transparent lead-plastic material that has been impregnated with approximately 30% lead by weight.

Cosmic radiation (cosmic rays). Very high-speed particles, mainly photons, that are generated as a result of extreme reactions with stars.

Dosimetery. Monitoring of radiation exposure to any person occupationally exposed on a regular basis to ionising radiation. This is accomplished by using a personal dosimeter badge that records exposure over a set time frame.

Exposure. The total electric charge per unit mass that x-ray and gamma ray photons with energies up to 3 MeV generate in air only. Exposure may be viewed as the amount of ionising radiation that may strike an object, such as the human body, when in the vicinity of a radiation source.

Genetic damage. Radiation damage to generations yet unborn.

Image intensification fluroscopy. The use of an image intensifier (II) to increase the brightness of real time image produced on a fluorescent screen during fluroscopy. Virtually all modern fluroscopy is image intensification fluroscopy.

Image intensifier (II). A device that increases the brightness of an image. An image is produced on a fluorescent screen by x-rays at the input end (input phosphor). A television camera, film or other recording device views the bright image at the output end (output phosphor).

Incident photon. Incoming photon.

International Commission on Radiological Protection (ICRP). Evaluates information on biologic effects of radiation and provides radiation protection guidelines through general recommendations regarding occupational and general public dose limits.

Last-frame-hold feature. An optional equipment feature in which the most recent fluroscopic image remains in view as a guide to the radiologist (or surgeon) when the x-ray beam is off.

Late somatic effects. Non-genetic effects that appear after a period of months or years following exposure to ionising radiation.

Leakage radiation. Photons that, instead of coming out of the collimator opening with the useful beam, emerge in multiple directions through the protective housing of the x-ray tube. Regulatory standards require that the leakage radiation exposure rate at 1 metre from the target should not exceed 100mR per hour when the x-ray unit is run at maximum operating conditions.

National Council on Radiation Protection and Measurement (NCRP). Reviews regulations recommended by the ICRP and decides how to include them in the home country (for example, Australia and the USA) radiation protection criteria.

Occupational and non-occupational dose equivalent dose limits. Upper boundary dose of ionising radiation that will result in a negligible risk of bodily injury or genetic damage.

Occupationally exposed persons. Individuals employed as radiation workers.

Photon. A particle associated with electromagnetic radiation that has neither mass nor electric charge.

Primary protective barrier. 1. A barrier designed to prevent primary or direct radiation from reaching personnel or members of the general public on the other side of the barrier. 2. A barrier located perpendicular to the line of travel of the primary or useful beam.

Protective barrier. Any medium of adequate composition and thickness that absorbs primary and/or secondary radiation, thereby reducing exposure of persons located on the other side of the barrier.

Rad ('radiation absorbed dose'). The unit that indicates the amount of radiant energy transferred to an irradiated object by any type of ionising radiation. One rad is equivalent to an energy transfer of 100 erg per gram of irradiated object.

Radiant energy. Energy that moves in the form of a wave and is transmitted by radiation such as x-rays or gamma rays.

Radiolucent. Transparent to radiation: material that allows radiation to pass through.

Rem ('rad-equivalent-man'). The traditional radiation quantity unit for dose equivalent, rem was defined as the dose equivalent of any type of ionising radiation that produces the same biologic effect as one Rad of radiation.

Remnant radiation. (See exit or image-formation radiation).

Scattered radiation. All the radiation that arises from the interaction of the x-ray beam with the atoms of an object in the path of the beam.

Secondary protective barrier. The barrier that affords protection from secondary radiation (leakage and scattered radiation) and, as such, is not designed to intercept the direct x-ray beam and provide adequate attenuation of it.

Secondary radiation. The radiation that results from the interaction primary radiation and the atoms of the irradiated object and the off-focus or leakage radiation that penetrate the x-ray tube protective housing. Secondary radiation consists of leakage and scatter radiation.

Side scatter. Photons that interact with the atoms of an object and are consequently deflected to the side.

Sievert (Sv). The SI radiation quantity unit for dose equivalent. I Sievert equals 1 joule of energy absorbed per kilogram of tissue (for x-radiation, QF=1). This unit is used only for radiation protection purposes. It provides a common scale whereby varying degrees of biologic damage caused by equal absorbed doses of different types of ionising radiation can be compared with the degree of biologic damage caused by the same amount of gamma radiation. 1000 milliSievert (mSv) = 1Sv.

Skin dose. The absorbed radiation dose, stated in gray or rads, delivered to the most superficial layer of the skin as a result of radiation exposure. Backscatter radiation contribution is included.

Stochastic effects. Non-threshold, randomly occurring biologic effects of ionising radiation in which their probability of occurrence (rather than their severity) is proportional to the dose. Examples of stochastic processes are cancer and genetic effects. They are also called probabilistic effects.

(Sources: Bushong 1993; ICRP 1996; Statkiewicz-Sherer, Visconti & Ritenour 1998).

CHAPTER ONE

INTRODUCTION

Dr Robert Stable, Queensland's Director-General of Health (2002, p. 2) states

> *Health services throughout the western world have been going through a period of tremendous changes over the past 15 years. Medical and technological advances have changed our health practices.*

A concern is whether those perioperative personnel who are exposed to radiation during their daily work routines are adapting their work practices in line with the changing technology, specifically regarding radiation use in the Operating Suite.

Similar to many developed countries Australia has adopted new surgical technologies in the past 15 years (Davies 2000a, 2000b; Johnston 2001, Smathers 1988). This included radiation in the form of Image Intensification (II). Minimally invasive procedures, using II as an adjunct to diagnosis or treatment, are increasing. These procedures are less traumatic to patients resulting in decreased operating time, postoperative morbidity rates and length of hospital stay (Jones & Stoddart 1998). Some of these procedures using fluroscopic guided II consist of closed reductions of fractures, closed locked intermedullary nailing and fracture fixation, percutaneous nephrolithotomies, retrograde pyelograms and ureteric stenting (Giblin, Rubenstein, Taylor & Pahira 1996; Goldstone, Wright & Cohen 1993; Jones & Stoddart 1998; O'Rourke, Crerand, Harrington, Casey & Quinland 1996).

The use of portable II has become a routine practice in many orthopaedic, urological and surgical interventions (Alonso, Shaw, Maxwell, McGill & Hart 2001; Newman 2000; Tse, Linsing, Khadra, Chiam, Nugent, Yeaman & Mulcahy 1999). It reduces the actual quantity of radiation needed to form an image (Arnstein, Richards & Putney 1994; Jones & Stoddart 1998). Radiation takes two forms – ionising radiation and electromagnetic (non-ionising) radiation. Ionising radiation is explored in this study as it is used when x-ray procedures and fluroscopy are employed. This radiation passes through matter producing positively and negatively charged particles and has the potential for biological damage to humans compared to non-ionising radiation (Brown, Smallwood, Barber, Lawford & Hose 1999; United States Environmental Protection Agency (USEPA) 1998a). Ionising radiation is the type to which perioperative personnel are exposed. The following text will refer to ionising radiation as radiation. Three problematic areas relating to radiation - dangers of radiation exposure, increasing usage of radiation technology and safe radiation practices - will be explored below. Specifically the study will explore knowledge and understanding of radiation exposure and safety held by perioperative personnel who are exposed to radiation. The results may enable perioperative personnel to strengthen or improve safe radiation practices.

Dangers of exposure to radiation

Radiation effects people by depositing energy in body tissue, which can cause cell damage or cell loss. In some cases there may be no effect while in other cases the cell may survive but become abnormal, either temporarily or permanently. The extent of the damage depends on the total amount of energy absorbed, the time period and dose rate of exposure and the particular organ(s) exposed (USEPA 1998b). An abnormal cell may become malignant due to changes in the chemical balance of cells. In addition, by damaging the genetic material in cells of the body, radiation can cause harmful genetic mutations that can be passed on to future generations (USEPA 1998b). Evidence of injury from low or moderate doses of radiation may not show up for months or even years. The types of effects and their probability of occurrence depend on whether the exposure occurs over a large part of a person's life span (chronic) or during a very short period of life span (USEPA 1998b). Perioperative personnel are at risk of being exposed to this low-dose radiation over varying periods of time. Authors such as Dewey and Incoll (1998) and Fuchs, Schmid, Eiteljorge, Modler and Stumer (1998) concede that carcinogenic potential exists from low-dose, long-term radiation exposures. In response to these potential risks research was conducted by the American Operating Room Nurses (AORN) association and led to the implementation of Standards, Guidelines and Recommended Practices governing radiation in the perioperative environment in 1994, revised in 2001.

Increased use of radiation in the perioperative environment

The dramatic increase in procedures using fluroscopic II was identified in the early 1990's and reinforced in 2001 (Alonso et al. 2001; Goldstone et al. 1993: Noordeen, Shergill, Twyman, Cobb & Briggs 1993; Henderson, Lu, Strauss, Treves & Rockoff 1994). Jones and Stoddart (1998) also concur that the use of fluroscopy has increased significantly over the past 20 years, especially in the orthopaedic trauma theatres. However, little is written about the knowledge and understanding of radiation held by perioperative personnel as became evident during the literature search phase of this study. Despite the increase in radiation use in the Operating Room (OR) there was no education material, policies or procedures governing its safe use available in the perioperative environment under study.

Safe radiation practice

The dearth of information concerning safe radiation practices employed by perioperative personnel was one motive for embarking on this study. A constant comment heard by the researcher when radiation concerns were voiced in the workplace was that most staff had never been given any formal education on radiation safety. Generally perioperative personnel expressed a total lack of knowledge of the dose of radiation a person could be exposed to that was considered 'safe'. The question that was frequently asked was related to just how far away from the source is safe. This lack of knowledge was also reported to be leading to complacency in some individuals. These concerns were raised at Unit meetings within the OR.

McConnell and Hilbig (2001) undertook a national study of perioperative nurse education and new technologies, which revealed that the most frequently identified method nurses used to learn technologies was via instruction from other staff members. They concluded that adequate education is the greatest factor in the safe and effective use of medical technology (McConnell & Hilbig 2001).

Purpose and aim of the study

The purpose of this study was to determine the knowledge and understanding of radiation exposure and safe radiation practices demonstrated by perioperative personnel when exposed to any potential risk from radiation. Knowledge is defined by the Australian Concise Oxford Dictionary (1996) as awareness or familiarity gained by experience; a person's range of information or the sum of what is known (Hughes, Mitchell & Ramson 1996). Understanding, from the same source, is defined as intelligence; the power of apprehension; an individual's perception or judgement of a situation (Hughes et al. 1996). The aim of this study was to gather data to ascertain the knowledge and understanding of radiation exposure and safety held by diverse categories of perioperative personnel – nurses, theatre assistants, surgeons and anaesthetists.

Research Question

Based upon the problem identified, this research sought to ascertain the knowledge and understanding of radiation exposure and safety held by perioperative personnel in their environment, hence the question that guided this study was

What was the knowledge and understanding of perioperative personnel in relation to radiation exposure and safe radiation practices in an Operating Suite?

Significance of the study

A perioperative environment is necessarily knowledge-centred, outcome-evidence seeking and efficiency-driven (Barnard 1997). When new technologies are introduced to this environment there is a responsibility to keep abreast of such technology (Barnard 1997; McConnell & Hilbig 2001; Tolson 1999). Under the guise of the Queensland Workplace Health and Safety Act 1995 (Queensland Parliamentary Council 1995) and moral and ethical obligations, both employers and employees have responsibilities in risk assessment and management. Perioperative staff were supplied with a rack of lead aprons and a handful of lead collars but that was the extent of risk management measures. When the posed research question was answered and the knowledge and understanding of radiation exposure and safe radiation practices were identified among perioperative individuals, and across the diverse categories of perioperative personnel studied, one could then judge whether current knowledge and understanding translated into safe radiation practice. By conducting this study safe radiation practices would at least be highlighted and possibly given more consideration.

Objectives and scope of the study

The objective of this study was, by achieving the aim outlined earlier, to maximise safe radiation practices amongst perioperative personnel. The motivation for the study was the researcher's concern that with increasing use of radiation in the perioperative environment what danger, if any, are perioperative personnel exposed to and, if that danger is real, who is most at risk? X-raying is common place now days in the orthopaedic and urology theatres and has a place in some general surgical procedures.

The perioperative nurses and theatre assistants rotate through most specialties with some minor exceptions. After-hours trauma has all perioperative staff – nurses, theatre assistants, anaesthetists and surgeons - potentially exposed to radiation at any given point of time. Orthopaedic surgeons and Urologists deal with radiation increasingly as minimal invasive procedures become more attractive.

Each category of perioperative personnel has varied educational backgrounds, experiences and working timeframes in the perioperative environment. Perioperative nurses, for example, come from both hospital training and tertiary education, either with or without undergraduate or postgraduate degrees. Nurses work in perioperative environments for vastly differing periods of time. Theatre assistants come from many diverse backgrounds and lengths of service. Surgeons and anaesthetists, although they have similar early educational backgrounds, once they decide to specialise, branch out into different educational streams dedicated to their specialty. As diverse as these personnel are, they all have one thing in common – radiation is becoming more frequent in their daily work lives and they may or may not be aware of the repercussions of radiation exposure or the safe practices required to minimise any risk. The scope of the study is limited to the one perioperative environment with its population of 82 involved in radiation usage during their daily work routines.

Conclusion

This chapter introduced the research topic, outlined the elements of the problem to be investigated, described the purpose and aim of the study, detailed the research question and discussed the significance, objective and scope of the study. Chapter two presents a review of published literature relevant to radiation in the perioperative environment and the problems identified. Chapter three presents the methodology, method, population, sample and sampling strategy adopted and finally, the data collection and analysis used to address the research question. Chapter four presents the findings of the study. Chapter five contains the discussion, limitations of the study, the recommendations for practice and recommendation for future research.

CHAPTER TWO

LITERATURE REVIEW

Introduction

Hospital employees have been the subjects of a number of epidemiological studies over the past 20 years aimed at determining whether OR environments pose a health risk (Bagley & Cubler-Goodman 1990, Dewey 1997, Henderson et al. 1994; McGowan, Heaton & Stephenson 1996; Otto & Davidson 1999 Rozgaj, Kasuba & Peric 1999, Saas-Kortsak, Purdham, Bazek & Murphy 1992). These have involved mainly anaesethetic agents although there has been some investigation into radiation in this environment (Saas-Kortsak et al. 1992). In order to identify current thinking on issues of danger of radiation exposure, the increasing use of radiation and the knowledge of radiation exposure and safety a search of the national and international literature for the past 10 years was undertaken. Standards and guidelines that encompassed the use of radiation in the perioperative environment were obtained. A review of the literature was performed to identify material that was directly related to the problem identified and the research question (Beyea & Nicoll 2000a).

Personnel with a diverse range of clinical knowledge, skills and experience can be found in any Operating Suite and they consist of theatre assistants, perioperative nurses, surgeons and anaesthetists, all with varying time spans of employment in this environment. Of the literature reviewed no studies focused upon radiation exposure and safe radiation practices performed by all categories of perioperative personnel. Attention was given to specific groups. Some literature targeted orthopaedic surgeons, anaesthetists, scrub nurses or urologists. However other categories had little or no mention, for example circulating nurses or theatre assistants. The theatre assistant (theatre orderly, porter) was not mentioned in any study and their role in patient positioning and limb holding, especially during some closed orthopaedic procedures under image intensification, is integral to these procedures. In the course of their work routines they are summoned to the theatres to change the position of theatre lights, connect power tools, apply tourniquets, position and support the patient. Hence, they often enter a theatre oblivious as to whether II is in use or not and are therefore unprotected. The literature reviewed focused on the problems identified in Chapter one. These were the a) the dangers of radiation exposure, b) the increased use of radiation within the perioperative environment and c) the knowledge of safe radiation practices.

a) Dangers of radiation exposure

Background information on radiation

To better understand the danger of radiation exposure a brief history is included. Wilhelm C. Roentgen announced the discovery of x-rays in 1895 and during the months that followed, experimentation with these x-rays resulted in acute biologic damage to both patients and radiation workers (Statkiewicz-Sherer et al. 1998). Cases of this somatic damage caused by radiation exposure were reported in Europe as early as 1896 (Brown et al. 1999; Newman 2000). In the United States of America the first radiation-induced fatality occurred in 1904 (Brown et al. 1999). Many radiologists and dentists developed cancerous skin lesions on their hands as a result of radiation exposure. Blood disorders, such as aplastic anaemia and leukaemia, were more common with early radiologists than among non-radiologists (Brown et al. 1999; Statkiewicz-Sherer et al. 1998). As a direct result 1921 saw the emergence of the first committee formed to investigate methods for reducing radiation exposure. Since then the International Commission for Radiation Protection (ICRP) and the National Council for Radiation Protection and Management (NCRP) and other major organisations share the responsibility for evaluating the relationships between radiation dose equivalents and induced biologic effects. They are also concerned with formulating risk estimates of somatic and genetic effects after irradiation and for making recommendations of acceptable radiation exposure levels for the occupationally exposed and the general public (Brown et al. 1999; Statkiewicz-Sherer et al. 1998). Their roles are to evaluate information on biologic effects of radiation and to provide radiation protection guidance to the individual governing bodies of the countries concerned (ICRP 1996; NCRP 1976). For example, Europe and Great Britain are governed by the Ionising Radiation Regulation 1999 (Alonso et al. 2001).

Control of radiation exposure in Australia is enacted through Commonwealth, State and Territory legislation. The National Occupational Health and Safety Commission (NOHSC) (1995a, 1995b) has developed national standards for limiting both general public and occupational exposure to ionising radiation. This is an advisory document and the application of any National Commission document in any particular State or Territory is the prerogative of that State or Territory. Queensland Health (QH) and the National Health and Medical Research Council (NHMRC) set Queensland's radiation health standards. This is in the form of The Radiation Safety Act 1999.

The main focus of the Radiation Safety Act 1999 is to protect persons from health risks associated with exposure to particular sources of ionising radiation and harmful non-ionising radiation (QH 1999a). This objective was achieved by establishing a licensing regime and a legislative framework to ensure radiation sources, and the premises at which they are used, comply with radiation safety standards. Now implemented is the legislative framework within which compliance monitoring and investigative and enforcement activities may be undertaken (QH 1999a). The Radiation Safety Regulation 1999 supplies the rules under which the Act is to be operated. It sets out the methods and procedures to enable the safe use of radiation in radiation practices and covers such things as timeframes for certificates of compliance attainment; Radiation Safety and Protection Plans; qualifications and functions of Radiation Safety Officers; and radiation dose limits (QH 1999e).

Standards that cover both the surroundings and equipment used in the Operating Suite are also incorporated in this Act. The Radiation Safety Standard PR004: 1999 governs the premises at which radiation apparatus is used to carry out health related diagnostic radiography or radiation therapy (QH 1999b). Radiation Safety Standard HR001: 1999 is primarily concerned with compliance testing of radiation apparatus for diagnostic radiography (QH 1999c). Radiation Safety Standard HR002: 1999 relates specifically to radiation apparatus used to carry out fluroscopy. This compliance testing of mobile II equipment is most relevant to the perioperative environment as it covers the mobile II machines stored and used exclusively in the Operating Suite for all diagnostic and treatment radiology (QH 1999d). NOHSC (1995a) identified that employees have a responsibility to adhere to these regulations.

The physics of radiation

Radiography is crucial to the care and treatment of patients (Shymko & Shymko 1998). Radiation passes through matter producing positively and negatively charged particles that can cause biological damage in humans (Brown et al. 1999). X-rays are carriers of this energy and if they enter material, such as human tissue, they may interact with the atoms of the biological material or pass through it without interacting. If they interact, energy is transferred from the x-rays to the atoms of the biological material (Brown et al. 1999; Statkiewicz-Sherer et al.1998). This transference of energy is called absorption. The more energy received by the atoms of the person's body, the greater the risks of biological damage (Brown et al. 1999). For safety, the amount of energy transferred should be kept as small as possible. However, without the phenomenon of absorption, and differences in the absorption properties of different body structures, diagnostically useful radiographs, in which different structures may be distinguished and perceived, could not be produced (Brown et al.1999; Pierson 1995; Revell 1994; Statkiewicz-Sherer et al. 1998).

