

**THE ANNUAL REPORT OF**

**THE RADIATION ADVISORY COMMITTEE**

**FOR THE YEAR ENDING SEPTEMBER 1996**

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**RADIATION ADVISORY COMMITTEE**  
Melbourne Australia

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ISSN 1035-7912

## **RADIATION ADVISORY COMMITTEE**

The Honourable Rob Knowles, MP  
Minister for Health

Dear Minister,

Pursuant to Section 108AK(10) of the *Health Act 1958*, the Radiation Advisory Committee submits the 1996 Annual Report of the Committee for presentation to Parliament.

Yours faithfully,

B M Tress  
(Professor)  
Chairman  
RADIATION ADVISORY COMMITTEE

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## THE RADIATION ADVISORY COMMITTEE

The Radiation Advisory Committee met on 7 occasions from September 1995 to May 1996. This ended the triennium of the Committee's appointment.

### Composition

Members of the Radiation Advisory Committee until May 1996 were:

### Meetings Attended

Professor B.M. Tress Department of Radiology University of Melbourne	:	Chairman	5
Dr. T.F. Sandeman Radiation Oncologist Peter MacCallum Cancer Institute	:	Member	7
Dr. K.H. Lokan Director Australian Radiation Laboratory	:	Member	3
Dr. J.C.P. Heggie Senior Physicist Department of Medical Engineering & Physics St Vincent's Hospital	:	Member	7
Dr. G. Giles Director Victorian Cancer Registry Director Cancer Epidemiology Centre Anti-Cancer Council of Victoria	:	Member	1
Dr. M. J. Kelly Director of Nuclear Medicine Alfred Hospital	:	Member	7
Mr. Kenneth Bennetts Chief Radiographer Preston & Northcote Community Hospital	:	Member	5
Dr. A.W. Wood Senior Lecturer in Biophysics School of Biophysical Sciences and Electrical Engineering Swinburne University of Technology	:	Member	5
Mr. F.P.J. Robotham Radiation Safety Consultant	:	Member	7
Dr. G.J. Rouch Chief Health Officer Department of Human Services	:	Member	7
Ms C. Isakow Radiation Safety Unit Department of Human Services	:	Secretary	

## THE RADIATION ADVISORY COMMITTEE FROM JUNE 1996

Following the end of the previous term of appointment both Dr Sandeman and Dr Giles advised that they were not available for re-appointment. They were replaced by Dr Wirth and Dr Sim.

The Radiation Advisory Committee met on 4 occasions from June 1996 to September 1996.

### Composition

Members of the Radiation Advisory Committee from June 1996 were:

### Meetings Attended

Professor B.M. Tress Department of Radiology University of Melbourne	:	Chairman	3
Dr. K.H. Lokan Director Australian Radiation Laboratory	:	Member	2
Dr. J.C.P. Heggie Senior Physicist Department of Medical Engineering & Physics St Vincent's Hospital	:	Member	4
Dr. M. J. Kelly Director of Nuclear Medicine Alfred Hospital	:	Member	2
Mr. Kenneth Bennetts Chief Radiographer Preston & Northcote Community Hospital	:	Member	2
Dr. A.W. Wood Senior Lecturer in Biophysics School of Biophysical Sciences and Electrical Engineering Swinburne University of Technology	:	Member	2
Mr. F.P.J. Robotham Radiation Safety Consultant	:	Member	3
Dr. G.J. Rouch Chief Health Officer Department of Human Services	:	Member	3
Dr Andrew Wirth Staff Specialist in Radiation Oncology Peter MacCallum Cancer Institute	:	Member	3
Dr Malcolm Sim Senior Lecturer & Head Unit of Occupational & Environmental Health Department of Epidemiology & Preventive Medicine Monash University	:	Member	2
Ms C Isakow Radiation Safety Unit Department of Human Services	:	Secretary	

## Responsibilities

The Radiation Advisory Committee was established by the Minister for Health under the Health Act 1958 (as amended) to advise the Minister or the Chief General Manager on any matters relating to the administration of the radiation legislation referred to it by the Minister or the Chief General Manager including the following:

- (a) the promotion of radiation safety procedures and practices;
- (b) recommending the criteria for the licensing of persons and the qualifications, training or experience required for licensing;
- (c) recommending the criteria for the registration of radiation apparatus and sealed radioactive sources;
- (d) recommending the nature, extent and frequency of periodic safety assessments of radiation apparatus and sealed radioactive sources;
- (e) codes of practice with respect to particular radioactive substances and uses of ionizing and non-ionizing radiation; and
- (f) any matter which the Minister agrees the Committee should consider and report on.

# 1. IONIZING RADIATIONS

## 1.1 Strontium-89 Guidelines

With the development of techniques for treatment of painful bony metastases using strontium-89, and requests by a number of practices to have strontium-89 included on their licences, the Committee saw the need to develop guidelines to ensure that only specialists qualified and experienced in the therapeutic use of radiopharmaceuticals administered strontium-89. The concerns were due to the radiation safety issues and potential toxicity of this treatment. Applicants for licence were advised that requests for strontium-89 treatments would be treated on a patient by patient basis and that no new licences would be issued until the proposed guidelines were developed. Amersham, the supplier of strontium-89 was also advised of this interim arrangement.

To develop the guidelines the Committee formed an ad hoc working party consisting of:

Dr M Kelly (RAC member)

Dr J Heggie (RAC member)

Dr T Sandeman (RAC member)

Mr A Melbourne (Radiation Safety Unit)

Mr D Sealey (Radiation Safety Unit)

Mr B van Every (Alfred Hospital)

To ensure that the guidelines took into account the comments of interested parties the Committee forwarded drafts to a number of professional organisations and committees, as well as some individual departments. These organisations included the Royal Australasian College of Physicians (RACP), Australian & New Zealand Association of Physicians in Nuclear Medicine (ANZAPNM), Royal Australasian College of Radiologists (Vic Branch)(RACR), RACR Oncology Faculty, the Joint Specialist Advisory Committee (JSAC) of RACP and RACR, and the supplier Amersham Australia. Advice was also sought from the National Specialist Qualification Advisory Committee (NSQAC) regarding the

grandfathering provisions recognising specialists in nuclear medicine and from the Therapeutic Goods Administration regarding product information for strontium-89.

The Committee was also made aware of the Therapy Sub-Committee which had been established by the RACP and included membership of a number of professional organisations. This sub-committee was also preparing guidelines on strontium-89 for the colleges. The Committee received comments on its drafts from the Therapy Sub-Committee and was in turn provided with Therapy Sub-Committee drafts for information.

Following this consultation process the Committee finalised the guidelines at its meeting of 2 May 1996 and they have subsequently been published by the Department and circulated to all hospital departments and practices involved in nuclear medicine and radiation oncology.

The final guidelines include an introduction, requirements for referring physician/specialist, administering physician/specialist, patient treatment (including indications, contraindications, relative contraindications, precautions, patient preparation, administration, facilities, post treatment, precautions following death of a patient), and written procedures. The guidelines also provide advice on patient information card, general patient instructions, and dosimetry and whole body retention of strontium-89. A copy of the guidelines is reproduced in Appendix I.

Applications from specialists wishing to obtain approval to use strontium-89 are now being received in accordance with the guidelines.

## 1.2 Patient Radiation Doses in Fluoroscopy

It was reported to the Committee that a high radiation dose causing a severe skin burn to a patient had occurred during a cardiology procedure in New Zealand. A copy of the report was obtained from New Zealand and the Committee

decided that an information circular should be prepared to be distributed to interventional radiologists and cardiologists in Victoria to emphasise the level of dose possible in such procedures and the importance of using radiation protection measures to minimise the dose to patients.

A circular was prepared with the Radiation Safety Unit and was circulated widely to X-ray departments, cardiology departments and professional bodies. A copy is included in Appendix II.

In view of the high doses involved the Committee recommended that in those cases where cardiologists had been issued licences to operate equipment without radiographers, that those licences should be amended to include conditions requiring a radiographer, other than in an emergency where a radiographer had been called and the patient may suffer irreversible damage if the procedure did not commence immediately. A further condition would require a written report to the Department within 24 hours on each occasion when the equipment was operated without a radiographer. These conditions are to be placed on licences when they next expire and are renewed. All licensees were advised of these changes when forwarded copies of the above circular. Their cooperation was requested in implementing these changes as soon as possible even though they will not officially take effect until the expiry of current licences.

### **1.3 Training and Licensing of Cardiologists**

The Committee discussed a number of matters relating to the training and licensing of cardiologists during the year. The issue was considered to be particularly important in view of the high doses to cardiology patients and to the cardiologists themselves.

(a) The need for a training course for cardiologists was discussed by the Radiation Safety Unit and the Australian Cardiac Society. It was agreed that a course based on a similar short course in WA would be appropriate for existing cardiologists. Committee members also arranged for a pilot

program to be trialed for cardiology registrars at Royal Melbourne Hospital. This program was subsequently thought to be too extensive, and further discussion led to a shorter program being agreed upon. This was based on a program being developed at Monash Medical Centre and again similar to the WA training.

(b) A request was received from Dr K Thomson & Associates at Epworth Hospital cardiology to licence cardiac technicians and nurses to operate equipment in view of the difficulty in obtaining radiography staff. The Committee considered the issue of staffing difficulties and also the position of the Australian Institute of Radiography. It was recommended that licences should not be issued to technicians or nurses, but that restricted licences to a limited number of cardiologists would be considered as a short-term measure.