There are three categories of radiation, two of which require protective shielding - primary radiation and scatter radiation (Brown et al. 1999). Primary radiation refers to the primary (or useful) beam produced inside the x-ray tube that is directed at a target (Brown et al. 1999). The useful beam is the primary radiation that comes from the x-ray tube towards the patient and is the most hazardous and most intense (Bushong 1993). Most leaded protective devices, although protective against secondary radiation, offer little protection against the primary beam (Statkiewicz-Sherer et al. 1998). Secondary radiation (the sum of scatter and leakage radiation) results when the primary beam interacts with the patient, or any object in its vicinity and is deflected or partially absorbed (attenuated). This attenuation causes a change in the direction of movement of the incident photon and a simultaneous loss of photon energy (Bushong 1993).

Scatter radiation poses the biggest hazard to personnel in the room during exposure (Shymko & Shymko 1998). The patient is the primary scattering object and the larger the patient the more scatter provided. During general radiography and II scatter occurs from within the patient (Bushong 1993; Shymko & Shymko 1998). Generally the intensity of scatter radiation, at one metre from the patient, is approximately 0.1% of the intensity of the primary beam directed at the patient (Bushong 1993). Scatter will travel in the air until absorbed by matter. As the distance from the radiation source increases the intensity of the radiation decreases (Bushong 1993; Shymko & Shymko 1998; Statkiewicz-Sherer et al. 1998). Patient doses of radiation during II are relatively high and although a lead apron may reduce the exposure factor by one-tenth, radiation exposure poses a hazard to personnel (Bushong 1993; Statkiewicz-Sherer et al. 1998).

Fluroscopic procedures using II have three significant benefits: 1. increased image brightness; 2. time saving for radiologists; and 3. a patient dose reduction. However, safety procedures are particularly important when II systems are in use because patterns of exposure direction are less predictable (Bushong 1993). Radiographers should exercise vigilance as they also have a responsibility to protect patients and personnel by reducing exposure levels and time (Revell 1994; Statkiewicz-Sherer et al. 1998). During procedures where cross-table exposures are used, an understanding of the patterns of scatter exposure is particularly useful. Basically there is a higher dose rate at the entrance side of the patient. Thus the location of lower scatter is on the side of the patient away from the x-ray tube. Outside of the beam the exposure caused by scatter is lower on the image intensification side (Statkiewicz-Sherer et al. 1998).

Remnant radiation, the third type of radiation, poses little threat to personnel because it is the radiation that exits the patient and imparts the image on the film (Bushong, 1993). By using the knowledge of radiation hazards that has been gained over the years and employing effective methods to limit, or eliminate, these hazards and being cognizant of existing standards one can exercise greater control over the use of 'radiant energy' (Statkiewicz et al. 1998). This is clear to a physicist but where does the knowledge of radiation hazards present itself to perioperative personnel? This knowledge should flow on to those working in the environments where this 'radiant energy' is being used.

The effects of radiation.

Any amount of radiation causes an effect and despite the phrase 'maximum permissible limit's, many investigators still caution that there is no absolute safe level of radiation exposure (Bushong 1993; Shymko & Shymko 1998; Statkiewicz-Sherer et al.1998). The ICRP (1996) and consequently QH (1999a) set these maximum permissible limits. They catagorises the three types of exposures as medical exposure (patient dose for treatment or diagnosis), occupational exposure (exposure incurred at work) and public exposure (all other exposures). The set limits for ionising radiation exposures are

- The total effective dose for the person must not be more than1 mSv=0.1 rem a year (occupational exposure 20 mSv=2 rem).
- The equivalent dose for each lens of a person's eye must not be more than 15 mSv=5 rem a year (occupational exposure 150 mSv=15 rem).
- The equivalent dose for a square centimetre of a person's skin must not be more than50 mSv=5 rem a year (occupational exposure 500 mSv=50 rem) (ICRP 1996, p. 17; QH 1999e, p. 28). (See Glossary and abbreviations pp. 11-12).

Radiation interacts with the human body on an anatomic level. If atoms are disrupted by x-ray photons (ionisation) it is then possible that somatic and genetic cells can become damaged, altered, or can die (Newman 2000). Radiation is deposited in cells randomly and the damage to the irradiated cells is sporadic; however the effects are not necessarily permanent and injuries often heal (Newman 2000). The lens of the eye, the thyroid gland, the gonads and the lymphocytes are especially radiosensitive and radiation damage to the body (within certain parameters) is said to be 90% replaced by special enzymes that help maintain homeostasis (Newman 2000). However Bushong (1993) and Shymko and Shymko (1998) warn humans can expect an average life span shortening of approximately 10 days for every 1,000 mRem (or 1 rem which equals 10 mSv) of exposure.

Existing research highlighting the dangers of radiation exposure

No qualitative studies investigating radiation in the perioperative environment were located. Previous research investigating radiation were quantitative studies that were interested either in determining whether existing set limits of radiation exposure were exceeded during their studies, or in the assessment and evaluation of protective devices. Unfortunately only specific categories of perioperative personnel have been investigated. For example, three American studies endeavoured to determine the levels of radiation exposure of anaesthetists and anaesethetic nurses (Henderson et al. 1994; McGowan et al. 1996; Otto & Davidson 1999). A number of studies have also investigated the radiation exposures of orthopaedic surgeons (Arnstein et al. 1994; Fuchs et al. 1998; Goldstone et al.1993; Jones & Stoddart 1998; Mehlman & DiPasquale 1997; Noordeen et al. 1993; O'Rourke et al.1996; Smith, Lavy, Briggs & Nordeen1992; Thomas, Holt & Coakley 1999). The findings of these studies unanimously agreed that the whole body doses received were within the recommended parameters although Smith et al.'s (1992) and Noordeen et al's (1993) studies recommended a reduction of set limits by one third. These were the only studies discovered in the literature search that looked at reducing set limits for radiation exposure. All of the studies emphasised caution due to the uncertainty of long-term effects of low dose radiation and they all came to the conclusion that there is no safe level of radiation and stressed that the ALARA (as low as reasonably achievable) principle should be resolutely adhered to.

Smith et al. (1992) had a secondary aim in their study that was to discover whether ionising radiation doses of orthopods were within limits for 'non-classified' workers. Staff working in any industry who are exposed to greater than 30% of the limits laid down in the Ionising Radiation Regulations 1988 (England) are termed 'classified' workers (Smith et al. 1992). As such, they are subject to certain statuary requirements, from which non-classified workers are exempt (Smith et al. 1992). For example, compulsory continuous monitoring and an annual medical examination are mandatory for 'classified' workers (Smith et al. 1992). According to the Ionising Radiation Regulation 1989 and 1999, the annual dose limit for whole body is 20 mSv (Alonso et al. 2001; Smith et al. 1992). However, if there is a risk of the dose reaching 6 mSv (30% of 20 mSv = 6 mSv) the individual should be designated as classified (Alonso et al. 2001). Although most cited studies maintained that exposure levels did not exceed set limits, only Smith et al (1992) and Goldstone et al. (1993) specifically identified, as a goal of their studies, investigation as to whether orthopaedic surgeons should or should not be considered 'classified'. Both studies recommended that orthopaedic trauma surgeons should be 'classified'. New Zealand orthopaedic surgeons are considered as 'radiation workers' (classified) and as such attract the higher annual doses of radiation (Jones & Stoddart 1998). No other study determined whether their participants approached or exceeded this 30% mark. It is accepted that this was not the intention of other studies but the delineation is a factor to consider. Alonso et al. (2001) believe that exceeding the 30% mark may occur in a busy trauma centre for those who fail to wear lead protection. They also argue that routine monitoring should be carried out for this group.

No studies were found that identified any specific classification of the level of exposure that governs Australian perioperative staff. On contacting the Senior Medical Physicist from Biomedical Environmental Health Technology Services (BEHTS) in Brisbane the researcher was informed that Australian perioperative personnel are categorised as 'non-classified' until studies are conducted in perioperative environments to calculate their exposure rates to determine if they approach, or exceed the 30% (Coakley, personal communication, 24th January 2001). This is supported by the NOHSC (1995a, 1995b). It would be advantageous to perioperative personnel to be considered 'non-classified', as the individual staff member would attract the lower level of annual dose limits as outlined above. However without research in this area is would not be possible to know the levels of radiation exposure of perioperative personnel.

In Thomas et al's (1999) study, although it concurred with the general consensus of not exceeding set limits, they concluded that in their study exposure per-screening-minute was greater than previous literature. As an example, when looking at the exposure rates to hands their study showed results a mean of 92 uSv/min when previous studies resulted in readings ranging between 28-55 uSv/min. Similarly, thyroid doses (outside protective collars) for their study were 180 uSv/min mean as opposed to a range of 10-45 uSv/min. This was a prospective study of 48 orthopaedic procedures. Their total time of exposure was 74.1 minutes whereas Tse et al.'s (1999) study of 20 urological procedures had a total screening time of 63.1 minutes but with significantly lower exposure rates. The figures that were compared were in relation to thyroid exposure. Thomas et al.'s. (1999) study demonstrated radiation exposure outside thyroid protection as 180 uSv and under thyroid protectors as 11 uSv while Tse et al's. study demonstrated 46 uSv outside and 2 uSv inside the protective collars. Other studies did not give definitive exposure times for their studies. Although Thomas et al's (1999) study looked at 2.4 times the procedures compared to Tse et al. (1999) the exposure rates only equated to an exposure rate at 2.4 times 46 uSv as 110.4 uSv, which is still significantly lower than the 180 uSv demonstrated by the Thomas et al. (1999) study.

Dewey (1997) published in the Australian Orthopaedic Association (AOA) Bulletin the results of a preliminary survey of the membership of the AOA conducted in 1996. The survey involved thyroid disease and 325 survey forms were returned from 840 sent. Of these three were female surgeons. The following thyroid diseases were recorded.

Benign goiter – 1; Nodular goiter – 4; Idiopathic thyroidatrophy – 1; Follicular carcinoma - 3 (2 under 44 years and 1 above 44). Comparison data for follicular carcinoma supplied by Dewey (1997) citing Professor Leigh Delbridge of Sydney University, gives the age standardised incidence of thyroid carcinoma among Australian males in New South Wales as 20 – 44 years as 1.1 in 100,000 and 44 – 64 years as 3.0 in 100,000. As a result of these statistics, Dewey (1997) recommended that a detailed statistical and epipdermiological study was required to determine whether the increased prevalence of thyroid carcinoma in orthopaedic surgeons is significant.

Dewey and Incoll (1998) responded to this need. The perceived increase in the incidence of thyroid carcinoma in orthopaedic surgeons prompted an assessment of the use and value of thyroid shields in the OR. The methodology consisted of measuring the radiation exposure to the thyroid area of 19 orthopaedic trainees, intraoperatively, over a three-month period and doing thyroid function testing of the participants. Their results showed that 13 trainees' exposures were within the guidelines set for the general population. Six trainees were excluded from the study due to lost dosimeters or failure to comply with the study requirements. Although the 13 trainees' exposures did not exceed set standards, one trainee, who wore a dosimeter under and one over his thyroid shield, demonstrated that the reduction in exposure using the thyroid shield was reduced by a factor of 13 (Dewey & Incoll 1998). In corroboration, Fuchs et al. (1998) purports that carcinogenic potential exists from low-dose, low-energy radiation, especially with the formation of malignant nodules of the thyroid gland. They claimed that very limited dose of radiation to the thyroid bed leads to a statistically increased incidence of thyroid cancer many years later (Fuchs et al. 1998).

The other aspect of Dewey and Incoll's (1998) study that set it apart from others was the thyroid function testing. Although all were within normal limits, it was disturbing to note that the higher levels occurred in trainees with the longest service. The conclusions drawn from this study purport that orthopaedic trainees and surgeons should wear thyroid shields when using ionising radiation. All hospitals should provide thyroid shields and monitor their use. Also, further teaching and research is needed to minimise the hazards from the use of ionising radiation during surgery (Dewey & Incoll 1998). However, yet again this was a study only concerning orthopaedic surgeons. If these results came from orthopaedic trainees with their relevant years of orthopaedic surgery (first to fifth year approximately) and radiation exposurers, what of the accumulative radiation levels of many perioperative personnel who have worked in this environment for periods up to or in excess of 20 years?

Rozgaj et al. (1999) who researched chromosome aberrations in OR personnel investigated another aspect of the effects of radiation. They targeted two areas of concern – anaesethetic agents and x-rays. They studied a group of 170 OR personnel (anaesthetists, surgeons and OR nurses) who worked with both anaesthetic agents and x-rays and compared their results with a control group not in contact with either agent in their working life (Rozgaj et al. 1999). Heparanised venous blood samples were used and cultures were set up according to conventional techniques (Rozgaj et al. 1999). The results showed an increased rate of chromosome aberration in the exposed subjects. The differences in frequency of these aberrations between particular job tasks (surgeons, nurses and anaesthetists) were not distinct. Although the radiation doses were mostly below detectable limits some job titles, anaesthetists and orthopaedic surgeons, were found to have a significantly higher rate of chromosomal aberrations than others (Rozgaj et al. 1999). The findings in this study once again highlight the necessity of regular control of OR personnel (Rozgaj et al. 1999).

The only Australian perioperative article on radiation in the perioperative environment located was that of Webb (2000). A small paragraph in the 14-page article discussed ionising radiation and the possibility of producing cancerous tumours of breast, lung, thyroid and blood. Highlighted was the probability of genetic changes or damage passed on as an inherited disease, and that there is risk of foetal malformation or cancer caused by irradiating the foetus. The only suggestions to come from this article were to wear personal dosimeter badges for personnel who have high exposurers and that lead aprons and collars must be correctly worn and handled carefully to prevent damage to them. The fact that only one article was located highlights the dearth of information available in Australia for those working in this environment. The article, although it demonstrates the emphasis placed on protection did not mention the necessary education to use such protection correctly.

American perioperative nurses felt the need to implement Standards, Guidelines and Recommended Practices governing radiation use in their specific environment. AORN put these place in 1991 and they were subsequently revised in 1994 and 2001. Research conducted by AORN led to the implementation of these standards and recommended practices for radiological safety in the practice setting. AORN (Online 2000) purport that these standards and recommended practices are intended as achievable recommendations representing what is believed to be an optimal level of practice.

Policies and procedures establish authority, accountability and serve as operational guidelines (AORN Online 2000). The introduction and review of such policies and procedures should be included in orientation manuals and ongoing education of personnel to assist in the development of knowledge, skills and attitudes that effect patients and self-care. AORN (2001) believe also that policies and procedures assist in the development of quality assessment and improvement activities. These are the outcomes that should come from this proposed research and be guided by those who require such policies, procedures and education packages to empower them to function in a safer environment. Australia's national perioperative body, the Australian College of Operating Room Nurses (ACORN) does not currently have any standards governing radiation in the perioperative setting.

b) The increased use of radiation in the perioperative environment

The dramatic increase in procedures in orthopaedic surgery using fluroscopy screening was identified as early as 1993 by Goldstone et al. and Noordeen et al., reiterated in 1994 by Henderson et al. and by Alonso et al. in 2001. Jones and Stoddart (1998) also concur that the use of fluroscopy has increased significantly over the last 20 years, especially in the orthopaedic trauma theatres. Giblin et al. (1996) made similar claims regarding urology and the increased use of x-ray treatment and diagnosis.

c) Safe radiation practices

Radiation protection

The ICRP (1996) purports that radiological protection, and more generally, a high standard of safety depends critically on the performance of people and compliance with institutional policies and procedures. Their report allocates the primary responsibility for achieving and maintaining a satisfactory control of radiation exposure directly on the management bodies of the operating institutions. Everyone in an undertaking, from the individual workers to the senior management, should regard protection and accident prevention as integral parts of their everyday functions. These attitudes have become known as a 'safety culture' and it should be reinforced, by the issuing of clear operating instructions and the formation of a formal management structure for dealing with radiation protection, including the optimisation of radiation protection (ICRP 1996). Distance from the source, protective shielding and limiting exposure times are the most effective means of protection from ionising radiation (Brown et al. 1999).

Existing research that highlights methods of safe radiation practice

According to authors such as Pierson (1995), Revell (1994) and Shymko & Shymko (1998), moving away from the source is not always the best way of reducing radiation exposure. At low energies, lead shielding is very effective and it is for this reason that leaded aprons are used for radiation protection in diagnostic radiography. 0.5 mm lead thickness is most widely used for aprons and thyroid collars and leaded glasses of 0.35 mm of lead equivalents are also recommended (Statkiewicz-Sherer et al. 1998). The proper handling and storage of protective apparel is imperative to prevent damage. When damaged the protective properties are compromised. Biannual inspections and radiological testing of these items must be carried out (Pierson 1995; Shymko & Shymko 1998). Racks are supplied for the protective apparel and inspections of this apparel should be conducted regularly.

If the radiation has the energy of 100 keV (keV = million electron volts) then about 1 mm of lead, or 10 cm of brick, will reduce the intensity by a factor of 1,000 (NCRP 1976). One would need to increase the distance between oneself and the source 30 fold to achieve the same reduction in radiation intensity (Brown et al. 1999). One other factor that should be mentioned is that all doors should be kept closed when x-ray is in use. This offers substantial protection for persons in adjacent areas. These doors should also be lead-lined (Statkiewicz-Sherer et al. 1998). X-ray photons travel at the speed of light and they exist at that speed or not at all. In other words, x-radiation is not the same as radioactivity, which decays over time and can remain an exposure threat for long periods (Revell 1994; Shymko & Shymko 1998). What needs to be ascertained is whether perioperative personnel are aware of these principles of safe radiation practice.

Bagley and Cubler-Goodman (1990) performed a qualitative study that involved the urologist, a circulating nurse and patients. Radiation exposures of the urologist and circulating nurse were measured during a series of 13 ureteroscopic procedures. As this study was primarily related to shielding, it was noted that the exposure rate was clearly related to this shielding (Bagley & Cubler-Goodman 1990). It was found that although the circulating nurse was farther away from the x-ray machine, he/she received the same exposure to the unprotected thyroid that the urologist did. Therefore, as Bagley and Cubler-Goodman (1990 p. 1358) noted *"lead shielding is essential for all personnel in the room during ureteroscopic procedures using fluroscopy."*

Another American study by Giblin et al. (1996) measured radiation to the urologist during endourologic procedures and compared standard body protection to a newly designed surgical radiation shield. With the increasing use of these urologic procedures to diagnose and treat urologic conditions using II the urologist's exposure to radiation becomes an important safety consideration (Giblin et al. 1996). Standard body shields and thyroid guards were utilised first then the study was repeated using a newly designed surgery radiation shield. The danger to urologists lies in the head, neck and upper extremities which comes directly from scatter radiation from the patient who is usually in the lithotomy position (legs elevated in stirrups). The bony pelvis and abdomen of the patient serve as the major source of this scatter (Giblin et al. 1996). This study method entailed a series of radiation surveys, during a variety of urological procedures and was conducted by a health physicist. Data reflecting the effectiveness of various configurations of shielding were collected and analysed (Giblin et al. 1996).

Radiation doses recorded during the initial study revealed maximum exposure of 1,100 mRem / hour at a position of 6 inches from the patient's perineum. The maximum yearly whole-body exposure, as recommended by the ICRP (1996), is 5,000 mRem. The assistant standing 3 feet from the patient's perineum recorded an exposure rate of 500 mRem (Giblin et al 1996). The second phase of this study, using the surgical radiation drape, reduced the exposures to negligible. Another aspect of this study highlighted that exposure time is reduced due to the print capabilities of the modern II machines (Giblin et al. 1996).