(c) A report was received from Royal Melbourne Hospital that a cardiologist who did not hold a licence had instructed a nurse to operate equipment without a radiographer being present. A report was received from the hospital indicating that the radiographer had been called but had not arrived and the examination was considered to be urgent. The Committee recommended that a licence be issued to the cardiologist with conditions requiring that a radiographer be present, except in an emergency and where a radiographer had been called. A written report was to be provided to the Department within 24 hours on each occasion where equipment was operated without a radiographer. A further report from RMH was received in August 1996 indicating that a second incident of this type had occurred, where a procedure had been carried out without a radiographer, and no report had been forwarded. The explanation provided was that the radiographer had been paged but the wrong pager number had been called. The Committee advised that a letter be sent to the cardiologist, and to the CEO of Melbourne Private Hospital reminding both of the licence requirements and seeking information regarding the paging procedures in such situations.

(d) The Committee also recommended that licences to operate equipment without a radiographer not be granted to cardiologists at

Knox Private Hospital. In addition, Dr Rose (cardiologist) was advised that his licence would not be extended to allow operation without a radiographer at Knox Private Hospital. He was also advised of the changes proposed to licence conditions.

(e) Warringal Private Hospital was advised of the Committee's concerns about cardiology doses and asked to advise why radiographers could not be employed. The hospital was also subsequently advised of the changes to licence conditions for cardiologists.

(f) A letter was received from Dr WJ McKay, Director of Nuclear Medicine at Austin & Repatriation Medical Centre, querying the qualifications to administer radiopharmaceuticals of a number of cardiologists at two other hospitals. Investigation by the Radiation Safety Unit determined that the cardiologists had nuclear medicine recognition from NSQAC, although one did not hold the appropriate operator licence. This matter was resolved by the Radiation Safety Unit.

(g) A letter was received from Dr Styles, Director, Medical Imaging, Geelong Hospital regarding the proposed restrictions on the licence for cardiologist Dr Black. Dr Styles provided data on dose measurement supporting the argument that no restriction was necessary in this case. The Committee reviewed the information provided, and while it was happy to see the level of monitoring and supervision undertaken the Committee decided that no exceptions should be allowed.

#### **1.4 Radiation Safety Unit Project Reports**

The Committee received progress reports from the Radiation Safety Unit (RSU) on a number of patient dose surveys and an electromagnetic field survey being conducted. The patient dose projects included a survey of neonatal chest X-ray doses, a survey of adult chest X-ray doses, a survey of doses from selected paediatric procedures, a survey of doses and image quality in CT scanning, an evaluation of mammography doses from examination of data already collected by the RSU, and a survey of doses in selected fluoroscopic procedures

#### **1.5 Research Involving Radiation Exposure of Human Volunteers**

During the year the Committee reviewed 18 new or continuing research projects. Research projects involving radiation exposure of human volunteers requires approval from both the institution's Ethics Committee and the Department. Institutions proposing to undertake such research must provide copies of the research protocol, patient information sheet, radiation dose estimate, and evidence of approval by the institution's Ethics Committee. This information is reviewed by the Committee before recommendations approving the research are made.

In a number of cases the Committee requested revised or more detailed dose estimates or revision to the patient information sheet statements on risk prior to approving the research.

The projects approved are listed in Appendix III

The Committee was also advised of 5 other research projects involving radiation exposure. As these projects involved patients, where a potential direct benefit to the individual would apply, rather than volunteers, where there would be no individual benefit, but a potential societal benefit resulting from the research, the Committee was of the view that these projects should be treated as medical management rather than volunteer research.

#### **1.6 Release of Patients Treated with Iodine-131**

The Committee considered a proposal that guidelines on release from hospital of patients who have been treated with therapeutic quantities of iodine-131 should be based on dose considerations rather than the activity remaining in the patient (which is the case in the current NHMRC guidelines). The Committee was advised that the NHMRC guidelines were currently under review and recommended that the proposal be forwarded to NHMRC to be considered in the review.

#### **1.7 Disposal of Iodine-131 Patient Waste**

The Committee had previously requested that the RSU seek information from interstate and overseas

on approaches taken to controlling the disposal of patient waste from patients treated with iodine-131. Current Victorian regulations set a concentration limit for disposal to the sewerage system and an activity limit. There is provision for exemption from the activity limit. The requests from two hospitals had argued that the practice of collecting patient waste to allow for decay prior to disposal was more hazardous than immediate disposal to the sewerage system. In view of the information collected on disposal limits and risks of iodine-131 disposal, and the small number of patients involved, the Committee recommended that an exemption from the activity limit be allowed provided that the concentration limit was still met. This was conveyed to the two hospitals, one of which could meet the concentration limits, and the other of which would still need to store patient waste for decay.

### **1.8 Mammography Equipment**

The Committee had previously discussed the issue of two mammography units which did not incorporate automatic exposure controls (AEC). The Committee supported a recommendation by the RSU to make AEC's mandatory on all mammography units. Subsequently, it was reported to the Committee that one of these mammography units had been decommissioned. The Committee also considered a submission from National Diagnostic Imaging (NDI) regarding the need to fit an AEC to its mammography unit. The Committee requested that the Radiation Safety Unit carry out an inspection of the mammography unit to determine the feasibility of the mammography unit being used in its current configuration.

The RSU reported that the unit failed a majority of the tests carried out. The Committee therefore recommended that the mammography unit not be used until it has been appropriately modified. NDI were notified accordingly.

### **1.9 Licence Application from Dr A Berger to use Xi-scan Image Intensifier**

The Committee reviewed an application from Dr Anthony Berger to use a Xi-scan image intensifier during orthopaedic procedures on the

hand and wrist. After clarification of ownership issues a limited licence allowing imaging of extremities was recommended.

### **1.10 Teleradiology**

The Committee also noted a response from the National Health Advisory Committee to the NHMRC Radiation Health Working Party. The response was due to previous correspondence to NHMRC from the Committee regarding a possible need for a code of practice on teleradiology. The response from NHAC considered that adequate safeguards existed to prevent misuse of such equipment. The Committee requested that further information on teleradiology issues be obtained from overseas, and will continue to monitor the issue.

Copies of internet downloads from the American College of Radiology were also tabled. These set out the College's standards for teleradiology. The Committee recommended that these be forwarded to the RACR to seek information on whether that College had, or were developing, similar standards, or saw a need to do so.

### **1.11 Radiography Students Working as Radiographers**

The RSU reported that it had been advised that it was possible that radiography students from interstate were being offered work as radiographers at some locations in country Victoria. The RSU was unable to verify the report but wrote to the Charles Sturt University and requested that it advise students that any such offers should be rejected as such work would contravene Victorian licensing requirements. The University circulated this information to students. The Committee also suggested that information be circulated to Victorian centres.

### **1.12 Operator Licence Application - Gastroenterologist**

Consideration was given to an application for a licence to operate fluoroscopy equipment by Mr Ian Hamilton a Gastroenterologist in the Latrobe Valley. The proposal was that the equipment would be operated without a radiographer being present. Following

investigations into the need for the licence and the type of equipment proposed to be used, the Committee recommended that a licence not be issued.

It was considered that equipment of the type proposed to be used had to be operated by a radiographer.

### **1.13 Thallium Stress Tests**

The Committee was asked to advise whether it would be appropriate for nurses to inject the radioactive thallium during cardiac stress tests under supervision of the specialist and nuclear medicine technologist. The Committee advised that there was no reason why the specialist or technologist could not administer the thallium and therefore nurses should not be approved to undertake this work.

### **1.14 Dr C Duncan - General Practitioner Licence Application**

Dr C J Duncan, general practitioner from Euroa applied for an operator licence but requested that he be exempted from the requirement to undertake the GP Radiography Course on the basis of his past experience. The Committee considered his request and recommended that a licence be issued with a condition requiring that he undertake the course within the next 12 months.

### **1.15 Request for Operator Licence – Mr D Butler, Army Trained “Radiographer”**

Mr David Butler, an Army trained “radiographer” from NSW applied for a licence to work as a locum radiographer in Victoria. The Army training is not recognised by the Australian Institute of Radiography, neither is it recognised for licensing as a radiographer in Victoria. In view of this, and since the request did not relate to a remote location where it is difficult to obtain qualified radiographers, the Committee recommended that a licence not be issued.

### **1.16 Radon Exposure in Tour Caves**

The Committee reviewed a report on the collaborative study between ARL, the University

of Sydney and the University of Auckland regarding radon levels in show caves around Australia. The report indicated that Buchan caves had levels of the order of 3000 Bq/m<sup>3</sup>. This exceeds the level of 1000 Bq/m<sup>3</sup> set in the NHMRC Recommendations for limiting exposure to ionizing radiation (1995). Above this level a radiation protection program must be implemented.

Ventilation can not be used to reduce the radon levels as it would destroy the ecology of the caves. The RSU reported that more detailed information on exposures at both Buchan caves and Princess Margaret Rose caves in Nelson would be required. This should be obtained in consultation with the Department of Conservation and Natural Resources, the managers of the tour caves.

The Committee supported the need for more detailed study and requested to be kept informed on this issue.

### **1.17 Personal Monitoring of Theatre Staff at Royal Victorian Eye & Ear Hospital (RVEEH)**

A request for exemption from monitoring of theatre and ward staff had been received last year from Dr Sephton of PMCI (who is also radiation protection adviser to RVEEH) in relation to treatments using iodine 125 eye plaques. At that time an exemption was recommended for ward staff but it was recommended that a further year’s monitoring be undertaken on theatre staff before the matter could be reconsidered. This monitoring had now been undertaken and in view of the low doses received and the small number of procedures attended per person, the Committee recommended that an exemption be granted. This exemption did not apply to surgeons who attend more procedures, are closer to the plaques, and consequently receive higher doses.

### **1.18 Request for Exemption from Monitoring Royal Dental Hospital**

The Committee received a request for exemption from monitoring from Royal Dental Hospital for clinical dentists who take on average less than 6 X-rays per week. The exemption would not apply to dentists in the Radiology Department

who take many more X-rays. In view of the low doses recorded and low workload the Committee recommended that an exemption be granted. The Committee requested that the letter approving the exemption should point out the increased importance of notification and investigation of any incidents which would be likely to lead to high doses.

### **1.19 Effects of Low Dose Radiation**

The Committee received a copy of information presented at the 43rd Annual Meeting of the Society of Nuclear Medicine in Denver, Colorado in June 1996. The information was provided by Dr M Lichtenstein of Royal Melbourne Hospital. The report questioned whether low doses of radiation were associated with any adverse health effects. The Committee was aware that the information was not new and had not been universally accepted. It was noted that some national and international authorities had recently made statements which continued to support the linear, no threshold hypothesis. Dr Lichtenstein was thanked for providing the information.

### **1.20 Licensing to Use Unsealed Sources for Nuclear Cardiology and Radiotherapy**

The Committee discussed the contents of a letter sent by Dr Colin Styles, Director of Medical Imaging at Geelong Hospital. The Committee advised that a number of the issues raised were covered by the development of the strontium-89 guidelines and that the others were matters of medical practice rather than radiation safety.

### **1.21 Letter from Dr Shing regarding Restrictions on General Practice Registrations**

Dr Shing, general practitioner, wrote to the Committee requesting clarification of the basis for restrictions on the registration of his X-ray unit. Dr Shing was advised that a sub-committee had been established to examine several issues related to general practice and that he should have his issues addressed via general practice representatives on that sub-committee.

### **1.22 Numbers of Licences and Registrations Issued**

The Committee was provided with data from the RSU's computer register of licences and equipment registrations issued under the Health (Radiation Safety) Regulations. The details are in Appendix IV.

### **1.23 Radiation Safety Testing**

A summary of testing of currently registered equipment appears in Appendix V.

### **1.24 Modified Dental Panoramic Tomography Unit**

Dr David Lipp, radiologist, applied for registration of a dental panoramic tomography (or OPG) unit that had been modified by a local service engineer to perform linear tomography. This technique is used in dental implant work. The RSU had inspected the unit as well as other units purpose-designed to carry out linear tomography. The unit has a different shape beam to an OPG and has additional, computer-controlled movement of the tubehead. It is otherwise similar to an OPG. Dr Lipp is negotiating with the manufacturer regarding the modifications. The Committee recommended approval of the registration, but requested that the RSU undertake dose measurements to confirm that doses are similar to OPG doses.

### **1.25 Exemption from Minimum Distance Requirements for Mobile Image Intensifier**

Wonthaggi Hospital requested approval to use a mobile image intensifier at less than the standard focus to skin distance of 300 mm in operating theatre procedures. This was sought due to the difficulty in manoeuvring the unit around the operating table for some projections with the normal cone. Approval was recommended, subject to requirements previously approved at other locations, ie that the short cone only be used in operating theatre procedures; that the minimum distance of 200 mm only be used by trained staff informed of the potentially higher dose rates associated with the equipment in that configuration; and that the equipment be fitted

with a warning label on the control panel advising to maximise the patient to skin distance.

### **1.26 Other Matters Considered**

The Committee received a request for advice from the chairman of an ethics committee who was drafting a protocol for research involving radiation exposure of human volunteers at his institution. The Committee reviewed a draft of the protocol and provided suggestions to ensure that the protocol was consistent with Departmental requirements and international recommendations.

The Committee supported a proposal that the RSU establish a topic group for University and hospital radiation protection officers to meet several times per year to discuss radiation protection issues of concern or mutual interest.

The Committee also recommended approval of licences for two researchers to operate bone mineral densitometers at Geelong Hospital as part of medical research projects. The applicants would be trained and supervised by the radiographer responsible for the densitometer.

The Committee received copies of the recommendations of the Senate Select Committee on the Dangers of Radioactive Waste. The Committee felt that a number of aspects of the report were disappointing, but that the recommendation that some waste may be suitable for disposal at a uranium mine may be worthwhile.

Professor Tress attended the inaugural meeting of the EME Public Health Issues Committee of the Dept of Communications and the Arts. The Committee relates to electromagnetic radiation issues.

The Committee recommended that a licence be granted to Ms Joan Crane (physicist) at Prince Henry's Institute of Medical Research to operate a bone mineral densitometer. She had previously been issued a licence to operate the equipment for research projects. The licence would still be restricted to the one machine and same procedures, but would allow clinical work as well as research projects.

The Committee advised Epworth Biomedical Engineering that there was no requirement for a sign on the door of rooms for patients who have undergone lung function tests. This was due to the low dose rate around the patient and the relatively low doses used.

The Committee recommended approval of a licence for a research assistant involved in bone mineral density research studies, subject to confirmation of completion of the training described in her application.

The Committee considered a request for advice regarding a proposal to establish a CT scanner in a veterinary clinic. The proposal was that the scanner would be serviced by a radiologist, operated by a radiographer, and the veterinary surgeon would provide veterinary anaesthesia. The Committee advised that such a system would not contravene any requirements and gave in principle agreement. Approval was subject to a detailed proposal and application for registration being received.

## 2. SUB-COMMITTEE ON RADIOLOGICAL CONTROL IN GENERAL PRACTICE

### 2.1 Introduction

During 1995 the Committee met with representatives of the RACGP and AMA to discuss their concerns regarding some licensing issues and their request for representation on the Committee. As a result of this meeting the Committee decided to recommend establishment of a sub-committee to examine some specific issues in general practice radiography.

### 2.2 Terms of Reference

The sub-committee was established with the following terms of reference and sunset date:

To provide advice on matters relating to the provision of radiological services in existing general medical practices using radiographers and those with extended licence or registration conditions that are not in remote areas, the issuing of licences to persons at these practices, and the conditions applied to registrations of X-ray equipment at these practices.

To report to the Radiation Advisory Committee on the above matters.

The sub-committee will complete its work by July 1996.

### 2.3 Membership

Members of the sub-committee were nominated by the RACGP, AMA, RACR and along with representatives of the Committee and the Department. The members were:

(Chair) Prof Brian Tress	RAC,
Dr Duncan Mansie	RACGP,
Dr Mervyn Cass	RACGP,
Dr Francis Gallichio	AMA,
Dr Graham Rouch	DHS,
Mr Greg Power	AIR,
Dr John Stuckey	RACR.

Dr Jack Lipp deputised for Dr Cass at both meetings.

Dr Michael Martin deputised for Dr Stuckey at both meetings. Mr Ken Bennetts replaced Mr Greg Power on the sub-committee. Dr William McCubbery deputised for Dr Gallichio at one meeting.

Dr J North and Dr B Hassett of RACGP also attended one meeting.

### 2.4 Issues Discussed by Sub-Committee

The sub-committee commenced by discussing the terms of reference and sunset clause which were challenged by the general practitioner representatives present. They felt that there were issues outside the current terms of reference which justified an ongoing sub-committee.

Figures were presented detailing the numbers of general practitioners with extended licences and extended conditions of registration, those using radiographers, and 24 hour medical centres using radiographers. A comparison with licensing of general practitioners in other States was also presented.

The sub-committee then discussed a broad range of issues related to general practice radiography including training, rural/geographical issues, quality of service, Commonwealth requirements, accessibility of radiology services outside normal hours, and capacity of general practitioners to interpret films taken by a radiographer and the relevance of this to radiation protection.

### 2.5 Reports by Sub-Committee Members

Sub-committee members put forward the positions of their organisations to be taken into account in consideration of the issues.

These included:

AMA: That all skeletal radiography, chest and abdomen radiography should be permitted.

RACGP: That the sub-committee not interfere with existing licences. That ongoing training and quality assurance were needed. That RACGP and RACR needed to work together on training issues. That training for rural general practitioners was an important issue.

RACR: That current licences be maintained, and that they not be transferred. That new licences be for extremities only and that no new extended licences be granted.

AIR: That existing “grandfather” licences continue, but that their numbers not be allowed to expand.

## **2.6 Committee Response to Sub-Committee Report**

After consideration of the issues and positions raised by the sub-committee the Committee made the following decisions:

- i) That no further ‘extended’ operator licences be issued to metropolitan general practitioners. Existing ‘grandfathered’ general practitioners are permitted to continue taking those X-rays for which the Health Insurance Commission has previously authorised payment.
- ii) That a working party be established between RAC and RACGP to discuss outstanding issues with particular emphasis on improving communication between the two groups.
- iii) That educational courses be established for country general practitioners (eg a 3 day basic course and 2 additional days for ‘extended’ operator licence).
- iv) That country general practitioners, remote area radiologists and an academic from a teaching institution be selected to participate on the working party.

Prof Tress, Dr Rouch and Mr Melbourne of the Radiation Safety Unit also met with AMA representatives at their request to further discuss the deliberations of the sub-committee.

### 3. NON-IONIZING RADIATION

#### 3.1 Papers Considered in the Past 12 Months Related to Biological Effects from Exposure to Power Frequency Electromagnetic Fields and Radiofrequency Radiation

The attention of the Committee was directed to the question of possible health effects associated with exposure to power frequency electromagnetic fields.

The Meta-Analysis Project Advisory Group in its report submitted to the Minister for Health in December 1988 recommended that the Minister for Health commission and publish each year for at least the next five years a report summarising studies in the literature within the previous year on the effects on human health of exposure to non-ionizing radiation at or near the powerline frequency.