A 1999 Australian study that investigated urologists was prompted by the reports of Dewey (1997) and Dewey and Incoll (1998) on thyroid cancer among Australian orthopaedic surgeons (Tse et al. 1999). It sought to evaluate the effectiveness of lead shielding in reducing radiation exposures to the thyroid region during endourological procedures. Radiation exposures to the surgeon and scrub nurse during 20 consecutive procedures, over a six-week period, using dosimetery badges (over and under a thyroid shield of 0.5mm lead equivalents) were monitored. Their results showed the radiation exposure to the thyroid area to the surgeon without lead shielding to be 0.46mSv and with lead shielding to be 0.02 mSv. The scrub nurse recorded, without lead shielding recorded 0.02 mSv and with lead shielding 0.04 mSv (Tse et al. 1999). These results demonstrate that protective lead shielding reduced radiation exposure to the surgeon by 23 times and the scrub nurse by 4 times. The radiation exposure under the thyroid shield compared favorably with the control point, which represented ordinary background radiation (0.01 mSv) (Tse et al. 1999). The recommendation from this study was that thyroid shields be easily available and worn by all urologists while using fluroscopy to minimise the harmful effects of radiation to the thyroid (Tse et al. 1999). This recommendation did not include scrub nurses yet exposure levels were reduced when they wore a thyroid shield (Tse et al. 1999).

An important aspect of safe radiation practice is distance away from the source. One receives less radiation exposure by standing further away from a radiation source. The 'Inverse Square Law' expresses the relationship between distance and intensity (quantity) of radiation. The Law reads *"the intensity of the radiation is inversely proportional to the square of the distance"* (Brown et al. 1999). This means, as the distance between a radiation source and a measurement point increases, the quantity of radiation measured at that point decreases by the square of its distance from the source. An American study by Mehlman and DiPasquale (1997) undertook dosimetery in an experimental study to determine how far away is far enough? Badge clusters were placed to represent members of the operating team. Surgeons (12 – 30.5 cm), first assistants (25 – 70 cm), scrub nurse (36 – 91.4 cm), anaesthetists (60 – 152.4 cm). The badges were systematically exposed by a protocol intended to maximise radiation scatter and a maximum time for continuous fluroscopy was set at 10 minutes (Mehlman & DiPasquale 1997). They concluded that unprotected individuals working 70 cm, or less, from the beam receive significant amounts of radiation. Those working 91.4 cm, or more, from the beam received an extremely low amount of radiation. Anaesthetists positioned at 152.4 cm did not register positive readings (Mehlman & DiPasquale 1997).

Mehlman and DiPasquale (1997) observed that the topic of exposure to radiation was associated with a surprising amount of fear, which they thought seemed odd considering that the technology represents a tried-and-tested tool that has been used in the medical field for over 100 years. They concede that such concern is due, in part, by names such as Hiroshima, Three Mile Island and Chernobyl. They demonstrated that exposure times, distance from the radiation source and protection, along with the ALARA concept, are essential because the long-term effects of radiation are largely unknown (Mehlman & DiPasquale 1997). Although this study offered reassuring information regarding the scrub nurse and the anaesthetist, the surgeon and first assistant need to stand further away from the patient during exposure (Mehlman & DiPasquale 1997). Two strong recommendations came from this study. Firstly, surgeons who frequently perform fluroscopy assisted procedures during which they are 70 cm or less from the beam should routinely use thyroid shields and also leaded glasses should be considered. Secondly, under no circumstances should surgeons allow their hands to enter the fluroscopic beam because established hand limits would be met, or exceeded after only 12.5 minutes of direct exposure. Circulating nurses or theatre assistants were not mentioned.

Alonso et al. (2001) measured the scatter radiation received by theatre staff during neck of femur fixations under II control, in a trauma hospital in England. Their results, similar to Thomas et al. (1999) and Jones and Stoddart (1998), showed that outside the two-metre area from the source, due to the inverse square law, the scatter radiation dose was consistently low (Alonso et al. 2001). Although they stated in their introduction that '*theatre staff are exposed to ionising radiation on a regular basis, with potential harmful effects*" (2001, p. 815) there appeared to be no concern for any potential long-term, low-dose residual effects. So much so that they concluded that wearing lead aprons outside the 2-metre area is probably unnecessary for fixation of hip fractures.

Another form of safe radiation practice involves the actual time of exposure to radiation. Noordeen et al.'s 1993 study looked at surgeon-controlled x-ray or II, as opposed to the usual practice of radiographer-controlled, as a potential means of reducing radiation. Five orthopods were involved in this study over a two-month period. During the first month the radiographer controlled the exposures and the surgeons assumed control, using a foot pedal, during the second month. At the end of the study the radiation dose levels to the orthopods were lower, by a factor of 20 or more, than recommended doses. However, the most significant finding from this study was that both exposures and exposure times were lower with surgeon-controlled exposures (Noordeen et al. 1993).

The consensus of these cited studies above is that protection, in the form of distance from the source, protective apparel and shielding and exposure times are safe radiation practices that are paramount to keeping the amount of exposure to radiation to a minimum. This study hopes to ascertain if indeed these safe radiation practices are understood and are practiced in the perioperative environment under study.

Education and safe radiation practices

It is important to provide adequate resources for the education and training in radiological protection for future personnel and technical staff in medical practice. The training program should include initial training for all incoming staff and regular updating and retraining and any system of protection should include an overall assessment of its effectiveness in practice (ICRP 1996). The links between the radiology departments and ORs was an area discussed by Kneedler and Dodge (1994). They believe that patients and personnel in the OR are exposed to the same radiation hazards as those in the radiology department. Although the amount of exposure was not as high, the same education and safety rules should apply in any area where there is a potential hazard to radiation. Revell (1994) was the only author found that insisted that radiation safety programs for radiology departments should include the OR. Safety measures should be constantly monitored and updated because a controlled environment in the OR still remains potentially hostile to both the patient and the surgical team as the low-dose, long-term effects of ionising radiation are largely unknown (Silo 1989). Mehlman and DiPasquale (1997) emphasised that few nurses or physicians receive formal training concerning the biological effects of radiation and recommended that that needed to be addressed.

In an American perioperative study, Shymko and Shymko (1998) recognised that misconceptions about safe radiological practice within perioperative nursing occur because perioperative and radiological staff are unfamiliar with each other's knowledge and practice guidelines. They also believed that when perioperative nurses are poorly educated about radiologic safety, nurses may avoid being in the room when x-rays are taken or assume that if they are not pregnant they need not concern themselves with radiation exposure. Without proper education perioperative staff may not be sure what the consequences of exposure are and are therefore unable to protect themselves (ICRP 1996; Shymko & Shymko 1998).

McConnell and Hilbig (1996, 2001) addressed the benefits of education and the level of knowledge required by perioperative nurses when constantly confronted with changing levels of health technologies, equipment or procedures. They considered that education is the greatest factor in the safe and effective use of medical technology and the perioperative nurse's knowledge of a technology's function and safety contributes significantly to positive staff and patient outcomes. Williams (1996) looked at increasing technologies and perioperative nurses' responsibilities to keep abreast of use and safety concerns as well as risk management for patients and staff in the perioperative environment. Earlier statements by Dewey and Incoll (1998), Jones and Stoddart (1998) and Mehlman and DiPasquale (1997) suggested the need for education, training and further research was required to minimise the hazards of radiation. Do perioperative personnel share these beliefs?

Apart from concurring with data already addressed, the British study by Goldstone, et al. (1993) reported that there is a legal obligation, in the form of the Ionising Radiation Regulations 1988, that training in radiation safety must be provided for all staff performing medical procedures using radiation in Great Britain. Lewall, Riley, Hassoon and McParland (1995) developed a teaching program for non-radiologists in Saudi Arabia. This Fluroscopy Credentialling Program included techniques for reducing the radiation received by the surgeon and the patient during orthopaedic surgery using fluroscopy. They stated that although fluroscopy delivers some of the highest doses of diagnostic radiation there is a documented lack of consistency in the training and credentialling of non-radiological personnel. They cited the American College of Radiology (1992) who made it clear that one of the most successful means of reducing radiation exposures to both patients and OR staff is education in the rudiments of radiation protection (Lewall et al. 1995).

This credentialling program met the strict requirements of the UK Ionising Radiation Regulations, 1988 and had three components - hands-on workshops conducted by a radiologist, a radiographer and a physician; a 12-page booklet, which surgeons were required to read which introduced the basic concepts of radiation physics, radiology and radiation protection relevant to radiography and fluroscopy; and, continued monitoring of total radiation exposure times for each surgeon. This allowed for review of procedures for which fluroscopic times were excessive (Lewall et al. 1995). It was found that this program was more successful than expected in reducing fluroscopy times - from 8.3 minutes to 0.9 minutes. This clearly demonstrates the importance of education and policy requirements.

O'Rourke et al. (1996) reiterated that hospitals run seminars on radiation in many countries and that all users of ionising radiation are obliged to attend these seminars.

The Ionising Regulation 1988, which is based on the European Community directive, has made it compulsory, since June 1990, for all staff working with x-rays to receive formal tuition in the hazards of radiation (Smith et al. 1992). Jones and Stoddart (1998) discussed the fact that little or no formal training is given to orthopaedic surgeons despite the 1980 Euratom directive, which stated that it was mandatory that training be given to all staff that use radiation for medical procedures.

An article from the American College of Physicians Annals of Internal Medicine, by Patterson, Craven, Schwartz, Nardell, Kramer and Noble (1985) looked broadly at occupational hazards to hospital personnel. They found that hospital workers poorly understood radiation exposure and safety. This study will determine if this is still the case or if knowledge and understanding of radiation exposure and safety held by perioperative personnel has increased.

Conclusion

In order to be able to protect people from ionising radiation it is necessary to measure the radiation they may be exposed to and quantify that exposure to compare with set limits. Many studies have been conducted to establish whether exposure limits set by the various governing bodies in various countries have been exceeded in practice. For example, Dewey (1997); Dewey and Incoll (1998); Noordeen et al. (1993); Smith et al. (1992); Thomas et al. (1999); Tse et al. (1999). Although the general consensus of most of the cited studies demonstrated that no set limits were exceeded, they did not conclude that radiation exposure within the perioperative environment posed no risks. To the contrary, these same studies identified that caution should still be emphasised due to the uncertainty of the long-term, low-dose effects of radiation. Smith et al.'s (1992) and Noordeen et al.'s (1993) studies recommended that these set limits should be reduced by one third for this reason. Evidence suggests that low-dose, low-energy radiation to the thyroid lead statistically to an increased occurrence of thyroid cancer many years later (Dewey 1997; Dewey & Incoll 1998).

Although safe radiation practice was nominated as a goal of many of these studies, the only practical attempt to look at knowledge and understanding of radiation exposure and safety came from Lewall et al (1995). Their Fluroscopy Credentialing Program demonstrated that it was more successful than expected in reducing fluroscopy times, and a reduction in exposure time is necessary to keep exposure rates low. This then is consistent with safe radiation practice. Without the required education for safe radiation practice perioperative staff may not understand the consequences of radiation exposure and may therefore avoid using protective apparel or adopting other safe radiation practices to protect themselves.

It should be appreciated that even small doses of radiation do have long-term effects, which are the cause of continuing controversy in setting 'safe' levels. The ICRP (1996) support this statement as they purport that there is sufficient evidence to conclude that somatic and hereditary effects attributable to radiation can occur, albeit at very low probability, even at very low doses. There will be no threshold of radiation below which there will be no risk (ICRP 1996). Education is the greatest factor in the safe and effective use of medical technology, and knowledge of the technology's function and safety contributes significantly to positive patient and staff outcomes (ICRP 1996).

In the opinion of the researcher the reviewed literature had a major problem area – all the studies, with few exceptions, targeted individual categories of perioperative personnel. Teams that work in ORs – nurses, surgeons, anaesthetists and theatre assistants – do not work in isolation. Activities are guided by multiple input factors including personal characteristics, attributes and qualifications; team compositions;

organisational cultures and climate; physical resources and the condition of the patients. These input factors guide processes during daily work routines, which include not only technical procedures but also the personal ones including team formation, decision-making and task prioritisation (Helmreich & Schaefer 1994). Targeting individual perioperative categories (such as anaesthetists or orthopods) instead of the group as a whole does not take these input factors into account.

The cited studies concentrated on the exposure rates of their participants and compared them to set standards. There was minimal discussion of any educational requirements coming from these studies. Knowledge and understanding of radiation safety was not discussed, nor did it seem to be a concern. If one was to speculate on this premise the reason may lie in the fact that the vast majority of recommendations from the cited studies appeared to put the improvement of, and the increased use of protective apparel as their priority for safe radiation practice. All the equipment possible cannot be used to its full potential unless its use is understood and the principles behind the protection vocalised. The most recent Australian studies (Dewey 1997; Dewey & Incoll 1998; Thomas et al. 1999) on orthopaedic surgeons may well pave the way for more in-depth studies of both exposures and thyroid function. The higher levels of thyroid function tests in the longest serving trainees (Dewey & Incoll 1998) brings home the importance of total perioperative studies because some perioperative personnel have worked in this environment for many more years than orthopaedic trainees.

The lack of available literature covering the knowledge and understanding of radiation safety and exposure suggests that there is a need for further exploration. The paucity of information of this identified subject, and its implications for perioperative personnel gave rise to the research question. This question formed the basis for this research, which explored the knowledge and understanding of radiation exposure and safety among perioperative personnel. As seen by the limited literature on knowledge and understanding of radiation exposure and safety there is a considerable gap. The current study will therefore attempt to address this gap in the literature by looking at all categories of staff within the perioperative environment – nurses, theatre assistants, surgeons, anaesthetists - and ascertaining the knowledge and understanding of safe radiation practices across this diverse group.

CHAPTER THREE

METHODOLOGY

Introduction

A qualitative focus group study was chosen as the most appropriate approach for this research study because qualitative studies emphasise the value-laden nature of inquiry and quantitative researchers seldom are able to capture participants' perspectives because they rely on more remote inferential empirical materials (Denzin & Lincoln 1998a, 1998b). The findings from qualitative studies have a quality of *undeniability* about them. Words, especially organised into incidents or stories have a concrete, vivid meaningful flavour that often proves far more convincing to a reader than pages of summarised numbers (Miles & Huberman 1994). A major feature of qualitative data is that they focus on naturally occurring events in natural settings and this buttressed with the fact that data would be collected in close proximity to the specific situation leads to the possibility for understanding latent or non-obvious issues (Miles & Huberman 1994). A focus group methodology was used to investigate the knowledge and understanding of radiation exposure and safety held by perioperative personnel in their work environments. Very little has been written about this topic, specifically with its effects on all perioperative personnel and the researcher sought to listen to informants and to build a picture of this knowledge and understanding (Creswell 1994). It was deemed essential by the researcher and supported by the literature that the study be pursued in the natural environment in which radiation usage occurs and in the same time/context frame that the researcher sought to understand (Guba & Lincoln 1989).

Focus group methodology

Focus group methodology originated in sociological research in the late 1930's and was primarily used in market research (Fontana & Frey 1998; Hines 2000; Kidd & Parshall

2000; Morgan 1988). Nyamathi and Shuler (1990) argued that focus groups were rarely used in early nursing research. However, with the increased use of qualitative methods in health care research growth in the appropriateness of focus group methodology and technique to investigate nursing problems was facilitated (McDaniel & Bach 1994; Saulnier 2000). Robinson (1999) purports that focus group methodology was founded on research purposes that distinguishes the use of focus groups from other group sessions.

Nyamathi and Shuler (1990) define focus group methodology as a qualitative research method for gathering information that allows the investigation of a multitude of perceptions on a defined area of interest. Authors such as Beyea and Nicoll (2000d), Cote-Arsenault and Morrison-Beedy (1999), Kitzinger (1994), Krueger (1988), McDaniel and Bach (1994 & 1996), Morgan (1988), Polgar and Thomas (1995), Robinson (1999) and Stewart and Shamdasani (1990) define focus group discussions as a qualitative research technique using in-depth, open-ended discussions, of one to two hours duration, involving a specific set of issues on a pre-determined and a limited topic. Jackson's (1998) belief that focus group discussions can be used to gain perceptions from participants and that they are a direct method of obtaining authentic, rich information within a social context influenced the researcher's decision to use this methodology as it was appropriate to answer the research question.

St John (1999) warns that the primary consideration in using focus group methodology is to clearly identify the purpose served by using it as opposed to other approaches. The rationale for the decision to use focus groups as the sole data collection method was that as this was descriptive research, the focus groups were self-contained and the results were expected to stand on their own requiring no further data collection (Morgan 1988; Saulnier 2000). A fundamental qualitative research assumption advocates the insider's standpoint on 'emic' perspective (Holloway & Wheeler 1996). As this study sought to discover the participants' knowledge and understanding of radiation exposure and safety group interaction was required as group discussion can prompt responses in others within the group (Jackson 1998). This challenges Agar and MacDonald's (1995) assertions that focus group discussions in qualitative research are severely limited if they are used as 'stand alone' tools. However, Cote-Arsenault and Morrison-Beedy (1999) and Stewart and Shamdasani (1990) purport that they can be used independently. They also warn that it is essential that researchers understand that scientific rigour is as important in focus group methodology as in every other type of research methodology.

There are advantages and disadvantages to focus groups (Beyea & Nicoll 2000b; Clarke 1999; Gray-Vickery 1993; Hines 2000; Robinson 1999; St John 1999). It was important to establish the knowledge and understanding of the participants governing radiation exposure and safety. Therefore the topic and issues were not of a sensitive nature and access to appropriate participants was not an issue as the researcher works in the perioperative environment (Beyea & Nicoll 2000b; Hines 2000; Robinson 1999; St John 1999). The potential for some limitations in using a group of immediate colleagues, or with the researcher being known to the participants, was not an issue. However, the researcher was mindful of the potential bias.

The advantages of focus groups that assisted in the choice of this methodology far outweighed the disadvantages. Primarily it used a highly efficient technique for qualitative data collection since the amount and collecting from several people at the same time increased the range of data (Clarke 1999; Robinson 1999). Natural quality controls on data collection operated in the form of participants' checks and balances

(Robinson 1999). Participants checking and validating each transcript of the groups and the final analyses ensured this.

The group dynamics helped in focusing on the most important topics and it was fairly easy to assess the extent to which there was a consistent shared and/or divergent view (Robinson 1999). Focus groups were also useful for probing the insights, perceptions and assumptions that underlined attitudes and generated more critical comments (Gray-Vickery 1993). Participants seem to enjoy the experience in a natural, safe and more relaxed setting (Kingry, Tiedje & Friedman 1990). The method was inexpensive, flexible and manageable. Participants were empowered to make comments in their own words while being stimulated by thoughts and comments of others in the group (Robinson 1999). Contributions were encouraged from people who were more co-operative within group situations as opposed to individual interviews (Beyea & Nicoll 2000b; Robinson 1999). The facilitator was able to seek clarification in the case of ambiguity and observed non-verbal gestures, which provided a more subtle interpretation of meaning, though this could create bias (Robinson 1999). Focus groups were particularly suited to examining how knowledge and ideas develop and operate within a cultural context (Robinson 1999). The knowledge and understanding of radiation exposure and safety of perioperative personnel certainly fit this description.

Focus groups are carefully planned and designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment. The group is 'focused' in so much as it involves some forms of collective activity. This technique made use of group interaction to stimulate participants to provide insights and data that were not accessible without this stimulus of group interaction (Jackson 1998; Lane, McKenna, Ryan & Fleming 2001; McDaniel & Bach 1994). Focus groups employ techniques to stimulate discussion; they are not a problem-solving session or a decision-making forum. They should not be approached as casual conversations, educational or gripe sessions (Cote-Arsenault & Morrison-Beedy 1999; McDaniel & Bach 1996; Robinson 1999; St John 1999). During these discussions agreements or disagreements were fundamental processes that influenced the nature and content of responses as the group progressed. Individual informants do not achieve agreements and they do not negotiate, confront, antagonise or directly criticise or commiserate with each other as happened in these groups (Kidd & Parshall 2000). While Bristol and Fern (1996) suggest that there is little empirical evidence to support the view that focus groups are superior to other methods, Ashbury (1995) argues that they provide data rich in detail that is difficult to achieve with other research methods.