In addition, the report of the Panel on Electromagnetic Fields and Health, commissioned by the Minister for Health, was released by the Minister in September 1992. One recommendation in the Minister's response to the report was that the newly appointed Radiation Advisory Committee continue to monitor, and produce regular updates, on the medical and scientific literature on possible health effects from power frequency electromagnetic fields.

A list of papers considered by the Committee in the past 12 months is presented in Appendix VI.

##### *Cell Studies*

The Committee considered a number of reports supporting hypothesised mechanisms of interaction between powerline fields and cellular processes. Whilst none of these mechanisms is new, it is of note that serious attempts are being made to either replicate earlier findings or to identify unambiguous effects. The hypothesis of weak fields being able to lengthen or at least alter free radical lifetimes has been commented on in previous annual reports. The work of Scaiano et al. shows that fields of 1000 times greater than power-line fields produce effects that are only just discernible, and that the effects of static fields (such as the

Earth's field) are identical to those of 50/60 Hz fields. Related to this, the hormone melatonin, levels of which are reportedly reduced by powerline field exposure, has been shown by Reiter et al. to be a powerful free radical scavenger, producing a 99% reduction in safrrole-induced DNA damage. Reduction in circulating melatonin due to magnetic field exposure might therefore increase risk of such damage, quite apart from a direct effect magnetic fields may have on free radical lifetimes. On the other hand, Bakos et al. found no evidence of changed urinary melatonin metabolite levels in rats exposed to between 50 and 5000 mG magnetic fields.

A number of workers have continued to investigate hypothesised resonance phenomena. Trillo et al., studying the incidence of neurite outgrowth in cells treated with Nerve Growth Factor together with a combined static and 45 Hz field, have shown results consistent with the group's theoretical model, termed ion paramagnetic resonance, but with several features unexplained. The applicability of these findings, even given independent replication, to the question of adverse health outcomes, is still unclear.

##### *Animal Studies*

The committee has continued to be kept informed of studies, like that of Bakos et al. referred to already, in which indicators of the general health of animals exposed to power-frequency fields over extended periods has been studied.

The report of Prato et al. is concerned with the effects of the angle between a static field of 780 mG (approximately Earth's field) and a 60 Hz field of 8,000 mG on aspects of snail behaviour. This animal model has been used by this group for a number of years to test whether the endogenous opiate system may be affected.

Margonato et al. examined the effects of continuous exposure of rats to 50 mG 50 Hz fields for several weeks and found no significant changes in growth rate, morphology and histology of internal organs or in bone marrow, lymph nodes or blood. Levels of the neurotransmitters dopamine and serotonin were likewise unaffected.

In another study (Kowalczyk et al.), male rats were exposed to 100 mG 50 Hz fields. There were no significant changes in the number of pregnant females, nor of other indicators of fertility or genetic mutation.

### **Epidemiology**

Epidemiologic research reviewed during the past year has added little new substance to previous knowledge of health effects of exposure to power frequency electric and magnetic fields.

Cancer, particularly childhood leukaemia, brain tumours, and breast cancer, has once again been the main focus of research

Miller et al. studied personnel from a Canadian electrical utility, Ontario Hydro. This was one of the three utilities which participated in the Canadian/French Study by Theriault et al. (Cancer causes and control 1993; 4: 465-476). An odds ratio (OR) of 4.5 (95% CI 1.01-19.7) was obtained for cumulative exposure to electric fields of greater than 345 V/m.years for all leukaemia. An OR of 2.1 (0.6-7.2) was obtained for exposures between 172 and 344 V/m.years. ORs for exposure to magnetic fields were only slightly elevated. Combination of high cumulative magnetic and electric field exposure levels gave high (and significant) ORs. The ORs for brain tumour were raised (but non significant) for magnetic fields but not electric fields.

Preston Martin et al. investigated childhood brain tumour cases in relation to magnetic field measurements and wiring configurations. Risk did not correlate with measured fields either inside or outside the home. An OR of 2.3 (1.2-4.3) was obtained for underground wiring configurations (the lowest of the Wertheimer-Leeper categories). This was attributed by the authors to an artefact of data collection. The prevalence of high fields (>2mG) is very low in the Los Angeles area, however, so the power of the study is poor.

Gurney et al. studied the magnetic field exposure of cancer cases *in utero*. The exposure surrogates were a 5 level or 2 level wiring code, and ever/never use of electric blankets or heated water beds. ORs were distributed around 1.0, with no dose-response trend. ORs for individual appliances

ranged from 0.7 for bedside dial clocks, hair driers and colour TVs to 1.8 for bedside digital clocks. The authors concluded that *these data do not support the hypothesis that exposure to magnetic fields... is associated with the subsequent occurrence of brain tumours in children.*

Coogan et al. carried out a study on occupational exposure to 60 Hz magnetic fields and risk of breast cancer in women. Exposure categories were classified as background, low, medium and high, based on job classification, but no magnetic field measurements were made. The OR for the high exposure group was 1.43 (0.99 - 2.09), ie. not significant. In this category, the risk among pre-menopausal women was higher, and did reach significance.

Other health outcomes have also been investigated. For example, Bracken et al. found no evidence of changes in birthweight or intrauterine growth retardation due to exposure to magnetic fields. Savitz and Ananth also found no evidence for adverse pregnancy outcome in relation to elevated residential magnetic field or wire code, and Robert et al. found no evidence for congenital anomalies associated with proximity to high voltage powerlines. Beale and Pearce found a relation between time integrated magnetic field exposure and (i) speeded coding task; and (ii) self rating of general health and illness and anxiety symptoms.

All the epidemiologic studies still suffer from the ongoing problems of possible confounding and bias, control selection, and the fact that the exposure assessment, whilst improved, is still imperfect. It is important that these problems are thoroughly addressed, particularly exposure assessment, before epidemiologic research in this area will be able to produce more meaningful results.

In relation to possible confounding, Pearson and Wachtel examined Savitz's 1988 Denver data found that residential and lifestyle factors were associated with wire codes; and Merchant showed that there was a correlation between residential magnetic fields and road type and traffic in the UK.

In summary, one of the continuing problems with regard to epidemiologic research in this area is that, because of the generally low odds ratios obtained

(of the order of 2), it is quite possible that the effects being seen are due to the problems mentioned above. Thus it is still not possible to reach the conclusion that exposure to power frequency electric and magnetic fields plays a role in contributing to chronic health effects such as cancer.

### ***Dosimetry***

International research is continuing to attempt to quantify trends of domestic and occupational exposure to power frequency magnetic fields. This information can be used in epidemiological studies of possible health effects associated with the magnetic fields.

Cheng et al. computed the distribution of induced currents in the human head due to the use of electrical appliances such as hair dryers and electric shavers. A magnetic dipole was used to model the appliances.

For the minimum appliance distance considered, the maximum current density reached a maximum of  $2.5 \mu\text{A}/\text{cm}^2$  about 3.5 cm inside the head. The average current density reached a maximum of about  $0.75 \mu\text{A}/\text{cm}^2$  about 2.5 cm inside the head. These figures may be compared to natural currents in the brain that are of the order of  $0.1 \mu\text{A}/\text{cm}^2$ .

Tofani et al. calculated the electric field and current density distributions induced in the human head by the use of a hair dryer. A helical coil was used to model the hair dryer.

Calculations were carried out assuming the hot air outlet was in contact with the surface of the head. The maximum current density was  $25.8 \mu\text{A}/\text{cm}^2$  and the maximum average current density was  $4.5 \mu\text{A}/\text{cm}^2$ .

These induced current densities are much greater than those induced due to exposure to magnetic fields from high tension power lines.

### ***Reviews and Editorials***

Overall these suggest that evidence regarding possible health effects from exposure to power frequency electromagnetic fields is “weak and inconsistent” and that “there remains uncertainty about basic facts”.

### ***Other Papers on Power Frequency Electromagnetic Fields***

Henshaw et al. point out that electric fields produced by electrical wires and appliances in the home, for example, increase the rate at which radon daughters are deposited on surfaces in the vicinity of the wires, etc (note: this deposition is called *plateout*).

The authors speculate that electric fields may increase the radiation dose from radon daughters due to electrical effects inside the lungs; and that their observations may have implications for the apparent enigma that there is no persuasive biological evidence to show that power frequency fields can influence any of the accepted stages in carcinogenesis.

The National Radiological Protection Board of the UK, in one of its press statements, pointed out that if, as a consequence, there are fewer radon daughters remaining in the air to be breathed in by the occupants, exposure to radon daughters will be lowered.

Further, an increased risk of lung cancer has not been shown to be associated with exposure to electric or magnetic fields. On the other hand, it has not been established that exposure to radon and radon daughters causes any other cancer than lung cancer. In addition, when epidemiological studies have found associations, these have generally been between various cancers and surrogates for magnetic field exposure, not electric field exposure.

### ***Radiofrequency Radiation***

The Committee has been supplied with numerous press and media articles reflecting community concerns in relation to mobile communications towers and has reviewed a number of scientific studies carried out at comparable frequencies.

The study of Lai & Singh presented evidence for increased incidence of single-strand DNA breakage in rat brain cells exposed to 2450 MHz radiation at around 1 W/kg tissue. Both pulsed and continuous wave radiation seemed to be effective, but given the weight of evidence that this form of radiation is not mutagenic, this study should be independently

replicated before its significance in relation to health risk assessment can be assessed.

Reports of two earlier studies were also considered by the Committee: that of Balcer-Kubiczek & Harrison indicated that 2450 MHz radiation (modulated at 120 Hz) in combination with a cancer promoter added to the effect of the latter in a similar manner to X-ray exposure, but that radiofrequency radiation alone had no effect. Cleary et al. estimated cell proliferation by the rate of uptake of components of DNA. Uptake rates were significantly increased at moderate power densities and reduced at higher ones. The moderate power densities were at least ten times those associated with mobile communications systems, however.

Buffler has reviewed the available epidemiology data and concludes that there is no evidence of a link between radiofrequency radiation and adverse health outcomes in the short term.

The Committee noted a preliminary report by Dr Bruce Hocking, former Chief Medical Officer at Telstra, quoted in *Microwave News*, Vol. 15(6), which maintains that children living within 4 kilometres of Sydney's main TV broadcast towers had twice the rate of leukaemia than children living outside the 4 kilometres radius. Considering the low levels of radiofrequency (RF) radiation in areas occupied by persons within 4 kilometres of the towers, and the lack of any substantive evidence for a link between exposure to RF radiation and an increased risk of leukaemia, it is likely that this is either a chance finding, due to a bias in the study, or due to some other factor. Dr Hocking has, in fact, stated that his findings are preliminary and that no firm conclusions should be drawn from them.

### **3.2 The Committee's View on the Health Effects of Electromagnetic Fields**

The additional evidence concerning health effects of electromagnetic fields reviewed by the Committee during the past year has not been sufficiently compelling to alter the Committee's position concerning this issue. This is that, overall, there is insufficient evidence to come to a firm conclusion regarding possible health effects from

exposure to power frequency electric and magnetic fields.

### **3.3 The Committee's View on the Health Effects of Radiofrequency Radiation**

The Committee considers that there is no substantive evidence to suggest that exposure to radiofrequency radiation can increase the risk of chronic health effects such as cancer. It has, however, noted the extent of public concern over the issue, particularly in view of the current controversy regarding mobile phones and base transmitters, and will continue to review the relevant research literature.

### **3.4 Enquiry from Western Australia Regarding Control of Lasers**

The Committee was advised that the Radiation Health Section (RHS) of the Health Department of Western Australia wrote to the Radiation Safety Unit (RSU) of the Department of Human Services seeking information in relation to the control of lasers in Victoria.

The Committee asked the RSU to write a letter in response to RHS's queries, a copy of which was brought to the Committee's attention. The RHS was advised that lasers were controlled in Victoria under the the Occupational Health and Safety (Plant) Regulations 1995 and the Equipment (Public Safety) Regulations 1995, administered by the Victorian Workcover Authority.

### **3.5 Third International Non-Ionizing Radiation Workshop**

The Committee was advised that a scientific officer from the RSU attended the Third International Non-Ionizing Radiation Workshop held in Baden, Austria, April 22-26, 1996.

The workshop covered sources of non-ionizing radiations, including ultraviolet, infrared, lasers, radiofrequency radiation, static and extremely low frequency electric and magnetic fields, and ultrasound; summarised their biological effects and dosimetry; and covered various international standards.

Concerning radiofrequency radiation (including microwave radiation) and power frequency electric and magnetic fields, the Workshop maintained the view that there is no conclusive evidence for chronic health effects, e.g. cancer, from exposure to them, and that exposure limits can only be derived from biological effects that have been conclusively and consistently demonstrated.

### **3.6 Survey of Magnetic Fields in Offices**

The Committee was advised that the RSU was carrying out a survey of power frequency magnetic fields in Victorian offices, due for completion in November 1996. Measurements of the magnetic field are made in selected offices at positions occupied by persons and at positions in their vicinity. The survey will add to information on magnetic field levels in typical office environments.

## 4. RADIATION INCIDENTS

### 4.1 PMCI Leaking Tc-99m Generator

Peter MacCallum Cancer Institute reported a spill of radioactive material that occurred on unpacking a new technetium generator. On removing the generator from its delivery packaging the nuclear medicine technologists had observed a small amount of liquid in the plastic wrapping and on the generator. The technologists recognised this as a radioactive spill and took action to contain the spill, remove any contamination and store all contaminated items.

Australian Radioisotopes, the supplier of the generator, investigated the leakage and discovered two probable causes, both identified with the generator leads to the bottom capping /spigot of the alumina column held within the generator's shielded container. The leads may have been damaged during manufacture, or during transport to the supplier.

The supplier reviewed the manufacturer's method of assembly and quality control procedures. The manufacturer has implemented new assembly methods and quality control procedures, and the supplier has implemented modified quality assurance testing of the leads. The supplier is also investigating the use of new leads.

### 4.2 RMH - Error in Administration of Radiopharmaceuticals

Royal Melbourne Hospital reported that an incorrect radiopharmaceutical had been administered in a nuclear medicine procedure. The consulting nuclear medicine physician determined that sufficient diagnostic information was obtained and it was not necessary to repeat the procedure using the correct radiopharmaceutical. Estimated effective dose to the patient is less than would have been received using the correct radiopharmaceutical.

Radiopharmaceuticals were stored in colour coded lead elution pots. Different radiopharmaceuticals were sometimes stored in lead pots of the same colour. The radiopharmaceutical administered was stored in a pot of the same colour as another radiopharmaceutical, with no labelling on the pot

to identify the radiopharmaceutical stored within. The technologist administering the dose correctly identified the colour of pot but did not withdraw the dose vial to examine the labelling on the vial.

The Committee examined Royal Melbourne Hospital's initial report of the incident and noted that the existing calibration and reconstitution protocol did not adequately address the checking of vial contents. Royal Melbourne Hospital revised their calibration and reconstitution protocol, extended the colour coding system and is considering purchase of newer model lead elution pots.

### 4.3 Depleted Uranium in Scrap Metal from Aircraft

The Committee was informed that the RSU had been notified that a truck passing through the front gate of Smorgon Steel had activated the radiation monitors on the gate. RSU was advised that the load was from an aircraft being dismantled at Avalon Airport. Following an inspection of the load it was ascertained that the radiation monitors had detected depleted uranium. The material was returned to Avalon Airport for examination.

Inspection and monitoring of the dismantled aircraft showed that 27 depleted uranium blocks were used as ballast and as counter weights. All the blocks were accounted for and put aside, and were collected by ASTAAS Pty Ltd for storage and disposal.

During discussions with ASTAAS Pty Ltd they advised that the standard procedure was to determine and remove any hazardous materials before dismantling was commenced. However, depleted uranium had been overlooked as a possible hazardous material to be removed.

To avoid recurrence ASTAAS Pty Ltd advised that in any future dismantling of aircraft it will be ascertained specifically from the aircraft owner whether radioactive material is present in the aircraft.

#### 4.4 Radioactivity Detected in Scrap Metal

It was reported to the Committee that the RSU had responded to a report on 22/03/96 that a load of scrap metal entering Smorgon Steel, Altona had triggered the radiation monitoring equipment at the entrance to their premises. RSU attended the site and the load of scrap was returned to the originating company, Norstar Steel Recyclers, Altona for monitoring.

The radioactive item was an old aircraft engine that had been sold as scrap metal. Using a contamination monitor it was determined that a cast alloy "ring" around one end of the engine was the only part that was radioactive. The offending part was broken away from the engine and all pieces were collected for analysis.

Part of the metal was analysed and it was confirmed that the alloy contained radioactive thorium. The material was most likely a magnesium/thorium/aluminium alloy containing about 2% thorium. The total amount of radioactivity involved was quite small, approximately 1.5 MBq.

The source of the aircraft engine was investigated through Norstar to attempt to determine whether other similar engines were likely to be found in future. However, as they collect scrap metal from several hundred sites, no conclusion could be drawn as to the possible source of the engine.

#### 4.5 Damage to Sr-90 Applicator

An incident occurred in which the active plate of a strontium 90 applicator became detached from the backing plate and mounting 'boss'. It was initially thought that the strontium 90 from the applicator had been lost. The incident occurred following an ophthalmic treatment when a radiation therapist was rinsing a strontium 90 applicator over a sink. The active source plate became detached from the backing plate and mounting 'boss'. When this occurred, it was thought that the radioactive strontium 90 had washed down the drain in the sink. The various parts of the applicator in the sink were collected. The s-bend under the sink was removed to try to locate the source, however nothing was found. A plumber was then called to

isolate the building from the main sewerage pipes. Again, nothing was found.

At this time, the radiation therapist called the RSU to report the incident and request assistance. The radiation therapist had assumed that the strontium 90 in the applicator was sandwiched between two brass discs and had fallen into the sink. RSU advised that it was possible that the source plate may, in fact, have been one of the 'brass discs'. An 'autoradiograph' of the parts of the applicator was taken by the radiation therapist. This showed that the source plate was still present. All parts of the applicator were then placed in the storage container for transport to a licensed consultant. He advised that a source plate could become detached due to the adhesive used to attach the source plate to the backing plate degenerating over time. This occurs because of the radiation exposure and the action of the cleaning/sterilising liquids used.

During the time between the apparent 'loss' of the source plate until it was correctly identified, the radiation therapist had handled the bare source plate (assuming it to be inactive) for between 30 and 90 seconds. The Ophthalmologist had also handled the plate for approximately 20 seconds.

RSU advised the therapist and Ophthalmologist to have medical examinations undertaken by a Radiation Oncologist to check for any radiation damage to their hands. No radiation effects were reported.

RSU required the damaged applicator to be presented for inspection. The applicator was subsequently repaired and leak tested by a licensed consultant. There was no leakage of strontium 90 from the applicator. All persons involved in the incident were required to submit detailed written reports on the incident. Subsequently all strontium 90 users were advised of the incident and that they should be aware of the construction of their applicators.