Characteristics of focus groups

While size is a key issue in the planing and formulation phase of the focus groups it is not a starting point. It is the purpose for which the sample is recruited that determined the number of participants to be selected (Parahoo 1997). The ideal number of participants for each focus group varies somewhat from author to author. Critical analysis of the literature gives the optimal focus group having from 5 to 12 homogeneous participants (Ashbury 1995; Krueger 1994; Robinson 1999; Morse 2000; Stewart & Shamdasani 1990). The area of concern when deciding on numbers of participants revolves around too many or not enough. Too many can become unmanageable while too few can lead to the potential dominance of one or two individuals (Stewart & Shamdasani 1990). As a precaution against late cancellations of recruited participants, over recruitment of approximately 20% was factored into the focus group numbers (Cote-Arsenalt & Morrison-Beedy 1999; Saulnier 2000; St John 1999; Stewart & Shamdasani 1990). With regards to homogeneousity of focus groups Clarke and Procter (1999) postulate that it is normally advisable to have homogeneous focus group membership as the inter-personal dynamics of these groups is a key issue to its success. Participants may feel more comfortable expressing their views when they share similar backgrounds and experiences within the group (Cote-Arsenalt & Morrison-Beedy 1999; Kidd & Parshall 2000; Reed & Payton 1997). Homogenous groups usually result in more effective data collection because less time is used maintaining the group (Morgan 1996; Robrecht 1995; Saulnier 2000; St John 1999).

Environment

The site selection and development of the study question occurred simultaneously (Janesic 1998). As access and entry are sensitive components in qualitative research the researcher aimed at establishing trust, rapport and academic communication patterns with participants (Janesic 1998). The OR seminar room proved to be the ideal setting for the participants and the investigator because it was the most central venue for those concerned and also because it was a familiar neutral environment in which participants felt comfortable and willing to participate fully (Kingry et al. 1990). This assisted in limiting any negative potential such as travel, accessibility, expense or unknown territory. Stewart and Shamdasani (1990) warn that using workplaces for focus groups has psychological implications for participants with the potential to negatively effect data collection by introducing barriers to communication such as some reluctance on the part of participants to reveal any organisational weaknesses or traversing organisational ethos. However, they concede that rooms within the health care agency separate from the usual work environment do provide the positive aspects of ease of access, a familiar environment where participants could feel comfortable without feeling they were at work. Both Oppenheim (1992) and Krueger (1994) support this argument by adding that focus groups are increasingly using workplace areas with successful explorations into many topics.

The OR seminar room fulfilled this criteria as it was a room used for some inservice sessions or as a meeting place and was sufficiently removed from the main theatres with its own access that permitted entrance without having to change into theatre attire. Using this room ensured no distractions or interruptions over the required period because the room was pre-booked for each group and signage was attached to each of the two doors restricting disturbance (Byrne 2001b; Oppenheim 1992). Room preparation consisted of chairs for each participant assembled around a table, refreshments provided just prior to the commencement of each session, the acoustics previously tested for the audiotaping and the tape recorder placed in the centre of the group (Eaton, McComish & Greenberg 2000). Signs were placed on the doors stating "Meeting in progress. Do not disturb."

The facilitator

The groups were convened by the researcher who played the key role guiding the discussions to fulfil the research aim and to ensure all participants were given the opportunity to make an effective contribution (Robinson 1999; Stewart & Shamdasani 1990). As the researcher was the sole facilitator this provided the continuity deemed necessary by Robinson (1999). The researcher conducted the recruitment, group moderation and post-group validation (Robinson 1999; Saulnier 2000); Leask, Hawe & Chapman 2001). The goal of the facilitator was to fulfil the aim of the study by purposively guiding the discussion while ensuring that all participated in the discussions (Reed & Payton 1997; Robinson 1999). The facilitator used common facilitating techniques to continue to support variation in responses (Saulnier 2000). For example, by saying, "*That's very helpful. Now that we have heard from a few people who agree, I'm hoping that some people who have different ideas will tell us what they think.*"

The researcher as a perioperative nurse was known to all the participants as a colleague with no ability to negatively impact on their careers. This familiarity provided some positive aspects to the study which included assisting in recruitment, understanding group dynamics and comprehension of the role and language of perioperative personnel. Some research exists that demonstrates that the facilitator who is immersed in the group culture enhances the communication and interaction of the group (Stewart & Shamdasani 1990). However the direct challenging of the personnel's' knowledge and understanding of radiation reduced any potential bias by relying solely on the participant's responses and not on the role of the facilitator.

The facilitator was also familiar with the topic under investigation and the group dynamics of the various groups (Cote-Arsenault & Morrison-Beedy 1999). This was inevitable as orthopaedics is the specialty of the researcher and radiation plays a large part in this branch of surgery. Maintaining the clarity of group purpose was the goal.

There was no attempt during the discussions to reach consensus or define a majority or correct opinion on the topic (Krueger 1994). Previous researchers have highlighted the importance of such tactics for clarifying participants' input (Kitzinger 1996; Lane et al. 2001). During the study controlling dominant group members while ensuring the contributions of the more reserved participants proved crucial to ensuring that all members had the opportunity to contribute to the discussions (Lane et al. 2001). The facilitator offered no personal opinions during the discussions, even when sought. In the introduction to each discussion a description of the facilitator's role was included to emphasise that the participants were responsible for the data generation.

Site of the study

The site of the study was an Operating Suite where the researcher and participants come in contact with radiation in their day-to-day working environment. This site was where the concern of the researcher originated.

Population

The population from which the sample was selected was the combined staff mix of the OR of one Queensland metropolitan hospital who were in contact with radiation in their normal work routines. Table 1 depicts this population.

Table 1. Study population

Perioperative nurses	39	(47.5%)
Theatre assistants	6	(7.3%)
Surgeons (general, orthopaedic, urology)	15	(18.3%)
Anaesthetists	22	(26.9%)
Total	**82**	**(100%)**

The perioperative nurses were both registered and enrolled nurses and they and the theatre assistants, surgeons and anaesthetists were employed for the full duration of the project. Residents and interns were excluded as they had short OR terms during their normal medical rotations.

Sampling strategy

Sampling from this population involved selecting the most appropriate groups involved with radiation in the perioperative environment (Llewellyn, Sullivan & Minichello 1999; Mays & Pope 2000). Random sampling was not considered because it yields low and unrepresentative responses (Lane et al. 2001). Focus groups usually employ purposive sampling where participants are not selected randomly but are selected as groups because of the nature of the research question (Robinson 1999). Unlike surveys, or other research methods that are heavily dependant on maximising standardisation for accuracy, qualitative methods of focus group discussions take advantage of variability, highlighting the specific qualities and needs of a given research population. Therefore, identification and solicitation of participants need to vary by population (Saulnier 2000). It is acknowledged that such sampling procedures may impose limitations on the findings, most notably through selection bias, and that the homogeneous nature of most focus groups may result in unintentional contamination of the data (Lane et al. 2001). However Clarke and Procter (1999) argue that it is normally advisable to have homogeneous focus group membership, as the interpersonal dynamics of such a group is a key issue in its success. Despite these limitations purposive sampling deliberately aims to ascertain theoretical insights into the knowledge of the population regarding radiation and tends to generate rich data, which broadly reflects the population from which it is drawn and this is what the researcher is looking for (Lane et al. 2001). Morgan (1996) argues in support of this decision as 'segmentation' (the conscious varying of group composition) created groups of a particular category of people that had the potential to stimulate discussion due to the similarity of participants.

Therefore the sampling strategy relied on identifying the common ground – for example, surgery, anesthetics, nursing or theatre assistant - that applied to the sample group. This was followed by sampling specific instances of that common ground that related to the topic under study (Llewellyn et al. 1999). Kitzinger (1994) purports that it is useful working with pre-existing groups as they provide a social context within which ideas are formed and decisions are made. This strategy required that the researcher had a considerable amount of prior knowledge about the phenomena of interest that influenced the development of operational definitions of the criteria by which one wished to sample. Examples of these criteria included the working background (each category as a unit), educational background and how radiation was included in their daily work routines. One of the advantages of this strategy was the potential for some degree of comparison of those in each category (Llewellyn et al. 1999). Participants felt more comfortable expressing their views when they shared similar backgrounds and experiences with the others in the group (Cote-Arsenault & Morrison-Beedy 1999; Reed & Payton 1997; Kidd & Parshall 2000).

In addition barriers may exist between participants if the groups were mixed – that is, nurses and theatre assistants may have felt intimidated by surgeons and anaesthetists and not share their views willingly or surgeons and anaesthetists may not have the same level of knowledge or understanding of radiation issues. St John (1999) argues that group interaction can be affected by the personal interactions of participants and by social factors such as social class, gender and race. The level of experiences may not come forward in mixed groups and the researcher explored these issues in order to gather rich meaningful data because of the experiences and qualities of the participants, and their willingness to be involved (Oppenheim 1992).

Recruitment

The researcher personally approached potential participants after selecting them for the contribution each could bring to the study coupled with their availability. To minimise selection bias, assistance was sought from the perioperative educator who also nominated participants for inclusion in the groups. The rationale for this was that the perioperative educator was conversant with the various strengths and communication skills of the individuals and validated the researcher's selected sample in recruiting participants who were able to contribute to the data generation. After initial contact was made it was followed by a written invitation to participate (Appendix 1). Four groups resulted from the sampling process – perioperative nurses, surgeons, anaesthetists and theatre assistants. Due to the difficulties of shift work and roster complications over-recruitment strategies were implemented. 12 x perioperative nurses, 12 x surgeons, 5 x theatre assistants and 12 x anaesthetists were initially invited to participate in their nominated focus groups. Of the 41 participants, invited 23 agreed to participate and this brought the groups into the targeted numbers of between five and nine, with the exception of the theatre assistants as they only numbered six in total. Table 2. illustrates sample demographics.

Table 2. Focus group participation and representation

Perioperative nurses	5	from 12	41.6%
Theatre assistants	3	from 5	60%
Surgeons	6	from 12	50%
Anaesthetists	9	from 12	75%
Total	**23**	**from 41**	**56.1%**

Data collection

Although naturally occurring groups may be used for focus group studies there is a need to be aware of how group hierarchy may affect data (Kitzinger 1994). This point was considered in the planing stages and raised in the post-interview debriefings. Participants from each group and from all hierarchical levels indicated that the presence of participants from other hierarchical levels presented no problems. The following table illustrates the group dynamics, composition and basic job description and the timeframes of the four focus group discussions.

Table 3. Focus Group Dynamics and Timeframes for Discussions.

Group	Category	Number and Tasks	Date/Time
Group 1	Perioperative nurses	1 x enrolled nurses - anesthetics 1 x enrolled nurse – anaes / circulate 2 x registered nurses – scrub / circulate / anaes 1 x registered nurse –management	29/5/01 @ 5pm.
Group. 2	Theatre assistant	3 x theatre preparation, portage and patient duties	30/5/01 @ 2.30pm
Group 3	Surgeons	3 x orthopaedic consultants 3 x orthopaedic registrars	6/6/01 @ 8am.
Group. 4	Anaesthetists	4 x consultants 3 x registrars 2 x principle house officers	8/6/01 @ 8am.

Semi-structured questions

Semi-structured questions were used to promote discussion and generate data for the study. These are used in qualitative research to understand the reasons why people act in particular ways, by exploring participants' knowledge and understandings and to generate ideas in order to develop or change practice (Harvey-Jordan & Long 2001). One of the advantages of using this technique is the richness of data yielded. During each discussion participants were free to talk openly as they wished and the frankness got to the heart of the matter (Harvey-Jordan & Long 2001; Norton 1999).

The main topic area of the study was 'knowledge and understanding of radiation exposure and safety in the perioperative environment'. Although prior to the focus groups the researcher identified this topic area, the discussion guide framework (Appendix 1) was sufficiently flexible to allow concepts that developed throughout the discussions to be explored (Harvey-Jordan & Long 2001; Miles & Huberman 1994). Kidd and Parshall (2000) and Saulnier (2000) agree that constraining discussion to a focal situation or experience may run counter to some of the assumptions underlying focus group methodology. Although the focus of the study is somewhat narrow, there was considerable information to be collected about the topic area from those directly involved with this area of study. Some focus group methods seek information about newly emerging concepts. However focus groups have been used at times somewhat inflexibly to gather narrowly specified information (Saulnier 2000). Extremes in standardization, both at the emergence and the rigidity ends of the standardisation continuum, are generally avoided in focus groups but the tendency is towards making them somewhat more systematic (Saulnier 2000). However too much standardisation defeats the purpose of exploratory research and qualitative research is not for those who need tight structure with little ambiguity (Morgan 1996; Orona 1997). With that in mind, the researcher determined the discussion guide and prompts and how they would be adapted to meet the needs and responses of each focus group. These took the form of semi-structured questions mentioned above

Discussion guide

The introduction for the focus groups (Appendix 2) and the discussion guide were developed both from the literature and from the researcher's years of experience in perioperative nursing (Beyea & Nicoll 2000b, 2000c; Cote-Arsenault & Morrison-Beedy 1999). Informal discussions following concerns about radiation use in ORs raised at Unit Meetings, published literature and experiences as an Orthopaedic Clinical Nurse elicited information that was used to design the guide (Gettleman & Winkleby 2000). Prior to developing the guide it was important that the researcher was familiar with the participants' world and the topic under investigation as this allowed for consideration of the range of issues that needed to be covered during the discussions (Minichello, Madison, Hays, Courtney & St John 1999). The researcher started with an outline of the categories that were relevant to the research and then developed sets of preliminary questions that were relevant for each of the categories (Berg 1995). Working in orthopaedic surgery gave the researcher an insight into how perioperative personnel inter-related with radiation use in the OR. However the direct challenging of the personnels' knowledge and understanding of radiation reduced any potential bias by relying solely on the participant's responses and not on the facilitator's role. The researcher during each of the focus groups, outside leading the discussions, gave no input. For example, in order to discover the knowledge and understanding of radiation exposure among participants the first two questions required asking.

1. *What do you know about radiation and safety?*
2. *What do you understand to be safe radiation practice?*

Also, discussion on good and bad experiences pertaining to x-ray use in the OR opened up discussion on individual interpretations of actual practices during x-raying.

3. *What have been your experiences with the use of x-ray in your theatre – good experiences or bad experiences?*

Questions four and five directly linked to the individual's knowledge and understanding of radiation exposure and safety.

4. *Some staff may consider that x-rays are relatively harmless. What do you think?*

5. *Do you know/understand if it is necessary to wear protective covering when working with x-rays? (Prompts yes, no please elaborate).*

Published literature, as demonstrated in the literature review, demonstrated that some categories of perioperative personnel are more 'at risk'. Questions six and seven endeavored to establish what knowledge and understanding was held by perioperative staff of these risk levels.

6. *What staff categories do you believe are most at risk during procedures using x-rays and why?*

7. *How do you know what, if any, are the potential risks of radiation? (Prompts – through education, past experiences, length of service, common sense, published literature, standards).*

As little research exists on the knowledge and understanding of perioperative personnel on radiation exposure and safety, this presented a challenge. Care was taken to ensure that the guide should avoid the potential narrowing of discussion and introduction of interviewer bias that may accompany a list of set questions (Stewart & Shamdasani 1990). This was done by pilot testing the guide for clarity, the capacity to fulfil the research aim and the critical evaluation of research data to ensure bias was minimised and quality data was obtained (Morgan 1995). Two individual interviews were conducted with a perioperative nurse and a retired surgeon, both of whom were not involved in the research study (Stewart & Shamdasani 1990). After minor modifications the revised guide was used as a basis for the four discussions. The researcher had the latitude to use a personally congenial way of asking and sequencing the questions and to segment appropriately for different respondents to enable a wider range of responses to be captured (Miles & Huberman 1994).

The guide was expanded prior to holding subsequent groups as analysis of the first discussion suggested a question needed to be added to the subsequent focus groups. The first group introduced the roles and responsibilities of the attending radiographers and it became apparent that subsequent groups may have more to contribute on this subject. (See Question 8 of the discussion guide-Appendix 1). This followed the advice of Kidd and Parshall (2000), Morgan (1996) and St John (1999) who recommend that prior to each focus group the researcher determine whether the guide should be adapted to meet the needs of each group. Minor changes were made based on the responses from previous groups to ensure the taping of a range of experiences relevant to the focal situation as the guide was intended as just that, an instrument to guide the discussions (Kidd & Parshall 2000).

The discussion guide employed a series of open-ended questions based on the topic areas the researcher intended to cover and provided opportunities for various concepts and categories to develop (Harvey-Jordan & Long 2001). St John (1999) claims that questions should usually be open-ended although both open-ended and closed questions may be used. Questions one to four of the guide were open-ended questions used to open up discussion to permit participants' freedom to give multi-dimensional responses (Nyamathi & Shuler 1990; St. John 1999). Questions five to seven had a narrower focus in an effort to demonstrate potential differences in opinions within the group and consequently provide a basis for further discussion (St John 1999). The warning by Minichello et al. (1999) on not picking up on issues raised by participants and adjusting the line of questioning, coupled with not reviewing the guide as a result of the analysis, are the two main problems to be avoided during the focus groups. Hence, the researcher was constantly alert to incorporating new insights and not remaining 'locked into' the assumptions used to develop the guide (Minichello et al. 1999; Walker 1999). Probe/prompt questions were included in the guide to assist if participants did not relate to the initial question. These were used to more expansively explore a topic (Ashbury 1995). An example of a probe used in subsequent discussions centered on asking participants to explain what they meant in a previous statement or why they responded as they did (Minichello et al 1999).

The conduct of the focus groups

Once the participants, the environment and the time frames were finalised focus group discussions commenced. The facilitator began each session with an introduction that included a welcome, a brief explanation of the research topic, the importance of confidentiality of participants and discussion content (to prevent sensitising future participants), a brief description of the role of the facilitator and a reminder that the sessions would be audio taped (Appendix 2). Once the introduction was completed and the participants were comfortable with the format the facilitator guided the discussion using the guide (Appendix 1).

A full transcript of the proceedings is a requirement for the analysis of the exact statements of the participants (Oppenheim 1992; Sim 1998). At times researchers are tempted to hold focus groups back-to-back to achieve efficiency. However time had to be allocated for accurate tape transcription and participant verification (Appendix 5) before analysis of that group discussion was completed. Verbatim transcripts of one focus group were prepared within hours of the completion of the session, returned to the participants for verification, and an initial analysis performed before the next focus group to allow for any adjustment of the guide. Each group followed the same format (Saulnier 2000). They were held over a period of 11 days. The number, time and date of each focus group, along with the group dynamics are set out in Table 3 (p. 58). The tapes were transcribed with no attempt to identify speakers. Instead, a change in speaker was denoted as (...) and this convention was adopted for all quotations used in the data analysis (Clarke & Procter 1999). It was essential to tape these sessions because there could be much that escaped the busy facilitator in the stress of the actual discussions (Oppenheim 1992). One advantage of audiotaping is the opportunity that the tapes offer for analysis for independent observers (Harvey-Jordan & Long 2001). Once returned, the transcripts were analysed to identify any emerging concepts. Identifying and validating concepts was a complex process that required ongoing analysis and strict adherence to qualitative methods to ensure reliability and validity of the findings (Beyea & Nicoll 2000d; Hines, 2000).

During the discussions participants commented on each other's points of view, often challenging each other in a pointed fashion. Participants also modified their opinions, or their statements about them based on the give and take of discussion as the group progressed (Krueger 1997). In each focus group people were encouraged to talk to one another, ask questions, exchange anecdotes and comment on each others' experiences and points of view, emphasizing their knowledge and understanding of radiation exposure and safety, in an effort to bring out as much relevant discourse as possible. The explicit use of group interactions to produce data and insights would have been less accessible without this interaction found in a group (Reed & Payton 1997).