#### 4.6 Loss of Co-60 Veterinary Radiotherapy Source

In March 1996, the RSU was advised of the loss of a cobalt-60 pad from the University of Melbourne Werribee Veterinary Clinic (UMWVC). The pads

are owned by radiation consultant Mr Ray de Groot and are used at UMWVC. The cobalt-60 pad was used for treating lameness in horses. Following an investigation by the RSU, it appeared that the pad had been inadvertently disposed of with bandages following a treatment. As such, the pad was most likely to have been disposed of at Corio Tip. There was a lower probability of it having been disposed of at the Werribee Tip.

The operators of both tips were notified of the possibility that the pad was at their tip however, with the large tonnage of garbage disposed of at each tip per day, the likelihood of recovery was extremely low.

A calculation of the source's activity and half-life showed that in seventy years, the activity of the source would be below the current licence/registration exemption limit for cobalt-60. The projected lifetime for both tips is at least fifteen years. After this time, the anticipated use of the land for the foreseeable future is parklands and grazing land. By that time, the source would be located approximately 4-5 metres below the surface and would not result in a radiation exposure to any person.

In consultation with Mr de Groot, the UMWVC has changed their procedures to ensure that the cobalt-60 pads are easily visible among bandages and that the pads are monitored before being put back into the storage safe.

#### **4.7 Industrial Radiography (Intico at Mobil)**

The Committee was advised that the RSU had received a report from a Mobil employee on 1 April 1996 indicating that there had been an incident on that day involving an "out of control" Iridium-192 industrial radiography source. The company involved was Intico however there was no advice received from them at the time.

Intico was contacted on 2 April 1996 to ascertain the nature of the incident. It was indicated that the 370 GBq (10 Ci) Iridium-192 source being used at the site could not be returned to the shielded container due to a mechanical fault. Several further attempts had been made to retract the

source using the normal method however this was not successful.

The Intico Radiation Safety Officer went to the site and recovered the source into an emergency container. The TLD monitors worn were sent for immediate processing and the doses reported were 1070 TSv and 370 TSv for the two operators and zero for the Radiation Safety Officer.

#### **4.8 Decommissioning of Phosphoric Acid Plant - ICI Yarraville**

The Committee received a report on the proposed decommissioning of the former ICI phosphoric acid plant at Yarraville. The plant had been sold to Albright & Wilson some 15 years ago and had not operated for about 3 years. During evaluation of clean up of the site a radiological survey had been undertaken by Tracerco. This survey had detected above background levels of contamination in parts of the plant. This contamination resulted from natural radioactivity in the phosphate rock used in the acid production and was primarily in the rubber of rubber-lined steel vessels and rubber connecting pipes throughout the plant.

The RSU had inspected the site and a radiation management plan for the decommissioning process was drawn up by Tracerco. The work plan was considered to be satisfactory. It included measures to be taken during dismantling and transport to ensure radiation safety. A review of disposal limits for such material was undertaken. The Committee recommended that disposal of waste from the site should meet the NHMRC Code of Practice for the Disposal of Radioactive Waste by the User (1985). This code sets a quite restrictive level of 0.25 Bq/g for each radionuclide. As the analysis by Tracerco had identified up to 13 radionuclides from the uranium/thorium series, it was agreed that a level of 3 Bq/g should be the limit for the waste material. The EPA were advised of the proposal and the waste was planned by ICI to go to a hazardous waste site rather than a municipal tip.

Uncontaminated parts of the plant were disposed of as scrap metal. Two small pieces of contaminated rubber-lined steel were inadvertently included in the clean scrap, but were detected by monitoring at the scrap metal plant and were

returned to be included with the contaminated material for disposal.

#### **4.9 St Vincent's Hospital - Error in Administration of Radiopharmaceutical**

St Vincent's Public Hospital reported an incorrect radiopharmaceutical had been administered in a nuclear medicine procedure. Estimated effective dose to the patient is approximately half the amount received from natural background radiation in one year.

Radiopharmaceuticals were stored in colour coded lead pots. The radiopharmaceutical administered was stored in a pot that was labelled correctly, but was the same colour of pot used to store the radiopharmaceutical required for the procedure. The technologist administering the dose correctly identified the colour of pot but failed to note the label details. Each pharmaceutical now has its own uniquely identifiable colour.

The Committee examined St Vincent's report of the incident and the strategy proposed to prevent similar incidents in future, and agreed that no further action was required.

#### **4.10 High dose to TLD monitor - Steritech**

The RSU received notification that the personal monitor (TLD) of a worker at Steritech had received a dose of 300 mSv during its two-month wearing period. As this dose represents fifteen times the average annual dose limit for an occupationally exposed person, an immediate investigation of the notified dose was carried out by the RSU.

Upon investigation, it appeared that the wearer had dropped the TLD inside the irradiation cell during a maintenance check. This occurred at the end of his shift (day shift) and he did not realise the TLD was missing. The afternoon shift operator subsequently found the TLD and replaced it on the rack with the other TLDs but did not report the fact that he had found it inside the maze.

Consequently the day shift operator found the TLD in its usual location at the start of the shift and no loss was suspected.

Due to the size of the dose received by the TLD, the RSU required the operator to undergo precautionary blood tests for lymphocyte count and chromosome aberration. Both tests were normal.

Since this incident, Steritech has introduced a "sign in" book for TLDs to ensure that all TLDs are accounted for at all times. Furthermore, it has been emphasised to all staff by both the RSU and Steritech that any TLD found inside the cell must be assumed to have been exposed. The TLD must be reported lost immediately so that it can then be urgently assessed and a new TLD issued to the wearer.

At a subsequent meeting the RSU reported that it had taken part in a training session arranged by Steritech to ensure that staff were aware of radiation safety requirements and the role of the Department.

#### **4.11 High Dose to TLD Monitor - Industrial Radiographer**

It was reported that Mr M A Greig, Australian NDT Services P/L had received a dose of 10610  $\mu$ Sv to his TLD in a one month period. The report from the company indicated that Mr Greig had inadvertently left his jacket (with the TLD in the pocket) near an iridium 192 source for 3-4 hours, but had not reported this to his supervisor. The RSU has written to both Mr Greig and the company to remind them of their obligations and the need for reporting of such circumstances. The company was requested to provide a copy of its work procedures.

## **5. PROSECUTIONS**

### **5.1. Olympic Park Sports Medicine Centre**

In April 1995 it came to the attention of the Radiation Safety Unit that there was an unregistered X-ray unit located at Olympic Park Sports Medicine Centre (OPSMC). Further investigations showed that it was being operated by several doctors one of whom (Dr P Brukner) was not appropriately licensed. Several letters addressing the situation were sent to both OPSMC and Dr Brukner however no response was received.

As a result OPSMC and Dr Brukner were successfully prosecuted. Dr Brukner pleaded guilty to a charge of using an ionizing radiation apparatus while not holding an appropriate licence. He was placed on a twelve month bond (without conviction) and ordered to pay \$1000 in costs. OPSMC pleaded guilty to a charge of using an ionizing radiation apparatus while it was not appropriately registered. They were also placed on a twelve month bond (without conviction) and ordered to pay \$1200 costs.

### **5.2 Dr S Cheung, Dentist**

The RSU investigated a dentist (Dr S Cheung) following his failure to pay the renewal fee for his licence to operate irradiating apparatus. On a subsequent visit to his premises an unregistered X-ray unit was discovered. Several letters regarding the situation were sent to Dr Cheung with no response being received.

As a result Dr Cheung was successfully prosecuted. He pleaded guilty to charges of using an ionizing radiation apparatus while it was not appropriately registered and using an ionizing radiation apparatus while not holding an appropriate licence. He was convicted on both charges and fined a total of \$200. He was also ordered to pay statutory costs of \$46 and legal costs of \$2000.

## APPENDIX I

### Guidelines for the Therapeutic Administration of Strontium-89

*These guidelines have been prepared by the Radiation Safety Unit and Radiation Advisory Committee following wide consultation with interested persons and organisations. The guidelines are to be used in conjunction with the licensing requirements of the regulations to ensure that therapeutic use of strontium-89 is only carried out by appropriately trained persons taking account of relevant radiation protection issues*

#### Introduction

The treatment of painful bony metastases with bone-seeking radiopharmaceuticals has emerged as an effective new therapy for selected patients in clinical practice. The recent approval by the Therapeutic Goods Administration (TGA) of [<sup>89</sup>Sr] chloride (strontium-89) led to the need for guidelines for therapeutic administration to be established, particularly in view of the radiation safety issues and potential toxicity of this treatment.

Strontium-89 is a  $\beta$  emitting radioisotope that is a physiologic calcium analogue, with similar whole body biodistribution. It has preferential uptake and retention by osteoblastic bone metastases compared to normal bone, with whole body retention dependant on the extent of osteoblastic tumour burden (ranging from 11-88% administered dose). The mechanism of action is believed to be through the direct action of beta particles on the metastasis itself or on adjacent bone. Dose-dependent marrow toxicity is observed, and is the limiting and only major reported side effect of strontium-89 therapy.

#### Referring Physician/Specialist

The physician/specialist referring a patient for treatment with strontium-89 must have appropriate qualifications, training and experience in managing patients with prostate cancer. It is extremely important that the strontium-89 be given in the context of overall patient management which takes into account

the current clinical picture, previous radiotherapy and alternate treatment options appropriate at that time. A multidisciplinary and consultative approach must be adopted, and the patient must be properly assessed and followed up after the strontium-89 has been given.

The referring physician/specialist must have specialist qualifications in Radiation Oncology, Medical Oncology, or Urology.

Prior assessment by a radiation oncologist should be undertaken before strontium-89 therapy.