Data analysis

In contrast with quantitative research, qualitative theories may emerge from the study while the data collection is in progress and following the commencement of data analysis (Morse & Field 1995; Webb 1999). A framework analysis method of analysing the data was the approach employed for this study in which it is the group, rather than individual participants that represents the unit of analysis although there is controversy about this (Carey 1995; Carey & Smith 1994; Lane et al. 2001; Morgan 1995; Morgan 1996). The most important point is to devise analytical processes sufficiently flexible to identify any undue influence of the group on any individual participant(s) or vice versa (Kidd & Parshall 2000). A major aim of analysis with focus group data was to identify common or diverse comments on the knowledge and understanding of radiation exposure and safety to better understand how perspectives arise and are modified in a group (Carey & Smith 1994; Reed & Payton 1997; Sim 1998).

Analysis involved summarizing and classifying data to lend structure and comprehension and ensure that the original data was not skewed and was presented clearly and accurately (Lane et al. 2001). The stages in the construction of the data analysis framework included: familiarisation, identifying a theoretical framework, coding and interpretation of key objectives (Ritchie & Spencer 1994). Analysis began by going back to the study's intent. A key principle was to remember the purpose and aim of the study and to use the depth or intensity of analysis appropriate to the problem (Krueger 1997). Each transcript was read independently with the researcher searching for similar words, patterns and concepts. Specific comments were then extracted from the transcripts, compiled summarised and organised into categories. This study used a code and retrieve function whereby data were coded and sorted according to the category schemes developed by the researcher during the data analysis process (Beyea & Nicoll 2000d; Burns & Grove 1999; Byrne 2001a; Franklin & Bloor 1999; Grbich 1999; Hallberg, Pause & Ringdhal 2000; Norton 1999; Powers 1996; Saulnier 2000; Singer, Martin, Giacomini & Purdy 2000; Wright & McKeever 2000).

The basic unit of analysis used for this study was a concept – an idea. Categories are major concepts or groups of concepts that are useful in understanding or explaining the data (Browne & Sullivan 1999; DeSantis & Ugarriza 2000). The word concept is used to mean an idea that a category is based on. Categories and sub-categories emerged, into which data seemed to fall naturally. Furthermore, distinct relationships emerged between concepts, categories and sub-categories (Lane et al. 2001). Thematic analysis from each group was compared and cross-referenced between groups. Notation sheets, or memos, detailed the analysis framework, set out specific comments, transcript page numbers and the affiliated category (Dick 2000; Grbich 1999; Lane et al. 2001; Miles & Huberman 1994; Norton 1999; Talbot 1995).

Segments of transcripts were often assigned multiple non-exclusive codes, because at this preliminary stage, it was premature to rule out any of the analytic topics to which a segment related (Franklin & Bloor 1999: Pope, Ziebland & Mays 2000). The coding was cyclical. As new codes were used in coding transcripts of subsequent focus groups, the researcher returned to earlier transcripts to determine if the new code should be applied (Bourke, Cikoratic & Mack 1999; Saulnier 2000). It was important that the categories that were generated were as few as possible while explaining as much as possible about the area under study (Hallberg et al. 2000). Categories emerged through the comparison of incidents and properties of categories emerged through further comparisons (Hallberg et al 2000). The use of memoing was particularly useful by analysing the researcher's own thoughts and feelings as much as possible before, during and after the focus group process (Parritt & O'Callaghan 2000). The researcher wrote memos as the thoughts came, without the need to be orderly or linear. The only mandate was to write what was emerging from the data (Orona 1997).

The major concern for data analysis of focus groups was to focus on participant interaction and not on the participant/researcher discussion (Reed & Payton 1997). The researcher's task was to prepare a statement about what was found, a statement that emerged from, and was supported by, available evidence. Emergence is the process by which codes and categories fit the data and not the process of fitting the data to predetermined themes or categories (Baszanger 1997; Hallberg et al. 2000; Kendall 1999; Orona 1997; Wuest 2000). The final step in the data analysis process was to return the data to the participants to discover whether the interpretations of the researcher were a true reflection of their thoughts and experiences. The members of the original focus groups were asked to comment on the relevance of the analysis to their experiences. This enabled the researcher to validate and clarify the interpretations of the data (Clarke & Procter 1999; Robinson 1999). An adequate analysis of focus group data should inform the audience credibly about the focus and the groups' reports (Kidd &Parshall 2000).

Establishing rigour

Silverman (1998) describes two methods of validation – triangulation and participant feedback. Triangulation is a quantitative process described by Janesic (1998) as the use of a variety of data sources in a study to prove the validity. The process of participant validation of the transcripts and the preliminary analysis ensured validity in this study. Every effort was made by the researcher to reduce any possible error or bias and so strengthen the validity and reliability of the study. This was done by maintaining meticulous records of discussions and by documenting the process of analysis in detail so that an independent researcher could check the process (Emden & Sandelowski 1998; Harvey-Jordan & Long 2001; Koch 1994). Also, each group was asked to refrain from discussing anything outside the sessions for the two reasons, for the confidentiality of the participants and also to prevent any sensitisation of subsequent groups

Ethical issues

The ethics adopted for the study involved the four principles of mutual respect, non-coercion and non-manipulation, the support of democratic values and institutions and the belief that every research act implies moral and ethical decisions that are contextual (Denzin & Lincoln 1998a). Every ethical decision effects others with immediate and long-range consequences, which involve personal values, held by the researcher and those studied. The researcher built relationships of trust that were non-coercive and not based on deception (Denzin & Lincoln 1998a). This study was conducted for a Master's Degree at Central Queensland University (CQU) and was appropriately supervised. Ethics approval was granted from the Human Ethics Research Review Panel at CQU and the Health Service District Human Research Ethics Committee. This followed the guidelines as set by the National Health and Medical Research Council of Australia (NHMRC) (1999). The basic ethics principle governing data collection for this study was that no harm should come to the participants as a result from participation in the research study. This referred to physical, as well as emotional harm and concerned the conduct of the discussions. With this study the emphasis was on emotional harm not being caused by the content or behaviour of other participants. Also the participant's right to privacy and the right to refuse certain questions, or to be interviewed at all, was respected and no pressure was brought to bear (Oppenheim, 1992). These issues were addressed in the participant's letter and the informed consent form (Appendices 3 & 4).

Another focus of attention was to address the relationships the researcher had to the participants. The researcher was a Clinical Nurse in the OR and the participants varied from theatre assistants, enrolled nurses, registered nurses, Level 1, 2 and 3 as well as surgical registrars, consultants and visiting medical officers. The researcher was aware of the potential inequality of relationships between the researcher and some personnel, as well as the overall diversity of the total number of participants. The one thing that transcended any perceived barriers within the study, was that focus groups were held in the natural setting of the OR seminar room and the groups consisted of like participants such as, perioperative nurses, theatre assistants, surgeons and anaesthetists in their own groups. The success of focus groups rests with deliberate thought about the planning of each step of the process (Beyea and Nicoll 2000c). As with all ethically sound research, the focus group participants were provided with written material on the aims and objectives of the study. In addition, to enable the researcher to maximise the accuracy of the data, the interviews were tape-recorded. All participants gave their consent to this method of recording the interviews (see Appendix 3 & 4).

Confidentiality was also assured as no names or identifying characteristics were reported in the verbatim transcripts, nor will they be included in any published data. However there may be some anonymous quotes or anecdotes used in the final report. No guarantee could be given to participants regarding absolute confidentiality because the researcher had no control over participants when they left the discussions although the request was made during the introduction to each session not to discuss the content. During the study all notes, tapes and transcripts remained in a locked filling cabinet for the duration of the study and will remain there for a further 5 years after the completion of the study. The researcher undertook the transcription of the interviews and this negated the need for a typist to access the information.

Conclusion

In summary, the implementation of a focus group study, using focus group discussions as the sole data collection method, enabled the research question to be addressed and identified the knowledge and understanding of radiation exposure and safety held by perioperative staff in their working environment. The analysis of the four focus groups is described in the next chapter.

CHAPTER FOUR

FINDINGS

Introduction

The analysis of the four focus groups generated the following five categories:

(1) the dangers of radiation exposure

(2) the lack of knowledge and education of radiation exposure and safety

(3) the radiation environment

(4) protective devices and apparel and

(5) the radiographers' role and responsibilities.

These categories developed from a manual line-by-line, paragraph-by-paragraph analysis of the transcripts after repetitive listening to the audiotapes and reading of the transcripts (Webb 1999). This led to a grouping of responses into categories using colour highlighters and cutting and pasting techniques. Simultaneously memos were written about the links between different properties of the categories referring to things like data location. Notes describing emerging concepts were written concurrently with this process, with some being discarded, until the five categories were generated. These identified categories determined the final organisation of the findings. Quotes were selected that illustrated the points that had been chosen as key topics for this chapter. It was found that, despite the diversity of education and backgrounds, perioperative personnel shared similar knowledge and understanding of radiation exposure and safety in their work environment.

(1) The dangers of radiation exposure

This category developed primarily from the discussion resulting from several of discussion guide questions – Q 1. What do you know about radiation exposure and safety? Q 2. What do you understand to be safe radiation practices? Q 4. Some staff may consider that x-rays are relatively harmless. What do you think? Q 6. What staff categories do you believe are most at risk during procedures using x-rays and why? Participants endeavored to define 'radiation exposure' and just when and where one comes in contact with it. All the participants, to a person, believed that radiation was an invisible danger that was seen as

Output from the II machine. Also radiation in microwaves and mobile phones. There is radiation all around us (Group.2, 30/5/01).

There are all sorts of radiation: background, x-rays, beta rays, gamma rays or fluro tubes. All those are known to have biological effects. So you actually draw a line in the sand as to what you believe to be safe levels of exposure. Don't ask what they are, but that is what we trust the various health authorities to do – set safe limits of exposures. (Group 4, 8/6/01)

Being exposed to dangerous, invisible rays. Being exposed without proper protection. Yes to danger. Yes but you can't see it and you can't feel it, you don't ignore it but you can get blasé about it. (Group 1, 29/5/01)

Radiation exposure is an invisible danger. Getting zapped by cosmic rays over a period of time like a day, a week or over your total work life. The problem is you can't see x-rays so you don't know what's going on. (Group 3, 6/6/01).

When discussing whether there was harm in radiation, participants from Group 3 questioned plain films as opposed to II exposures. The consensus of this group was that II is supposed to be better than plain films but they asked of each other *"how much II exposure is equivalent to a plain film?"* (Group 3, 6/6/01). Participants questioned each other in this group but many of the questions could not be answered in that forum. All participants fully endorsed the concept that radiation was harmful.

A lot of the earlier radiographers got skin cancers because they put their hands in the beam. (Group 3, 6/6/01)

(2) Lack of knowledge and education on radiation exposure and safety

Lack of knowledge and education on radiation exposure and safety emerged from all group discussions and from each of the discussion guide questions. Primarily from Q1 What do you know about radiation exposure and safety? And Q2 What do you understand to be safe radiation practice? and Q7 How do you know what, if any, are the potential risks of radiation? Safe levels of radiation exposures were unknown by all participants and this was greatly lamented by them. The participants asked each other what they knew of radiation exposure and what levels were considered safe. This part of the discussions was possibly the most emphatic.

I certainly don't know what level of radiation we are allowed to be exposed to within the unit or outside. External radiation causes cancer of the limbs and disease. So what is the level of radiation? Well we don't really have a protocol saying what is a safe level of radiation. Where these extremes are who knows basically. When I first started here there was no inservice at all in radiation. It should go back to education. We would just like a protocol in place just so that it is a safe practice. (Group 2, 30/5/01).

Participants from Groups 2, 3 and 4 expressed using "common sense" when trying to determine safe practices.

Common sense is prevailing there at the moment. I've only learned wearing the gowns and talking to the older x-ray guys. (Group 2, 30/5/01).

Common sense is there you know. But common sense is based on knowledge. (Group 4, 8/6/01).

Discussion concerning knowledge and education on radiation exposurers drew these main points: there were unknown repercussions; the lack of any information on radiation exposure was greatly lamented; there was no scientific evidence made available; and, there was no knowledge of long term effects of exposures. When perioperative personnel were asked where their knowledge of radiation came from it sparked some definite responses. The vast majority had not received any form of education or inservice that related in any way to radiation.

Well I suppose nobody gives us any education on radiation. I certainly never had any radiation education in my training or when I was doing my degree. Like I still don't know what it is, what it does, what it can do. (Group 1, 29/5/01). No one admitted to ever asking to have any education on radiation in the Operating Suite or in the Anaesthetic, Orthopaedic or Surgical Departments. Orthopaedic surgeons were the only group to admit to some formal education in radiation. Some of their comments were,

Primarily by some formal education (orthopaedics). By reading published literature. Common sense is there you know but common sense is based on knowledge. With a healthy dose of paranoia as well. Paranoia is good. (Group 3, 6/6/01)

However participants stated that they still needed to know safe dose limits. They felt that knowledge came primarily from word of mouth and past experiences, as there was no formal education on radiation given at all.

If it is you who has developed something, or somebody else, even if it is too late. You don't know if it is a symptomatic thing or a true causal thing. (Group 4, 8/6/01)

(3) The radiation environment

This category was touched on in all the group discussions and emanated from every discussion guide question in some way or another. In every group there was reference to how to deal with radiation when working with it. In order to present this broad category it was further broken down into five sub-categories: a) safe radiation practices, b) distance from the source, c) experiences with radiation practices in the OR, d) signage and warning systems and e) exposure times.

a) Safe radiation practice.

This sub-category emerged from the discussion around whether x-rays are harmless or not and on whether protective covering should be warn during x-raying. An enlightened comment from a participant when discussing safe radiation practices summed up everyone's feelings.

Like safe sex, you need to be protected! (Group 3, 6/6/01).

Other comments included

Avoid radiation. Minimise exposure (Group 4, 8/6/01).

Protection is also distance away from the source. (Group 3, 6/6/01).

A warning on being cautious came from one participant

Look basically we just have to be cautious in the theatre complex with any II. A lot more people take more care of their ovaries and genital area. (Group 2, 30/5/01)

b) Distance from the source.

Distance from the source also comes under safe radiation practice but the comments from participants warranted its own analysis. This subject drew comment from all the focus groups, both in its own right and when discussing protective devices and apparel. Some participants firmly believed that the patient was most at risk from radiation as they are closest to the source.

Because 9 times out of 10 the patients aren't protected. Group 2, 30/5/01)

Other participants argued this point because they believed that the patient would not be at risk, and stated it emphatically.

Wouldn't be the patient as they are usually having a one-off procedure. (Group 3, 6/6/01)

Closest to the source is most at risk was the unanimous decision of the group. There was some discussion as to who that was and finally the consensus was that the following order of risk was agreed on. The surgeon, then the scrub nurse, then the theatre assistant, then the circulating nurse and the anaesthetist.

Whether it's a theatre assistant and a surgeon, or a nurse and a surgeon, whoever is close to it. (Group 2, 30/5/01)

In orthopaedics the surgeon is primarily most at risk. Then the scrub nurse because

... they are often doing it on a regular basis. (Group 3, 6/6/01)

Then the theatre assistant.

For closed reductions they are there. ...and certainly after hours. They are usually farther away but there is scatter of course so you don't have to be right in the beam to get irradiated. (Group 3, 6/6/01)

Circulating nurses and anaesthetists can absent themselves from the room during x-rays or stand behind the lead screen.

c) Experiences with radiation practices in the OR

When asking for comment on some of the participants' experiences (good and bad) and the use of x-ray in the OR the responses were

mixed. Bad experiences encompassed things like a blasé attitude. Many participants admitted that they had gone, or had seen others go, into a theatre where they were x-raying and did not bother to gown up for that short time.

I know I'll go into a theatre and I'll dart behind somebody in a lead apron because I'm only going in there for a minute to deliver a message or something; so I'll just run in and shoot behind somebody. (Group 1, 29/5/01)

Some participants believed that there was insufficient warning before x-raying. However another participant felt things had improved.

Things have improved because I can remember a few years ago not being told x-raying was going on and now they are a lot more conscientious about other people in the room or being told that there is actually screening going on. (Group 4, 8/6/01)

After this comment discussion tended towards the idea that it is better than it was but it is still not good enough. It was felt that the following improvements were now seen; the effort is made to minimise the number of people exposed in a theatre, and lead gowns are now very much encouraged. There was then a feverish swapping of past experiences and the belief that things are slightly better now. One of the better experiences had by some members was that the greater the level of experiences of the radiographer and the surgeon, the lower the level of exposure.

That goes to their ability to perform tasks with minimal exposure to radiation. (Group 3, 6/6/01)

d) Signage and warning systems

This discussion was stimulated by the general duties of theatre assistants. These duties consist of patient transport and transfer to and from the OR table, equipment procurement and set up and adjustment of theatre lights, to name a few. They are summoned to any of the theatres and

9 times out of 10 you are actually walking in and they are x-raying and nobody lets you know at the time and we have no lead gowns or protection on when we walk into the theatre. Even on the doors there should be a sign saying that II is being used or something so you can look before you come in. (Group 2, 30/5/01)

The second area of concern voiced was regarding the warning light on the II console.

I think the II machine should be upgraded because the little light they have on top of the machine doesn't shine most of the time. The old machine had a bigger light that we could actually see coming on. Group 2, 30/5/01)

The light just tells you it is on. It gives you the time the radiation has been used for. That is assuming the light comes on. Group 3, 6/6/01)

One participant called for audible alarms on the II machine during exposurers and reiterated the need for signage on the outer doors.

e) Exposure times.

The time or repetitions of exposures paralleled the risk of being close to the source.

Depends on how often they have been x-raying. Like with constant II they are taking a shot all the time while rotating a limb. You are then getting more exposure than if they were only taking a quick shot. The x-rays are actually going for a couple of minutes just to make sure everything is right. (Group 2, 30/5/01)

That goes to their ability to perform tasks with minimal exposure to radiation. I mean sometimes you look up and they have the light on just to try and position it rather than positioning it before exposing it. (Group 3, 6/6/01)

(4) Protective devices and apparel

This category emerged from concepts from the fifth discussion guide question - Do you know/understand if it is necessary to wear protective covering when working with x-rays? There were also some comments for this category from Q 3. What have been your experiences with the use of x-rays in your theatre – good experiences or bad experiences? and Q 6. What staff categories do you believe are most at risk during procedures using x-ray and why? This category was also broken down into four sub-categories: a) is protection necessary; b) the integrity of protective apparel; c) the appropriateness of protective apparel and devices; and, d) areas of the body needing protection.

a) Is protection necessary?

In discussion as to whether protection is necessary, every participant in each focus group replied strongly in the affirmative. Responses included that it should be mandatory to wear protective apparel during x-ray screening. Protection is definitely essential.

Lead aprons and thyroid collars. (Group 2, 30/5/01).

Cause if you leave it up to the individual there will be people who will think' well I'm not going to wear it'. It might be their ignorance or laziness. (Group 1, 29/5/01).

b) The integrity of protective apparel.

This fifth question stimulated a response from groups that demonstrated some knowledge of protective apparel. The points raised covered storage, handling and regular testing procedures of lead aprons and thyroid collars.

Cause one had a tear in it. (Group 1, 29/5/01)

The discussion on integrity of protective apparel developed around how well the protective equipment is maintained. Are they ever tested? Comment was made that some aprons are a little thin.

People just throw on a lead gown, which may have been left lying around, creased or folded. Some of them feel a little thin on and it's a bit hard to know how well they operate or whether they are ever tested or checked." (Group 4, 8/6/01)

c) The appropriateness of protective apparel and devices.

There was discussion among all participants as to the appropriateness of the half gown – a lead apron that only covers the front of the body and ties at the back. It affords protection only to the front of the body. After lengthy discussion the following points were forthcoming from the participants.

All half gowns should be removed. Animated discussion ensued as to the inappropriate coverage given by these lead aprons.

I mean they are now saying that you need a gown that goes right around you cause you are turning all the time. Fair enough. We only have what you call half gowns. We have two of the full suits. Should we get more of them? (Group 2, 30/5/01)

Also the scrub nurse, if he or she is not careful, have their back turned and its not covered on the back. I know a lot of times you turn around to get something or be preparing something and they are taking another x-ray. (Group 1, 29/5/01)

Group 2 (30/5/01) purported that *"the surgeons nearly always take the two full suits, and that seems reasonable, however more are required."*

All participants endorsed that there is no eye protection offered.

Dosimeters for anaesthetists, surgeons and scrub staff should be compulsory to determine dose levels of radiation.

I've worked in oncology units where you have to wear dosimetery badges and the level of exposure is a lot lower there than in the OR. (Group 4, 8/6/01)

One group raised continued good use of the leaded glass screen and whether we should have more of them.

I always use it. It's great and you don't have to wear a heavy gown (Group 4, 8/6/01)

I think we should have one in each theatre (Group 2, 30/5/01).

A call for an audible alarm on the II machine during exposures came from a group.

Would anyone feel there is any benefit in having audible alarms on the II machine? Say for anyone just walking into the theatre and doesn't realise that x-ray is on (Group 4, 8/6/01).

Participants verbalised the need for signs on doors warning that x-ray is in use.

Like we come in from side doors and we may not know the II is there but you can't see that little light that is actually on the machine (Group 2, 30/5/01).

Group 1 (28/5/01) and Group 4 (8/6/01) believed that only lead aprons that are new or looked after should be in use and that they should be tested.

Well we don't know how well they are maintained (Group 1, 28/5/01).

Some of them feel a little thin and it's a bit hard to know how well they operate or whether they are ever tested or checked or whatever (Group 4, 8/6/01).

Full suits, rather than half aprons, to be supplied was the consensus of all groups.

I go the full Monty. It is double lead in front and the most comfortable to wear. The weight is evenly distributed – some on the shoulders and some on the waist. (Group 3, 6/6/01).

Comment was made of the constant excuse that we have no money to buy equipment. All groups felt strongly that there were insufficient lead gowns available.

Still people only look at the cost of the stuff. (Group 2, 30/5/01).

Just run out to the scrub room. That's what we normally do if there is not enough gowns to go round. (Group 1, 29/5/01).

One participant raised the concerns for the potential for three or more theatres using II at the same time, e.g. orthopaedics, urology and general surgery.

Then there is definitely insufficient gowns or thyroid collars to go round. The number of personnel in each theatre requiring protective apparel is a minimum of 7 (Group 1, 28/5/01).

d) Areas needing protection.

Discussion developed following comment about surgeon's hands being unprotected.

See though they don't put anything on their hands do they. (Group 2, 30/5/01)

The main discussion point was around orthopaedic surgeons who have their hands very close to the direct beam. One participant remembered that we once had some radiation-protection gloves but had not seen them for ages. Some discussion ensued about the use of radiation protection gloves. They are thick and cumbersome.

I think we put our hands in, at least I do. We protect our bodies fairly well but often we get our hands too close. (Group 3, 6/6/01).

Well even in the x-ray department they have got them (radiation gloves) for when you do manipulations or examinations there, but they are very cumbersome. It is very hard to get the feel if you are moving a joint. You often end up chucking them off and running the risk. (Group 4, 6/6/01)

Discussion on protection of the eyes during radiation exposure was then mooted. Nobody could supply any answers, only questions.

I've heard that if your eyes aren't protected you can predispose to cataract formation. You can get special glasses but if you already wear glasses it is very hard to put another pair over the top. Do normal glasses afford any protection? What about plastic ones? (Group 3, 6/6/01)

Pregnancy was touched on, mainly referring to the female patients not staff.

Especially if they are pregnant and don't know it.

Thyroids are not protected as well as they should be and eyes are not protected at all, was a common comment from all groups. It was felt that it was due in part to the limited numbers of thyroid collars available and no eye protection being offered. The consensus was strong. No one disputed this claim.

...rather that their eyes and thyroid, which is supposedly at as much, if not more, greater risk. (Group 2, 30/5/01)

(5) Radiographer's role and responsibilities

Under the question of good experiences with radiation in the OR, the first group listed the radiographers due care. It was a unanimous decision in this group that the radiographers were very good in their practices in the OR.

They will not x-ray if someone is in there without a gown on. (Group 1, 29/5/01)

During the data analysis of Group 1 the researcher felt it was important to discover how all the subsequent groups viewed the radiographer's role and responsibilities in relation to the effect radiographers may impact on the knowledge and understanding of radiation exposure and safety. Therefore a question was added to the discussion guide for the remaining groups. (See Q 8 in Appendix 4). Subsequent responses to this question differed from those of the first group.

The new radiographers, I feel, do hinder us a bit because they are a bit lackadaisical themselves with their practices. One point is that I think that they should call out if they are x-raying, which I don't believe they do. Second, like I said they are not basically being responsible for everyone that is in that theatre. Of course they are responsible, they are in charge of that machine! (Group 2, 30/5/01)

The discussion then returned to the specific duties of theatre assistants in that they are summoned to any of the theatres and

9 times out of 10 you are actually walking in and they are x-raying and nobody lets you know at the time and we have no lead gowns or protection on when we walk into the theatre. (Group 2, 30/5/01).

The response from other participants pertained to the inexperience of some radiographers. The greater the experience of the radiographer, and the surgeon, the lower the level of exposure.

That goes to their ability to perform tasks with minimal exposure to radiation. I mean sometimes you look up and they have the light on just to try and position it rather than positioning it before exposing it. (Group 3, 6/6/01)

Yet others believed that there was an identified need for general improvement in whose responsibility it is to allow people to have access to protective gear of appropriate sizes.

Often they wheel in the II and I will say 'can I have a gown and a thyroid shield' and someone will say 'oh they are over there'. You are not in a position to leave the patient and there is (sic) no more gowns your size or any thyroid shields left. The theatre assistant says that it isn't his (sic) job to get more gowns and so does the radiographer. (Group 4, 8/6/01)

This generated support and discussion. It was generally felt that radiographers are not living up to their responsibilities.

Although everybody gowns up, I think that there has been a drop off in the way radiographers do actually ensure that everybody is covered. Group 4, 8/6/01)

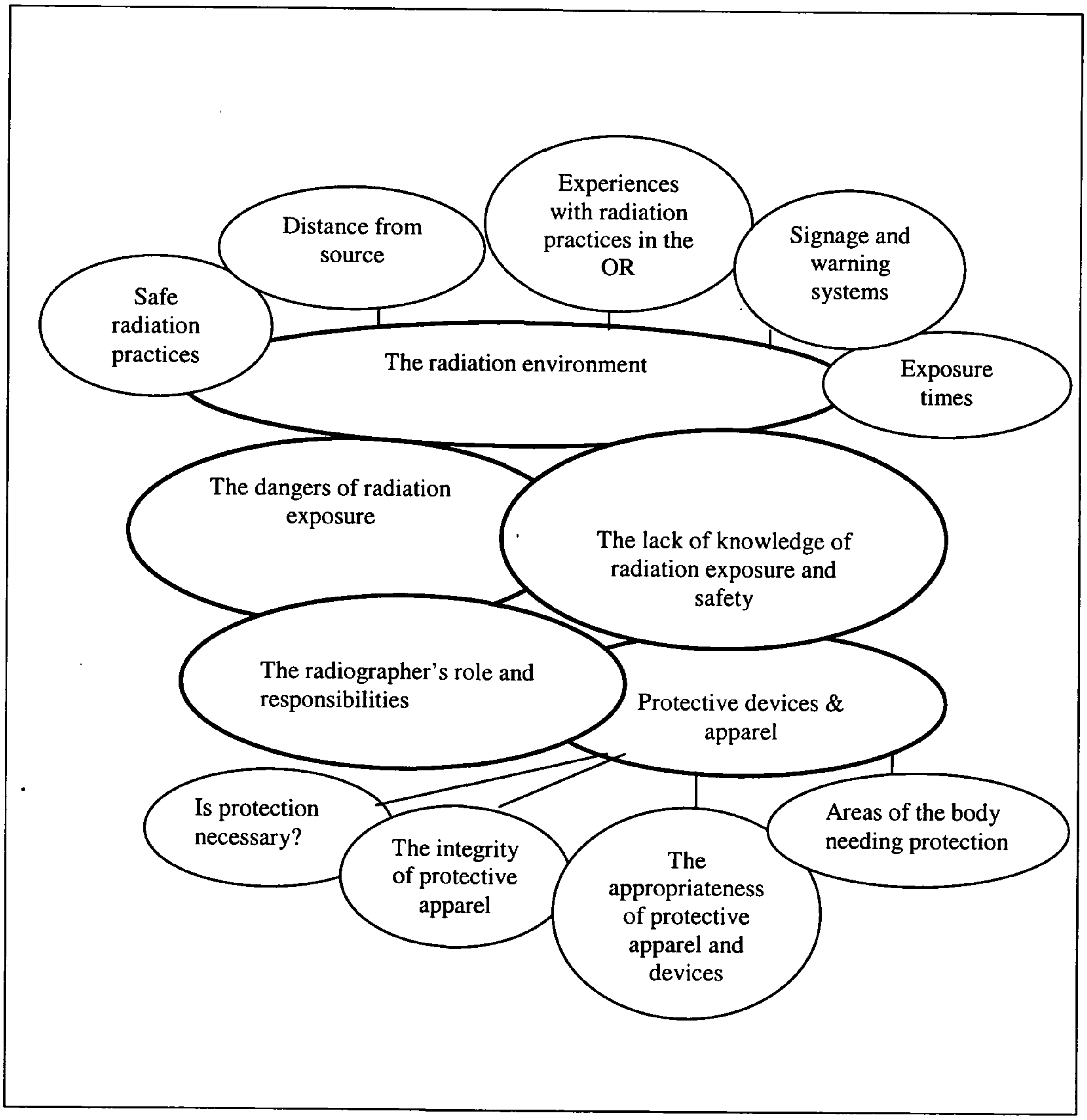
It was verbalized strongly that it is the radiographer's responsibility to ensure staff is protected. There are different cultures from institution to institution and the culture comes from the radiographers more than anybody else. They also believed that the younger ones tend to be more obsessive than the older ones.

Conclusion

The findings of this study provided five inter and intra related categories with their sub-categories. See Figure 1 for a diagrammatic presentation. The dangers of radiation exposure, the lack of knowledge and understanding, the radiation environment, protective devices and apparel and the radiographer's role and responsibilities were the categories that emerged from the analysis of the data collected during the four homogenous focus groups. The inter and intra related categories are aptly described by

Singer, et al. (2000) as facets of a gem. The following diagram demonstrates this analogy.

Figure 1. Inter and intra related categories (Singer et al. (2000).



The following chapter will discuss the findings, discussed above.

CHAPTER FIVE

DISCUSSION AND RECOMMENDATIONS

Introduction

The aim of this focus group research study was to gather data to ascertain the knowledge and understanding of radiation exposure and safety held by diverse categories of perioperative personnel: perioperative nurses, theatre assistants, surgeons and anaesthetists. The study fulfilled this aim and answered the research question "What was the knowledge and understanding of perioperative personnel in relation to radiation exposure and safe radiation practices in an Operating Suite?" Through a process of review the focus group transcripts were analysed and several themes and concepts emerged that led to the development of categories. These categories were grouped under five main headings; the dangers of radiation exposure; the lack of knowledge of radiation exposure and safety, the radiation environment; protective devices and apparel; and, the radiographer's role and responsibilities. Each of these categories, with their intra and inter relationships, will be discussed prior to the recommendations from this study.

Dangers of radiation exposure

The participants firmly believed that radiation is all around us in some form or another and that it is an invisible danger that can not be felt. The consensus from participants was that one can get a little blasé about the dangers of radiation but fortunately authorities have set safe limits on the exposures personnel can be subject to. Although no one was aware of just what these limits were, or whether they fit within these set parameters. This demonstrated a knowledge deficit on set radiation exposure levels that govern their radiation exposures within their work environment. This information is found in the Queensland Radiation Safety Act, 1999.

A question was asked during one focus group about the supposed benefits of II over plain films and no one in that group could provide any answers. Bushong (1993) identifies three benefits of II: an increase in brightness, time saving, and patient/staff radiation dose reductions. Jones and Stoddart (1998) confirmed that the amount of radiation used in plain radiographs is 16 times that of a single II flash. Although this knowledge is not a requirement for radiation practice in the OR, it does demonstrate a lack of knowledge and understanding of radiation exposure.

Lack of knowledge and education of radiation exposure and safety

Only orthopaedic surgeons received any form of formal education on radiation as radiation plays such a big part of their diagnosis and treatments. A good deal of this education was self-directed through perusal of the published literature. However this group also stated that they did not know what constituted the safe levels of radiation exposure. Of the remaining participants not one person had been given any training or education on radiation exposure or safe radiation practices. All participants indicated that no one knew what levels of exposure were considered safe. No participant admitted to asking for any education on radiation exposure and safety from their line managers although they indicated a need for policies and procedures or an education package to address this void. The reviewed literature supported this need. Few nurses or physicians receive formal training covering the biologic effects of radiation exposure (Dewey & Incoll 1998; Jones & Stoddart 1998; Mehlman & DiPasquale 1998; Revell 1994; Shymko & Shymko 1998).

Commonly Goldstone et al. (1993), O'Rourke et al. (1996) and Statkiewicz-Sherer, et al. (1998) confirm that, in the United Kingdom and parts of Europe, there is a legal obligation that training in radiation safety must be provided for staff performing medical procedures using radiation. Lewall et al. (1995) developed a teaching program for non-radiologists in Saudi Arabia. This Fluroscopy Credentialling Program included techniques for reducing the radiation received by patients and personnel during orthopaedic surgery. They cited the 1992 American College of Radiology who made it clear that one of the most successful means of reducing radiation exposure is education in the rudiments of radiation protection (Lewall et al. 1995). It was found that this program was more successful than expected in reducing fluroscopy times. Demonstrated reduction of times from 8.3 to 0.9 minutes on average was demonstrated (Lewall et al. 1995). QH (1999a) and the ICRP (1996) have set radiation exposure limits and perioperative staff should make themselves aware of these. According to the NOHSC (1995a, pp. r-18, r-19) "Regulatory or supervisory authorities, operators, employers and employees involved with practices which may lead to exposure to radiation all have responsibilities to ensure proper radiation protection. ...Employees are responsible for observing radiation safety practices as set out in the plan for controlling exposure to radiation, and for complying with the relevant safety instructions."

Participants discussed the importance of education and training in radiation and the requirements for an educational package for staff involved in radiation during their daily working routines. This knowledge will ultimately require the additional information as to whether perioperative personnel actually are exposed to radiation that remains within the set parameters. When AORN (2001) issued their *Recommended Practices for Reducing Radiological Exposure in the Practice Setting,* they believed that the responsibility for radiation safety in the practice setting is shared by the Departments of Radiology and Surgical Services, the Radiation Safety Officer and perioperative personnel.

The radiation environment

All groups determined that for a safe radiation environment to be maintained personnel require protection from radiation exposures. This can be achieved by maintaining a safe distance from the source, protective apparel and/or devices, minimal exposures, appropriate signage and warning systems (Brown, et al. 1999; Bushong 1993; Statkiewicz-Sherer, et al. 1998). Decreased exposure times and increased distance from the radiation source are still prime objectives (Jones & Stoddart 1998; Mehlman & DiPasquale 1998). Perioperative personnel demonstrated very limited knowledge of safe radiation distances and dose limits. This evolves from appropriate education and training on radiation exposures and safety issues. Many investigators still caution that there is no absolute safe level of radiation exposure (Bushong 1993; Kneedler & Purcell 1989; Revell 1994; Shymko & Shymko 1998; Statkiewicz-Sherer et al. 1998). Distance and shielding are still the most effective means of protection from ionising radiation (Brown et al. 1999; Bushong 1993; Kneedler & Purcell 1989; Shymko & Shymko 1998; Statkiewicz-Sherer, et al. 1998).

Protective devices and apparel

One aspect identified in this category was that issues such as limiting staff numbers in the OR before radiation exposure, increased distance from the source of the radiation and decreased, or minimal, exposure times all contribute to providing a safer radiation environment. Another area of concern was just who was most at risk from radiation exposure within the OR. This was an area of some disagreement. Some felt that the patient would be most at risk, as he/she was closest to the source during x-raying. Others purported that the patient was not really at risk from radiation as they usually have a 'one-off' procedure. However surgeons, scrub nurses, and sometimes, theatre assistants, are all close to the source and receive accumulative doses of radiation, and as such are at risk.

Participants felt that the blasé attitude to radiation, by those who do not bother to put on a lead apron before entering an OR using x-rays, even for short periods, is an area of concern. This staff is not practicing radiation safety. Another important point raised during these discussions was that the greater the experience of the radiographer, and the surgeon, the lower the level and time of exposure. Some groups purported that the wearing of protective apparel should be mandatory. As already pointed out, this is a requirement of both the Queensland Radiation Safety Act 1999 and the NOHSC (1995a) Standards.

There were two distinct areas of signage and warning systems that were discussed. Firstly, the total lack of warning signs within the perioperative environment indicating that x-ray is in use in any particular OR was a major concern. The problem that this should address is that the theatre assistants, and others, can be summoned to a theatre, for various reasons, and on entering can find themselves unprotected as x-ray is in progress. Hence, protection is not considered until it is too late. The second area of concern was the II machine and its internal warning devices. These points require clarification by the radiology department. Warning signs should be available for the doors of any theatre using x-ray, and a warning for women who may be pregnant should be on display in the reception area. Protective devices and apparel take the form of lead aprons, suits and wrap arounds, thyroid collars and the leaded glass screen and all are available, in limited numbers, within the Operating Theatre Suite. Participants also believed it is not enough just to have this protection provided, it must be well maintained, regularly inspected and tested in accordance with the relevant legislation. As was also identified, there must be sufficient of this apparel and devices to fully protect perioperative personnel at all times and under all circumstances.

Participants strongly believed that lead apparel should completely cover the trunk, either in the form of full wrap around or top and skirt combinations, to protect the body when turned away from the source. AORN Standards (1994, 2001) purport that when wearing lead aprons perioperative personnel should face the II machine. This demonstrates the potential harm that could come from wearing half gowns if the wearer has his/her back turned during x-raying. It was strongly suggested that all half gowns should be removed or replaced, by natural attrition, with the other types of protective apparel that cover the whole trunk. Hand and eye protection should be investigated and provided for those who require them. The use of the lead screen must be increased and participants mooted the possibility of one per OR. Fiscal considerations were mentioned, however, it was believed that the safety of perioperative personnel should be paramount. This is supported by the AORN (2001) who purport that the recommended practices are intended as achievable recommendations representing what is believed to be an optimal level of practice.

Education requirements on the appropriate use of protective apparel were identified. According to authors such as Pierson (1995), Revell (1994) and Shymko and Shymko (1998) moving away from the source is not always the best way of reducing radiation exposure. At low energies, lead shielding is very effective and it is for this reason that lead aprons and thyroid collars are used for protection in diagnostic radiography. 0.5mm of lead equivalents of protection is required for aprons and collars and 0.35mm for lead glasses are recommended (Statkiewicz-Sherer et al. 1998). The proper handling and storage of protective apparel is imperative to prevent damage. Biannual inspections and radiological testing of these items should be carried out, warn Pierson (1995), Revell (1994) and Shymko & Shymko (1998). Protective apparel within the research setting are inspected annually by the Medical Imaging Department. The ICRP (1996) purports that radiological protection, and more generally, a high standard of safety depends critically on the performance of people and institutional arrangements can greatly influence that performance.