#### Administering Physician/Specialist

All physicians/specialists who administer strontium-89 for the therapy of painful bone metastases must have appropriate qualifications, training and experience in the use of unsealed sources for therapy. The required qualifications are:

- Criterion 1 NSQAC recognised specialist qualifications in Nuclear Medicine or Radiation Oncology; **and**
- Criterion 2 adequate prior training, practical experience and a current licence for the therapeutic use of unsealed sources. The specialist must also be actively practising the use of unsealed sources for therapy.

*Adequate prior training* is defined as approved postgraduate study (by formal coursework and/or within accredited training programs) within the areas of:

- radiation biology
- radiation dosimetry
- radiation safety
- clinical uses of radioisotopes
- administration of radioisotopes

The training in these areas must relate to the *therapeutic* uses of any unsealed sources.

*Adequate practical experience* is defined as demonstration of regular prior therapeutic treatment of patients with unsealed sources (eg I-131, P-32) over 2 or more years, and/or supervised patient evaluation and administration of strontium-89 for a minimum of three patients. An adequate understanding of the literature on the use of strontium-89 is also required.

In instances where further practical experience is required, the required supervision of strontium-89 administration should be undertaken by a physician/specialist qualified to use strontium-89 and with access to health physics advice.

Applications for licences to administer strontium-89 should be made to the Radiation Safety Unit with a copy forwarded to the Joint Specialist Advisory Committee (JSAC) in Nuclear Medicine of the Royal Australasian College of Physicians and Royal Australasian College of Radiologists (145 Macquarie Street, Sydney, NSW, 2000. Tel: (02) 256 5444 Fax: (02) 252 3310). JSAC will evaluate the qualifications and advise the Radiation Safety Unit of their assessment. If the applicant is a radiation oncologist, JSAC will seek the advice of a representative of the Faculty of Radiation Oncology of RACR.

For those physicians/specialists who satisfy criterion 1 but not criterion 2, appropriate additional training recommended by JSAC and approved by the RAC will be required.

## Patient Treatment

### Indications

- The indications for patient treatment should directly conform to the Therapeutic Goods Administration (TGA) approved product information for the use of strontium-89 in force at the time of patient treatment. The current TGA approved indications for strontium-89 therapy are: As an alternative to external beam therapy for the palliation of pain from bone metastases secondary to prostatic carcinoma at the stage of hormone therapy failure.
- A bone scan performed within 4 weeks of proposed administration must show multiple

intense but focal areas of increased bony uptake which are attributable to metastases causing the patient's pain.

### Contraindications

- Strontium-89 therapy performed within the last 3 months.
- Spinal cord compression. Urgent surgery or external beam radiotherapy or other appropriate therapy must be considered immediately.
- Platelet count less than 100,000/mm<sup>3</sup>.
- Total white cell count less than 3,000/mm<sup>3</sup>.
- Wide field radiotherapy within the previous 4 weeks, depending on blood count values.

### Relative Contraindications

- Since the clinical benefit of strontium-89 treatment is not apparent for 3-4 weeks, a patient should not be considered for strontium-89 therapy if their life expectancy is significantly less than 3 months.
- Urinary incontinence is a relative contraindication for administration of strontium-89. There will occasionally be instances where urinary incontinence can be overcome by urinary catheterisation, and provided that radiation safety issues can be satisfactorily addressed, there is no reason to exclude such a patient from possible treatment.
- The presence of urinary obstruction requiring catheterisation should be a relative contraindication to treatment only, and provided appropriate radiation safety precautions are observed for handling of urine, such treatment can be satisfactorily undertaken.
- The treatment of imminent pathologic fractures should take precedence over systemic therapy with strontium-89.
- The presence of a diffuse increased uptake on bone scan (super scan) should be a relative contraindication for treatment only. The implication of a diffuse increased uptake or

super scan is that there may be increased toxicity from the strontium-89 therapy to bone marrow. This is an extremely variable parameter as some patients who have such a bone scan appearance can receive strontium-89 therapy with minimal toxicity, and other factors which can affect marrow reserve, eg. prior cytotoxic chemotherapy and extensive radiotherapy may have more impact on marrow toxicity following strontium-89 therapy. The likelihood of marrow toxicity following strontium-89 therapy will need to be evaluated by the treating physician/specialist after careful review of the patient's history and available investigations.

- Renal failure is a relative contraindication, as the marrow toxicity from strontium-89 can be increased in this condition. Careful evaluation of renal function and the patient's history should be undertaken prior to treatment with strontium-89.
- Recent treatment with diphosphonates or other drugs which reduce bone turnover may reduce strontium-89 uptake. Confirmation of uptake in metastases on bone scan after such therapies is required prior to treatment with strontium-89.
- Strontium closely mimics the biodistribution and metabolism of calcium in-vivo, and therefore any calcium supplements routinely administered to the patient should be withdrawn at least 1 week prior to strontium-89 therapy.

### ***Precautions***

- It should be recognised that there may be some temporary increase in pain in the days following Strontium-89 therapy (due to "flare" phenomenon) and the benefits of the therapy may not be apparent for several weeks after treatment. Appropriate medications for pain relief should therefore be made available for control of pain symptoms during this time period.

### ***Patient preparation***

- Informed patient consent to the procedure and to the restrictions imposed by radiation safety requirements must be obtained.
- Details of treatment must be described to the patient, and details relevant to radiation protection obtained so that potential problems are solved before administration of strontium-89.
- An appropriate health physics adviser should be aware of all patients considered for treatment with strontium-89, and in appropriate circumstances, should be directly involved with the patient's treatment. Therapy with strontium-89 should not be undertaken in situations where access to health physics advice is not possible, or radiation protection guidelines cannot be adequately adhered to.

### ***Administration***

- The administering specialist is to be present to carry out the clinical direction (and possibly the physical direction) of therapy administration.
- The dispensed activity must be checked by two persons licensed to use unsealed sources.
- Secure intravenous access is mandatory, given the consequences of beta-emitter extravasation. An intravenous cannula, preferably of a flexible material, must be inserted and a free flowing intravenous infusion established before injection of the strontium-89 therapy.

### ***Facilities***

- The design of specialised therapy inpatient rooms, and the procedures involved in use of strontium-89 must comply with the Interim Australian Standard AS2243.4 (Int)-1994 Safety in Laboratories Part 4; Ionizing radiations.

The necessity for isolating a patient within a single room following strontium-89 therapy should, however, be decided on a case by case basis.

**Post treatment**

- The patient must be provided with an instruction card detailing the type and duration of any radiation protection restrictions they must follow.
- The instruction card should be carried on the patient until the date when restrictions cease. A sample instruction card appears in Appendix 1.
- Appropriate follow-up of patients should be undertaken, and clearly scheduled prior to administration of strontium-89. Regular monitoring of blood counts to detect possible

toxicity should be performed following treatment and monitoring of the patient's symptoms should also be documented on a regular basis.

The scheduling of blood tests should be left to the discretion of the administering physicians/specialist and referring specialist, but should be performed at least at 2-3 week intervals until marrow recovery is evident, or 8 weeks have elapsed since treatment.

The results of these tests should be clearly recorded in the patient's medical records.

Suggested check list when planning strontium-89 therapy.	
1	Patient surname.
2	Referring physician
3	Result of bone scan Date of scan
4	Result of full blood count and biochemistry screen Date of test
5	Relevant details of any previous radionuclide therapy or other bone marrow suppressive therapy, especially hemibody radiation therapy
6	Notification of Radiation Safety Officer
7	Proposed date of administration
8	Patient's primary language. (An interpreter may need to be present when treatment is given)
9	Details of where the patient will stay after therapy
10	After therapy, will the patient have any contact with children or pregnant women. If so, what are the details?
11	Details of any factors likely to cause radiation protection problems during therapy (eg, incontinence, poor mobility)
12	Arrangements for followup blood tests

- When administering strontium-89 to a patient remaining in hospital, careful attention should be paid to radiation safety issues, particularly in regard to urine handling and disposal (most unbound strontium will be excreted within 24-48 hours of administration in the presence of normal renal function). Provided that appropriate radiation safety precautions are observed, patients will not require a single room following treatment, although each patient should be reviewed on a case by case basis.
- When discharging a patient to another institution (eg. nursing home, hospital) details of patient therapy (eg residual activity, estimate of activity excreted in the urine) and necessary radiation protection procedures must be supplied.
- The response of the patient to strontium-89 therapy (pain control, mobility, quality of life, use of other medications) should be carefully evaluated and documented. This information will allow evaluation of the efficacy of strontium-89 therapy to be made, and guide further treatment (including possible repeat therapy with strontium-89).

### ***Precautions Following Death of a Patient***

Post mortem, cremation and burial aspects, should the patient die with significant strontium-89 body residue, must be considered. An assessment of the possible risks of handling such bodies has been made by the National Radiological Protection Board (NRPB) in the UK. Their conclusions can be stated as follows<sup>(1)</sup>:

- Calculations have shown that there is negligible hazard to crematorium operators or other members of the public as a consequence of cremating a body that contains up to 500 MBq of strontium-89, a level more than three times that used for therapy.
- Specifically, the maximum effective dose to a crematorium worker would be about 0.1  $\mu\text{Sv}$  from inhalation and about 0.2  $\mu\text{Sv}$  from ingestion. The maximum effective dose to an adult member of the public as a result of

cremating one corpse would be less than 0.1  $\mu\text{Sv}$ .

- If post-mortems or embalming are to be carried out on corpses containing more than 50 MBq then the advice of a Radiation protection adviser should be sought. As a general rule, with the possible exception of “superscan” patients, the retention data discussed in Appendix 2 would suggest that there should be no problems in handling the corpses of patients who die more than 1 month after the strontium-89 administration.
- The limitations for burial are much higher at 2000 MBq.