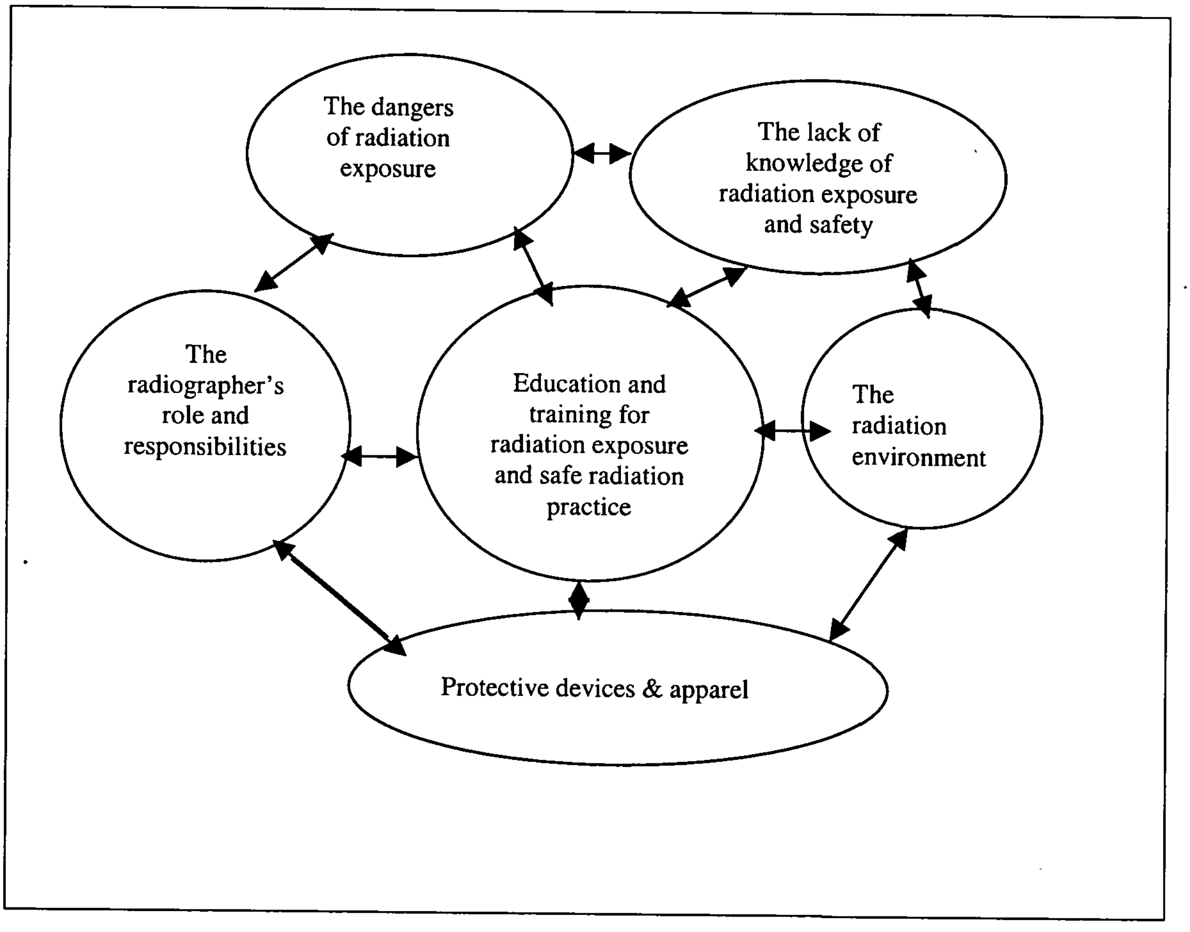
Radiographers' roles and responsibilities

Although not strictly in keeping with the aim of this study, ascertaining the knowledge and understanding of radiation exposure and safe radiation practices of perioperative personnel, a strong link with radiographers was discussed in all groups. Shymko and Shymko (1998) believe that without education and good communication with radiologic technologists, perioperative personnel may not be sure what the consequences of exposure are and therefore may not be able to protect themselves or their patients. They go further in saying that misconceptions about safe radiologic practice within the perioperative environment may occur because members of each discipline are unfamiliar with each other's knowledge and practice guidelines. Participants believed that they relied heavily on radiographers for direction and protection to assist them when dealing with radiation. A great deal of discussion on this topic lead to two distinct responses. There were those who thought that radiographers were diligent in warning when x-raying was imminent. Then there were those who believed that radiographers did not live up to their responsibilities. Analysis showed that perioperative personnel who remain in the OR for the complete procedure, including x-raying, felt that they were generally well warned, although there were some exceptions. Those who had to come and go, and consequently walked in often when x-ray was in progress, felt that the radiographer did not live up to their responsibilities. It was unanimously believed that the radiographer had the total responsibility of all in the OR during x-raying as they have control of the II machine. This is supported in the literature by Revell (1994) and Shymko and Shymko (1998) who emphasise that radiographers should exercise vigilance as they have a responsibility to protect patients and personnel by reducing exposure levels and exposure times. The question still remains 'Who is responsible for ensuring the appropriate numbers and sizes of protective apparel are available?' This needs to be addressed.

Intra and inter relationships of the identified categories

Emerging from the five categories and their sub-categories was a strong suggestion for 'education and training in radiation exposures and safe radiation practices' to address self-determined knowledge deficits. Figure 2 depicts the inter-relationships with each category and the link with education to optimise radiation safety within the perioperative environment. With education and training in radiation exposure and safe radiation practice knowledge and understanding of perioperative personnel will be enhanced. Participants felt that, at this point in time, safe radiation practices are not optimised within the research study site (perioperative environment).

Figure 2. Inter-relationships of the identified categories with education requirements



Recommendations

The results of this study have determined the knowledge and understanding of radiation exposure and safe radiation practices demonstrated by the participating perioperative personnel. The results also demonstrated that the participants value a safe perioperative environment in which radiation exposure is part of their daily working routines. Their self-determined knowledge deficits have been identified and the participants now wish to work with the key stakeholders to improve this situation. They identify these stakeholders as Medical and Nursing Administrators, the Medical Imaging Department, Nurse Educators, and, practicing perioperative personnel. As a consequence, it is recommended that these key stakeholders be responsible for providing and maintaining a safe perioperative environment for the continued use of radiation, both in treatment and diagnosis. The suggestion was that this group should:

1. Provide policies and procedures governing the safe use of radiation in the perioperative environment.
2. Provide an education package to be made available to all members of the perioperative team.
3. Ensure that appropriate protective apparel and devices are not only provided, but are well maintained and tested regularly and that this is documented in such a manner as to enable the staff utilising this equipment to be aware of its current status at any given time.
4. Ensure that adequate numbers of protective apparel or devices, such as lead gowns, thyroid collars and leaded glass screens are always available to cover any contingency that may arise. The potential for an adequate number of such protective devices/apparel to be stored in or near each OR to facilitate ease of access for the personnel in each OR, should be considered.
5. Provide signage in sufficient numbers that whenever any one or more OR is using x-ray a sign will be displayed on each door to the OR stating “X-ray in progress”

so that personnel may have appropriate apparel on before entering. Such signage should remain in or near each OR for ease of access when required.

6. Establish discussions with the Medical Imaging Department as to the appropriate warning systems in-built in the II machine to determine if they are working to their potential, or if they can be enhanced. Also to highlight the role and responsibilities of the radiographer while in attendance in the OR.
7. Ensure hand and eye protection is investigated as to the availability and practicality of use with a view to providing such protection for those who require it.
8. Explore the possibility of monitoring the radiation exposure levels of all the perioperative personnel who regularly come in contact with radiation in their daily work routines to determine whether they comply with the safe limits as set in the legislation.

Limitations of the study

The methodology and process of the study have inherent limitations that have been discussed in previous chapters, namely potential biases and beneficence. However, the study had specific limitations that required discussion. Demographic data of the participants was not collected. Years and type of experience were not considered thus differences were not highlighted. Participants spoke only of how they perceived radiation exposure at the time of the focus groups.

The results of this study do not reflect other similar perioperative environments. Participants in this study spoke only of their experiences with radiation exposure within this research setting. Since the sample was small in this study it would be inappropriate to generalize to all perioperative environments. However, the findings appear to be significant in relation to the current lack of policy and procedures governing radiation exposure in this environment.

In the 'surgeon' category only orthopaedic surgeons participated. Input from general and urological surgeons may have been beneficial. However, none were available for the focus group session due to work commitments and their numbers within the research setting are low. Only one urologist and three general surgeons, one of whom was on leave were employed at the time of the study. The small representation of perioperative nurses also bears some discussion. 12 from a possible 39 were approached to participate in their focus group and this was considered reasonable representation. Although nine agreed to attend circumstances led to four not being able to attend. A more representative sample would have been ideal but time, work and personal commitments often prevail in research projects and this one was no different.

Areas for further research

The results of this research also raise new questions that may serve as the basis for further research. Suggested further studies include:

1. Determining the radiation exposure rates of perioperative personnel who come in contact with radiation in their daily work routines to determine if they fall within set parameters as outlined by the Queensland Radiation Safety Act 1999. One self-determined knowledge deficit of perioperative personnel was lack of knowledge of the safe levels of radiation. Once this is addressed perioperative personnel may wish to progress to determine if they are practicing within these safe levels.
2. Determining if other perioperative environments display similar results.

Conclusion

This study demonstrated the self-determined knowledge deficits and limited understanding of radiation exposure and safe radiation practices held by the perioperative personnel of this Operating Room Suite. By raising the study question, *"What was the knowledge and understanding of perioperative personnel in relation to radiation exposure and safe radiation practices in an Operating Suite*?" radiation knowledge and safety was highlighted and participants became more aware of their knowledge deficits and their responsibilities regarding radiation during their everyday work routines. At the time of this study perioperative personnel believed that safe radiation practices were not optimised. However, the potential for a safe radiation environment within the Operating Room Suite is achievable. Education still remains the key to the understanding of radiation exposure and safety, while the acquisition of sufficient appropriate protective apparel and devices gives the means to practice safe radiation practices within our chosen working environment. It is important to know that the information generated by studies such as this may provide a safe working environment for the perioperative team by raising the awareness of this important issue.

REFERENCES

Agar, M. & MacDonald, J., 1995, 'Focus groups and ethnography', Human Organisation, 54, pp. 48-58.

Alonso, J. A., Shaw, D. L., Maxwell, A., McGill, G. P. & Hart, G. C., 2001, 'Scattered radiation during fixation of hip fractures. Is distance alone enough protection?' The Journal of Bone and Joint Surgery, vol. 83-B, no. 6, pp. 815-818.

American Operating Room Nurses (AORN), 1994, Standards and Recommended Practices for Perioperative Nursing, AORN Inc, Denver, Colorado.

AORN On line, 2000, 'Proposed Recommended Practices for safety through the identification of potential hazards in the perioperative environment' Available at http://www.AORN accessed on 12th May, 2001

AORN Recommended Practices Committee, 2001, 'Recommended practices for reducing radiological exposure in the practice setting', AORN Journal, vol. 73, no. 1, pp. 220-230.

Arnstein, P. M., Richards, A. M. & Putney, R., 1994, 'The risk from radiation exposure during operative x-ray screening in hand surgery', The Journal of Hand Surgery, vol. 19B, no. 3, pp. 393-396.

Ashbury, J. E., 1995, 'Overview of focus group research', Qualitative Health Research, vol. 5, no. 4, pp. 414-420

Bagley, D. H. & Cubler-Goodman, A., 1990, 'Radiation exposure during ureteroscopy', Journal of Urology, 344, pp. 356-8.

Barnard, A., 1997, 'A critical review of the belief that technology is a neutral object and nurses are its master', Journal of Advanced Nursing, vol. 26, pp. 126-131.

Baszanger, I., 1997, 'Deciphering chronic pain' in A qualitative analysis for social scientists, eds. A. L. Strauss & J. Corbin, Cambridge University Press, New York.

Berg, B., 1995, Qualitative research methods for social sciences, 3rd edn, Allyn & Bacon, Boston.

Beyea, S. C. & Nicoll, L. H., 2000a, 'Decision analysis – putting it all together', AORN Journal, vol. 71, no. 3, pp. 678-681.

Beyea, S. C. & Nicoll, L. H., 2000b, 'Learning more using focus groups ', AORN Journal, vol. 71, no. 4, pp. 897-900.

Beyea, S. C. & Nicoll, L. H., 2000c, 'Methods to conduct focus groups and the moderator's Role', AORN Journal, vol. 71, no. 5, pp. 1067-1068

Beyea, S. C. & Nicoll, L. H. 2000d 'Collecting, analysing and interpreting focus group data', AORN Journal, vol. 71, no. 6, pp. 1278-1283.

Bourke, S., Cikoratic, J. & Mack, G., 1999, 'Researching organisational behaviour: An introduction to grounded theory', (on line) DBA Research methodology, available at http://www.home.aone.net.au/bechervaise/DBAR5.htm accessed 27th September , 2001

Bristol, J. & Fern, E. F, 1996, 'Exploring the atmosphere created in focus group interviews: Comparing consumers feeding across qualitative techniques', Journal of the Market Research Society, vol.38, no. 2, pp. 185-195.

Brown, B. H., Smallwood, L. H., Barber, D. C., Lawford, P. V. & Hose, D. R., 1999, Medical Physics and Biomedical Engineering, Institute of Physics Publishing, Bristol.

Browne, J. & Sullivan, G., 1999, 'Analysing in-depth interview data using grounded theory', in Handbook for research methods in health sciences, eds. V. Minichello, G. Sullivan, K. Greenwood.& R. Axford, Addison-Wesley Longmont, Australia.

Burns, N. & Grove, S. K., 1999, Understanding Nursing Research, 2nd edn.., Mosby-Year Book Inc., St Louis.

Bushong, S. C., 1993, Radio logic science for technologists: Physics, biology and protection, 5th edn.., Mosby, St Louis.

Byrne, M., 2001,. 'Interviewing as a data collection method', AORN Journal, vol. 74, no. 2, pp. 233-235.

Carey, M. A., 1995, 'Concerns in the analysis of focus group data', Qualitative Health Research, 5, pp. 413-530

Carey, M. A. & Smith, M. W., 1994. 'Capturing the group effect in focus groups; Qualitative Health Research, vol. 4, pp. 123-127

Clarke, A., 1999, 'Focus group interviews in health care research' Professional Nurse, vol. 14, no. 6, p. 395.

Clarke, C. & Procter, S., 1999, 'Practice development: ambiguity in research and Practice', Journal of Advanced Nursing, vol. 30 no.4, pp. 975-982.

Cote-Arsenault, D. & Morrison-Beedy, D., 1999, 'Practical advice for planning and conducting focus groups', Nursing Research, vol. 48, no. 5, pp. 280-283.

Creswell, J. W., 1994, Research design: Qualitative and Quantitative Approaches, Sage Publications, Thousand Oaks.

Davies, B. S. G., 2000a, 'Extending nursing care into the world of technology', AORN Journal, vol. 71, no. 4, pp. 782-784

Davies, B. S. G. , 2000b, 'Changing times, changing roles', AORN Journal, vol. 72, no. 2, pp. 117-118

Denzin, N. K. & Lincoln, Y. S., 1998a, The Landscape of Qualitative Research: Theories and Issues, Sage Publications, Thousand Oaks.

Denzin, N. K. & Lincoln, Y. S., 1998b, Strategies of Qualitative Theory, Sage Publications, Thousand Oaks.

DeSantis, L. & Ugarriza, D. L., 2000, 'The concept of theme as used in qualitative nursing research' Western Journal of Nursing Research, vol. 22, no.3, pp. 138-149.

Dewey, P., 1997, 'Preliminary report on thyroid cancer', Australian Orthopaedic Association Bulletin, August, pp. 38-39.

Dewey, P. & Incoll, I., 1998, 'Evaluation of thyroid shields for reduction of exposure to radiation to orthopaedic surgeons', Australian and New Zealand Journal of Surgery, vol. 68, pp.635-636.

Dick, B., 2000, 'Grounded theory: A thumbnail sketch' (On line) Available at http://www.scu.edu.au/schools/gcm/AR/ARP/GROUNDED.html.. Accessed 27th September, 2001

Eaton, K. L., McComish, J. F. & Greenberg, R., 2000, 'Avoiding common pitfalls in data collection and transcription", Qualitative Health Research, vol. 10, no. 5, pp. 703-707.

Emden, C. & Sandelowski, M., 998.,'The good, the bad and the relative, part one: 'Conceptions of goodness in qualitative research', International Journal of Nursing Practice, vol4, pp. 206-212.

Fontana, A. & Frey, J. H., 1998, 'Interviewing. The art of science' in Collecting and Interpreting Qualitative Materials, eds. N. K. Denzin & Y. S. Lincoln, Sage Publications, Thousand Oaks.

Franklin, J & Bloor, M. 1999. 'Some issues arising in the systematic analysis of focus group materials' in Developing Focus Group Research, eds. R. S. Barbour & J. Kitzinger, Sage, Thousand Oaks.

Fuchs, M., Schmid, D. A., Eiteljorge, J., Modler, M. & Stumer, K. M., 1998, 'Exposure of the surgeon to radiation during surgery', International Orthopaedics, vol. 22, pp. 153-156.

Gettleman, L. & Winkleby, M. A., 2000, "Using focus groups to develop a heart disease prevention program for the ethnically diverse, low-income women', Journal of Community Health, vol. 25, no. 6, pp. 439-453.

Giblin, J. G., Rubenstein, J., Taylor, A. & Pahira, J., 1996, 'Radiation risk to the urologist during endourological procedures', Urology, vol. 48, no. 4, pp. 624-627.

Goldstone, K. E., Wright, I. H. & Cohen, B., 1993, 'Radiation exposure to the hands of orthopaedic surgeons during procedures under fluroscopic control', British Journal of Radiology, vol. 66, pp. 899-901.

Gray-Vickery, N., 1993, 'Gerontological research: Uses and application of focus groups' Journal of Gerontological Nursing, vol. 19, pp. 521-527.

Grbich, C., 1999, Qualitative research in health: An introduction, Allen & Unwin, Australia.

Guba, E. G. & Lincoln, Y. S., 1989, Fourth Generation Evaluation, Sage Publications, California.

Hallberg, L. R. M., Pause, U. & Ringdhal, A., 2000, 'Coding with post-lingual severe-profound hearing impairment: A grounded theory study', British Journal of Audiology, vol. 34, no. 1, pp. 1-10.

Harvey-Jordan, S. & Long, S., 2001, 'The process and pitfalls of semi-structured interviews', Community Practitioner, vol. 74, no. 6, pp. 219-224.

Helmreich, R. L. & Schaefer, H. G., 1994, 'Team performance in the operating Room' in Human Error in Medicine, ed. M. S. Bogner, Hillside, New Jersey.

Henderson, K. H., Lu, J. K., Strauss, K. J, Treves, S. T. & Rockoff, M. A., 1994, 'Radiation exposure of anesthesiologists', Journal of Clinical Anaesthesia, vol. 6, Jan/Feb, pp. 37-41.

Hines, T. 2000. 'An evaluation of two qualitative methods (focus group interviews and cognitive maps) for conducting research into entrepreneurial decision making', Qualitative Market Research, An International Journal, vol. 3, no. 1, pp. 7-16.

Holloway, I. & Wheeler, S., 1996, Qualitative Research for Nurses, Blackwell Science, Oxford

Hughes, J. M., Mitchell, P. A. & Ramson, W.S., (eds.)1996, The Australian Concise Oxford Dictionary, 2nd edn, Oxford University Press, Australia.

International Commission of Radiological Protection (ICRP). 1996 Radiological Protection and Safety in Medicine, IRCP publication 73, Pergamon.

Jackson, P., 1998, 'Focus group interviews as a methodology' Nurse Researcher, vol. 6, no. 1, pp. 72-84

Janesic, V. J., 1998, 'The dance of qualitative research design', in Strategies of Qualitative Theory, eds. N. K. Denzin & Y. Lincoln, Sage Publications, Thousand Oaks.

Johnson, P., 2001, 'Are 1990's surgical technologies really labour-saving?', **ACORN Journal,** vol. 14, no. 4, pp. 20-28.

Jones, D. G. & Stoddart, J., 1998, 'Radiation in the orthopaedic theatre', Australian & New Zealand Journal of Surgery, vol. 68, pp. 782-784.

Kendall, J., 1999, 'Axial coding and the grounded theory', Western Journal of Nursing Research, vol. 21, no.6, pp. 743-757.

Kidd, P. S. & Parshall, M. B., 2000, 'Getting the focus and the group: Enhancing analytical rigour in focus group research', Qualitative Health Research, vol. 10, no. 3, pp. 293-308.

Kingry, M. J., Tiedje, L. & Friedman, L., 1990, 'Focus groups: A research technique for nursing' Nursing Research, vol. 39, no. 2, pp. 124-125

Kitzinger, J., 1994, 'The methodology of focus groups: The importance of interaction between research participants', Sociology of Health and Illness, vol. 16, no. 1, pp. 105

Kitzinger, J., 1996, 'Introducing focus groups' in Mays, N. & Pope, C. 1996. Qualitative Research in Health Care, British Medical Journal Publishing group, London.

Kneedler, J. A. & Dodge, G. H., 1994, Perioperative patient care: The nursing perspective. 3rd edn., Jones Bartlett, Boston.

Kneedler, J. A. & Purcell, S. K., 1989, 'Perioperative nursing research. Part II. Intraoperative chemical and physical hazards to personnel', AORN Journal, March 1989, vol. 49, no. 3, pp. 829-854.

Koch, T., 1994, 'Establishing rigour in qualitative research, the decision trail', Journal of Advanced Nursing, vol.19, pp. 976-986

Krueger, R. A., 1988, Focus groups A Practical Guide for Applied Research, Sage Publications, California.

Krueger, R. A., 1994, Focus Groups: A Practical Guide for Applied Research, 2nd edn. Sage Publications, California.

Krueger, R. A., 1997, Analysing and Reporting Focus Group Results, Sage, Thousand Oaks.

Lane, P., McKenna, H., Ryan, A. A. & Fleming, P., 2001, 'Focus group methodology', Nurse Researcher, vol. 8, no. 3, pp. 45-54.

Leask, J., Hawe, P. & Chapman, S., 2001, 'Focus group composition: A comparison between natural and constructed groups', Australian and New Zealand Journal of Public Health, vol. 25, pp. 152-154.

Lewall, D. B., Riley, P., Hassoon, A. & McParland, B. J., 1995, 'A fluroscopy credentialling program for orthopaedic surgeons', Journal of Bone and Joint Surgery (Br), vol. 77B, pp. 442-443.

Llewellyn, G., Sullivan, G. & Minichello, V., 1999, 'Sampling in qualitative research' in Handbook for Research Methods in Health Sciences, eds. V. Minichello, G. Sullivan, K. Greenwood & R. Axford, Addison-Wesley Longmont, Australia.

Mays, N. & Pope, C., 2000, 'Qualitative research in health care: Assessing quality in qualitative research', British Medical Journal, vol. 320, pp. 50-52.

McConnell, E. A. & Hilbig, J., 1996, 'Quality patient care through education', ACORN Journal, vol. 9, no. 1, pp. 17-19.

McConnell, E. A. & Hilbig, J., 2001, 'A national study of perioperative nurse education in two technologies', AORN Journal, vol. 72, no. 2, pp. 254-264

McDaniel, R. W. & Bach, C. A., 1994, 'Research issues in focus groups: a data gathering strategy for nursing research', Nursing Science Quarterly, vol. 7, no. 1, Spring, pp. 4-5.

McDaniel, R. W. & Bach, C. A., 1996, 'Focus group research: The question of scientific rigour' Rehabilitation Nursing Research, vol. 5, pp. 53-59.

McGowan, C., Heaton, B & Stephenson, R. N., 1996, 'Occupational x-ray exposure of anaesthetists', British Journal of Anaesthesia, vol. 76, pp. 868-569.

Mehlman, C. T. & DiPasquale, T. G., 1997, 'Radiation exposure to the orthopaedic surgical team during fluroscopy', Journal of Orthopaedic Trauma, vol. 11, no. 6, pp. 392-8.

Miles, M. B. & Huberman, A. M. 1994. Qualitative Data Analysis, 2nd edn., Sage, Thousand Oaks

Minichello, V., Madison, J., Hays, J., Courtney, M. & St John, W., 1999, 'Qualitative interviews' in Handbook for Research Methods in Health Sciences, eds. V. Minichello, G. Sullivan, K. Greenwood & R. Axford, Addison-Wesley, Australia.

Morgan, D. L., 1988, Focus Groups as Qualitative Research, Sage, Newbury Park, California.

Morgan, D. L., 1995, 'Why things (sometimes) go wrong in focus groups', Qualitative Health Research, vol. 5, pp. 516-522

Morgan, D. L., 1996, 'Focus groups', Annual review of Sociology, vol. 22, pp. 129-152.

Morse, J. M. & Field, P. A., 1995, Qualitative Research Methods for the Health Professionals, 2nd eds.. Sage, Thousand Oaks

Morse, J. M., 2000, 'Determining sample size', Qualitative Health Research, vol. 10, no. 1, pp. 3-5.

National Council of Radiation Protection and Measurement (NCRP), 1976, NCRP Report 49. Structural shielding design and evaluation for medical use of x-rays of energies up to 10 MeV, NRCP, Washington, DC.

National Health and Medical Research Council. 1999. National statement on ethical conduct in research involving humans, Australian Government Printing Services, Canberra.

National Occupational Health and Safety Commission. (NOHSC) 1995a. 'National standard for limiting occupational exposure to ionising radiation', [NOHSC: 3022 (1995)], Australian Government Printing, Canberra

NOHSC, 1995b, 'National standard for limiting exposure to ionising radiation', [NOHSC: 1013 (1995)], Australian Government Printing, Canberra

Newman, J., 2000, 'Radiation protection for radiologic technologists', Radiologic Technology, vol. 7, no. 3, pp. 273-289.

Noordeen, M. H. H., Shergill, N., Twyman, R. S., Cobb, J. P. & Briggs, T., 1993., 'Hazards of ionising radiation to trauma surgeons: reducing the risks', Injury, vol. 24, no. 8, pp. 562-564.

Norton. L., 1999, 'The philosophical bases of grounded theory and their implications for research practice', Nurse Researcher, vol. 7, no. 1, pp. 31-42.

Nyamathi, A. & Shuler, P., 1990, 'Focus group interviews: a research technique for informed nursing practice', Journal of Advanced Nursing, vol. 15, pp. 1201-1288

Oppenheim, A. N., 1992, Questionnaire Design, Interview and Attitude Measurement, Pinter Publishers, London.

O'Rourke, P. J., Crerand, S., Harrington, P., Casey, M. & Quinland, W., 1996, 'Risks of radiation exposure to orthopaedic surgeons', Journal of the Royal College of Surgeons (Edinb.), vol. 41, pp. 40-43.

Orona, C. J., 1997, 'Temporality and identity loss due to Alzheimer's disease' in Grounded Theory in Practice, eds. A. Strauss & J. Corbin, Sage, Thousand Oaks.

Otto, L. K. & Davidson, S., 1999, 'Radiation exposure to certified registered nurse anaesthetists during ureteroscopic procedures using fluroscopy', Journal of the American Association of Nurse Anaesthetists, vol. 67, no. 1, pp. 53-58.

Parahoo, K., 1997, Nursing Research: Principles, Processes and Issues, Macmillan, London

Parritt, S. & O'Callaghan, J., 2000, 'Splitting the difference: An exploratory study of therapist's work with sexuality', Sexual and Relationship Therapy, vol. 15, no. 2, pp. 157-161.

Patterson, W. B., Craven, D. E., Schwartz, D. A., Nardell. E. A., Kasmer, J. & Noble, J., 1985, 'Occupational hazards to hospital personnel', American College of Physicians Annals of Internal Medicine, 102; pp. 658-680.

Pierson, M. A., 1995, 'Patient and environmental safety' in Alexander's Care of the Patient in Surgery, 10th edn. eds. M. R. Meeker & J. C. Rothrock, Mosby Year Book Inc., St Louis.

Polgar, S. & Thomas, S. A., 1995, Introduction to Research in the Health Sciences, 3rd edn. Churchill Livingstone, Melbourne.

Pope, C., Ziebland, S. & Mays, N., 2000, 'Analysing qualitative data', British Medical Journal, vol. 320, no. 7227, pp. 1145-116.

Powers, P., 1996, 'Discourse analysis as a methodology for nursing enquiry', Nursing Inquiry, vol. 3, p. 207-17.

Queensland Health, 1999a, Radiation Safety Act 1999, Goprint, Queensland.

Queensland Health, 1999b, Radiation Safety Standard PR 004: 1999, Goprint, Queensland.

Queensland Health, 1999c, Radiation Safety Standard Hr 001: 1999, Goprint, Queensland.

Queensland Health, 1999d, Radiation Safety Standard HR 002:1999, Goprint, Queensland.

Queensland Health, 1999e, Radiation Safety Regulation 1999, Goprint, Queensland.

Queensland Parliamentary Council, 1995, Workplace Health ad Safety Act 1995, Goprint, Queensland.

Reed, J. & Payton, V. R., 1997, 'Focus groups: issues of analysis and Interpretation', Journal of Advanced Nursing, vol. 26, pp. 765-771.

Revell, L., 1994, 'Monitoring and controlling the environment' in Perioperative Nursing Practice, eds. M. L. Pippen & M. Wells, W. B. Saunders, Philadelphia.

Ritchie, S. & Spencer, I., 1994, 'Qualitative data analysis for applied policy research' In Analysing Qualitative Data, eds. A. Bryman & R. Burgess, Routledge, London.

Robinson, N., 1999, 'The use of focus group methodology – with selected samples from sexual health', Journal of Advanced Nursing, vol. 29, no. 4, pp. 905-913.

Robrecht, L., 1995, 'Grounded theory: Evolving methods', Qualitative Health Research, 5(2), pp. 169-177.

Rozgaj, R., Kasuba, V., Peric, M., 1999m 'Chrosome aberrations in operating room Personnel', Journal of Industrial Medicine, vol. 35, no. 642, pp. 642-6.

Saas-Kortsak, A. M.; Purdham, J. T.; Bazek, P. R. & Murphy, J. H., 1992, 'Exposure of hospital operating room personnel to potentially harmful environmental agents', American Industrial Hygiene Journal, vol. 53, pp. 203-209.

Saulnier, C. F., 2000, 'Groups as data collection method and data analysis technique: Multiple perspectives on urban social work education', Small Group Research, vol. 31, no. 5, pp. 607-627

Shymko, M. & Shymko, T. M., 1998, 'Radiation safety', AORN Journal, vol. 68, no. 4, pp. 596-602.

Silverman, D., 1998, 'The quality of qualitative health research: the open-ended interview and its alternatives' Social Sciences in Health, vol. 4, no. 2, pp. 104-118

Singer, P. A., Martin, D. K., Giacomini, M. & Purdy, L., 2000, 'Priority setting for new technologies in medicine', British Medical Journal (International Edition), vol. 321, no. 7272, pp. 1316-1319.

Silo, H. M. S., 1989, 'Perioperative nursing research. Part V. Intraoperative recommended practices', ACORN Journal, vol. 49, no. 6, pp. 1627-1636.

Sim, J., 1998, 'Collecting and analysing qualitative data: Issues raised by the focus group' Journal of Advanced Nursing, 28, pp. 534-552.

Smathers, J. B., 1988, 'The use of ionising radiation and medical-care-related problems' Health Physician, 55, pp. 165-167.

Smith, G. L., Lavy, C. B. D., Briggs, T. W. R. & Nordeen, H., 1992, 'Ionising radiation: are orthopaedic surgeons at risk', Annals of the Royal College of Surgeons (Eng.), vol. 74, pp. 326-328.

Stable, R., 2002, 'Directions', Health Matters, vol. 7, no. 7, p. 2.

Statkiewicz-Sherer, M. A.; Visconti, P. J. & Ritenour, E. R., 1998, Radiation Protection in Medical Radiography, 3rd edn., Mosby Inc., St Louis.

Stewart, D. W. & Shamdasani, P. N., 1990, Focus Groups: Theory and Practice, Sage, Newbury Park.

St John, W. 1999. 'Focus group interviews' in Handbook for Research Methods in Health Sciences, eds. V. Minichello, G. Sullivan, K. Greenwood, K & R. Axford, Addison-Wesley Longmont, Australia.

Talbot, L. A., 1995. Principles and Practice of Nursing Research, Mosby-Year Book Inc., St Louis.

Thomas, M., Holt, M., & Coakley, K., 1999, Radiation Exposure in Orthopaedic Surgeons, A paper presented at the Australian Orthopaedic Association National Conference, Brisbane Convention Centre, October 1999.

Tolson, D., 1999, 'Practice innovations: a methodological maze', Journal of Advanced Nursing, 32(2), pp. 381-390.

Tse, V., Linsing, J., Khadra, M., Chiam, Q., Nugent, R., Yeaman, L. & Mulcahy, M., 1999, 'Radiation exposure during fluroscopy: should we be protecting our thyroids?' Australian and New Zealand Journal of Surgery, vol.68, pp. 847-8

United States Environmental Protection Agency (USEPA), 1998a, 'A fact on the health effects of ionising radiation', USEPA, EPA402-F-98-009, Ionising Series No. 1, Radiation Protection Program Publication.

USEPA, 1998b, 'A fact on the health effects of ionising radiation', USEPA, EPA402-F-98-010, Ionising Series No. 2, Radiation Protection Program Publication.

Walker, B. L., 1999 'Qualitative methods' in Understanding Nursing Research, 2nd edn. eds. N. Burns & S. K. Grove, Mosby-Year Book Inc., St Louis.

Webb, C., 1999, 'Analysing qualitative data: computerised and other approaches', Journal of Advanced Nursing, vol. 29, no. 2, pp. 323-330

Webb, E. R., 2000, 'Occupational health and safety – the employees' responsibility', Australian College of Operating Room Nurses (ACORN) Journal, vol. 13, no. 4, pp. 13-27.

Williams, C., 1996, 'Quality circles – assuring perioperative standards', ACORN Journal, vol. 9, no. 4, pp. 20-21.

Wright, J. G. & McKeever, P., 2000, 'Qualitative research: its role in clinical Research', Annals of the Royal College of Surgeons and Physicians Canada, vol. 33, no. 5, pp. 275-280.

Wuest, J., 2000, 'Negotiating with helping systems: An example of grounded theory evolving through emergent fit', Qualitative Health Research, Vol. 10, No. 1, pp. 51-70.

APPENDIX 1

Focus group discussion guide.

(This is a loose format and is intended as an interview guide only to enable the researcher to cover all the topics considered important).

1. What do you know about radiation exposure and safety?
2. What do you understand to be safe radiation practice?
3. What have been your experiences with the use of X-ray in your theatre –good experiences and bad experiences.
4. Some staff may consider that X-rays are relatively harmless. What do you think?
5. Do you know/understand if it is necessary to wear protective covering when working with X-rays? (Prompts) Yes. No. Why? Please elaborate.
6. What staff categories do you believe are most at risk during procedures using X-rays and why?
7. How do you know what, if any, are the potential risks of radiation?

   (Prompts) Through education, past experiences, length of service, common sense, published literature, standards.

Additional questions coming from previous groups.

(The previous group believed ...., What do you think?)

8. The previous group mentioned radiographers in their discussions. Do you have any comments to offer?

APPENDIX 2

Focus group discussion introduction.

The aim of this discussion is to explore the beliefs and meanings of radiation exposure and safety that are held by various research participants. This is the (1st, 2nd, 3rd or 4th) of four such group discussions to be held for this part of my research and I am extremely grateful for the generous gift of your time and commitment to this project.

The intent for this session is for free-flowing dialogue from the floor, stimulated hopefully by a few set lead questions.

One thing I do ask is that these group discussions are not repeated outside this room. There are two reasons for this. Firstly, to keep the participant's identity and responses confidential, and secondly, to prevent sensitising of future group discussions.

These sessions will be taped and I will take some notes. The tapes will be transcribed verbatim, without names, and you will each receive a copy for comment, correction and verification. I would ask that we listen to one speaker at a time and please speak clearly for the tape. There are no right or wrong answers and each participant's input is important.

If everyone is ready we will start. I will give you the first question and anyone can start. Don't worry if you get off the track. If you do I'll bring you back.

APPENDIX 3

Participant information letter.

Researcher	Tricia Tierney
	Clinical Nurse, Operating Theatre Suite, Ipswich Hospital.
Study title.	*Radiation exposure in the perioperative environment – are we safe?*
Study period.	April to June 30th, 2001.

Dear____________________

This letter is to invite you to participate in my research study looking at radiation in the perioperative environment. The study is aimed at involving perioperative personnel who will be working in the Operating Theatre Suite who come into contact with radiation during their day to day work routines. The study will be undertaken between April and June 30th 2001.

The purpose of this study is to identify any knowledge deficits perioperative staff may have of radiation exposure and safety within the perioperative environment. During the study period participants will be asked to attend a focus group for approximately 1 hour duration, to have the sessions audiotaped, transcribed and sent back to the participants at a later date, for comment and/or validation. Prior to each focus group discussion participants will be reminded of the confidentiality of each session.

The researcher is endeavoring to determine the various knowledge bases within the perioperative environment in order to address any identified deficits. Tapes and transcripts will remain the sole responsibility of the researcher and will not be shared with anyone. No names will appear in any data collected and all participants will be given code names. All transcriptions' participant consent forms and all data collected will remain in a locked filling cabinet, both during the study and for 5 years after completion of the study. The final report may contain some anonymous quotations and anecdotal situations and will be available at the end of the study.

There may be some direct benefits to you as a participant of this study. There may be changes to perioperative radiation procedures with some educational and professional policy and procedure development and implementation.

If at any time you have any complaints about the study, please contact either Mr. Lewis or Ms Ritchie (see below). All complaints will be treated in confidence, investigated fully and you will be informed of the outcome.

Mr. Steve Lewis, Ethics Officer

West Moreton Health Service District

Phone (07) 3271 8642 or 3835 9900 pager 72124

Email stevel@wph.uq.edu.au

Or

Ms Barbara Ritchie,

Head of the School

Faculty of Arts, Health and Science

University of Central Queensland

Phone (07) 49309602.

Thanking you in advance

Tricia Tierney

APPENDIX 4

Informed consent form.

Researcher	Tricia Tierney
	Clinical Nurse, Operating Theatre Suite, Ipswich Hospital.
Study title.	*Radiation exposure in the perioperative environment – are we safe?*
Study period.	April to June 30th, 2001.

This is to certify that, I ....(print name).have read the accompanying participant information letter and agree to voluntarily participate in the above named study.

I understand there will be no health risks to me resulting from this participation in the research.

I will participate in the focus group discussion on Tuesday 29th May at 5pm (nurses), Wednesday the 30th June at 2.30pm (theatre assistants), Wednesday the 6th June at 8am (surgeons), Friday the 8th June at 8am, in the Theatre Seminar Room and have these sessions audio taped and transcribed. I understand that these discussions will be approximately an hour long and will consist of 6 to 12 participants, moderated by the researcher (so nominated as Tricia Tierney) and held in the Operating Suite.

I understand that the information may be published and that I will not be identified in the final report.

I understand that I am free to refuse to participate and reserve the right to veto any documentation during the study. I also understand that I am free to withdraw from the study at any time without penalty.

I have been given the opportunity to ask whatever questions I desire, and all such questions have been answered to my satisfaction.

I understand that if I have any complaints about this study I am free to contact the West Moreton Health Service District Ethics Officer or Head of the School (as outlined in the participant's information letter).

....	....	....
Participant	Witness	Researcher

Date....................

APPENDIX 5

Thank you letter

Researcher Tricia Tierney
Clinical Nurse, Operating Theatre Suite, Ipswich Hospital.

Study title. *Radiation exposure in the perioperative environment – are we safe?*

Study period. April to June 30th, 2001.

Dear..........................

Thank you again for your time and input into my research project. I have had the audiotapes transcribed, and as promised, I have enclosed a copy of the discussions for your records. At times there were background noises on the tape that made it difficult to hear the voices, so I hope I haven't misquoted you. If you feel that I have attributed something to you that you are unhappy about, or I have missed something important, please let me know as soon as possible and I will make the corrections. I would also appreciate verification of the truth of the transcript if you are happy with your representation,

Yours sincerely

Tricia Tierney