In all instances, information must be available on the estimated activity remaining in the patient’s body. This information should be provided to the pathologist and/or funeral director.

### **Written Procedures**

Each centre using strontium-89 must have written procedures for the administration of strontium-89. These procedures should include:

- Contact name/number for the Radiation Safety Officer (*or appropriate health physics adviser*) in the event of problems developing.
- Procedures for loss or spillage of strontium-89 (including excreta).
- Follow up procedures for the patient.
- Nursing care instructions appropriate to the patient’s circumstances.
- A copy of these guidelines.

**Appendix 1 (of Sr 89 guidelines)*****Sample Patient Information Card for Strontium-89 Administration***

Patient Name: \_\_\_\_\_

Patient Age: \_\_\_\_\_ Patient UR Number: \_\_\_\_\_

Patient Address: \_\_\_\_\_  
\_\_\_\_\_

Referring Specialist responsible for continuing management: \_\_\_\_\_ Ph: \_\_\_\_\_

Administering Nuclear Medicine Specialist: \_\_\_\_\_

Date of therapy administration: \_\_\_\_\_

Activity of Strontium-89 administered: \_\_\_\_\_

Specific advice to patient based on individual circumstances: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_***General Patient Instructions After Strontium-89 Therapy***

Strontium-89 is a radioisotope that is used for the treatment of bone pain in patients with metastatic prostate cancer. It is important that you are aware of the general precautions that you should undertake after receiving this treatment. Your administering specialist and health physics adviser will explain any specific precautions to you, and can answer any questions that you may have.

**Personal hygiene and laundering instruction for the first week after Strontium-89 therapy:**

- Where normal toilet is available it should be used in preference to a urinal. The sitting posture should be used in preference to the standing posture.
- Wipe up any spilled urine with a tissue and flush it away.
- Ensure that you always wash your hands after using the toilet.
- Immediately wash any linen or clothes which become stained with urine. Wash them separately from other clothes and rinse thoroughly.

Please keep this information card with you and bring it to the attention of your medical advisers should you require medical care such as operation or hospital admission within the next 3 months.

Specifically, please bring this notice to the attention of your medical adviser should you develop obstruction to urine flow or incontinence of urine so they may contact appropriate radiation safety support for advice on management of potentially radioactive urine.

Make sure to keep appointments for follow-up blood tests.

Date of first appointment: \_\_\_\_\_ Doctor: \_\_\_\_\_

Telephone number for follow-up advice during normal office hours: \_\_\_\_\_

(Person to ask for: \_\_\_\_\_ )

Telephone number for follow-up advice out of normal hours: \_\_\_\_\_

(Person to ask for: \_\_\_\_\_ )

Name of person responsible for radiation safety advice: \_\_\_\_\_

Telephone and Fax numbers for follow-up radiation safety advice: Ph: \_\_\_\_\_ Fax: \_\_\_\_\_

## Appendix 2 (of Sr 89 guidelines)

### Dosimetry and Whole Body Retention of Strontium-89

- Half-life = 50.5 days
- Decay = 100% beta
- Mean Energy of Betas = 583 keV

The methodology of the ICRP<sup>(2)</sup> may be used to estimate the doses to the particular organs in the body. Values of some organ doses for normal adults are listed in Table 1 below. The effective dose is estimated as 310 mSv/100 MBq. For patients suffering from bone disease the absorbed dose to metastases may be expected to be substantially higher and the absorbed dose to other organs very much less. For example, Blake et al.<sup>(3)</sup> have estimated the mean absorbed dose to vertebral metastases as 23 Gy/100 MBq administered.

**Table 1**  
**Organ Absorbed Doses Following Administration of Strontium-89 chloride**

Organ	mGy/100MBq
Bone surfaces	1700
Red Bone Marrow	1100
Lower Large Intestine	470
Bladder Wall	130

In developing guidelines for safe practice the following information on the uptake and clearance of strontium-89 may be helpful. Based

on the work of Blake et al.<sup>(4)</sup> who used strontium 85 to follow the retention of strontium, the patients can be subdivided into three categories, depending on the extent of their metastases.

- For patients with a relatively light degree of metastatic bone involvement (defined as fewer than six discrete lesions) the clearance is relatively fast with a relatively low percentage of the strontium retained after 10 days. Typically, at 100 days the retained activity is about 5% of the injected dose.
- Patients with extensive metastases in the pelvis and axial skeleton but few in the extremities have an elevated retention pattern with approximately 10% of the injected activity remaining after 100 days.
- Patients with almost complete skeletal involvement (superscan) have high retention with minimal excretion and the 100 day retention is dictated largely by the physical half-life of the isotope.

A more complete summary of these findings is included in Table 2 where the amount of activity remaining as a function of time is tabulated for each of these scenarios. In all cases the administered dose is assumed to be 150 MBq of strontium-89.

**Table 2**  
**Retention as a Function of Time Following Administration of 150 MBq Strontium-89 Chloride**

Extent of Bone Disease	Activity Remaining (MBq) @ Specified Time			
	Day 3	Day 10	Day 30	Day 100
Few Metastases	95	45	25	7.5
Widespread Metastases	120	85	50	17
Total Skeletal Involvement	135	120	85	32

## References

1. Cooper JR, Walmsley A & Charles D. *Individual and Collective Doses from the Release of Sr-89 into the Environment Following Medical Administration*. NRPB-M193 (1989).
2. International Commission on Radiological Protection *Radiation Dose to Patients from Radiopharmaceuticals*. ICRP Publication 53 (1987).
3. Blake GM, Zivanovic MA, Blaquiére RM, Fine DR, McEwan AJ & Ackery DM. *Strontium-89 Therapy: Measurement of Absorbed Dose to Skeletal Metastases*. J Nucl Med 29 (1988) 549-557.
4. Blake GM, Zivanovic MA, McEwan AJ & Ackery DM. *Sr-89 therapy: Strontium kinetics in disseminated carcinoma of the prostate*. Eur J Nucl Med 12 (1986) 447-454.

## APPENDIX II

### Doses From Fluoroscopic Procedures

*The purpose of this circular is to inform interventional radiologists, cardiologists and radiographers of the potential hazards associated with cardiology and other interventional procedures using fluoroscopy, and to suggest methods to reduce patient and operator exposure.*

#### Introduction

The Department of Human Services has recently become aware of an incident in New Zealand where a patient has received a serious x-ray induced skin injury. The patient developed a skin lesion a few weeks after a coronary angiogram followed by a complicated angioplasty and stenting procedure. In addition there have been reports of similar incidents occurring in the USA. These cases are summarised in table 1.

This circular is directed to specialists and radiographers carrying out fluoroscopy for the following procedures:

- Radiofrequency cardiac catheter ablation.
- Vascular embolisation.
- Transjugular interhepatic portosystemic shunt.
- Percutaneous endovascular reconstruction.
- Renal angioplasty.
- Any other procedures that professional and medical specialty organisations suggest may cause x-ray induced skin injuries.

The types of injuries to the skin and adjacent tissues which result from x-ray irradiation are summarised in table 2.

#### Methods to Reduce Patient and Operator Exposure

The dose to the skin of the patient is related to the dose rate during the fluoroscopic procedure, the dose per frame of any recording system used, and the number of frames recorded. The dose rate during fluoroscopy is affected by the following factors:

- The field size used. In general, using the largest field size available, and collimating down to the area of interest reduces patient dose.

- The use of pulsed fluoroscopy and low dose fluoroscopy mode reduces the dose rate to the patient.

The Australian Standard 2398 (Int) 1994 recommends a maximum dose rate of 50 mGy/minute for manual equipment, 100 mGy/minute for equipment with automatic brightness control, and 150 mGy/minute for equipment with a high level boost. In addition, this standard sets out maximum input dose rates to the Image Intensifier. The registered owner of the fluoroscopy equipment should ensure that the equipment complies with these requirements.

The dose per frame of the recording system can vary considerably, and is much higher for DSA systems than for cinefluorography systems. Operators should be aware of the dose per frame for each system used.

It should also be noted that the operator exposure is related to the patient exposure. The radiation dose received by the operator is due predominantly to radiation scattered from the patient. Therefore, the higher the dose to the patient, the higher the dose to the operator. Reducing patient exposure will also reduce the exposure of the operator.

#### Recommendations

The following recommendations are made to avoid serious x-ray induced skin injuries during fluoroscopically-guided procedures:

1. The licensee needs to establish standard operating procedures and clinical protocols for each specific type of procedure performed. The protocols should address all aspects of the procedure, such as patient selection, normal conduct of the procedure, actions in response to complications and consideration of limits on fluoroscopy exposure times.

2. The licensee and clinicians working under the licensee should know typical radiation dose rates for the specific fluoroscopic system for each mode of operation used during the clinical protocol. These dose rates must be derived from measurements performed at the facility.
3. The licensee must assess the impact of each procedure's protocol on the potential for radiation injury to the patient.
4. The licensee must modify the protocol, as appropriate, to limit the cumulative absorbed dose to any irradiated area of the skin. The dose should be the minimum necessary for the clinical tasks. Approaching cumulative doses that would induce unacceptable adverse effects must be avoided.
5. The licensee should enlist a qualified health physicist to help in the implementation of these principles in ways that do not adversely affect the clinical objectives of the procedure.
6. The licensee should give consideration to rotating the tube and the image intensifier through 180° during prolonged neuroradiological procedures.
7. The licensee should give consideration to carrying out those cardiology procedures where multiple stenting is necessary over a period of weeks to fractionate the radiation dose.
8. When purchasing new equipment, the licensee should give due consideration to features offered by the manufacturer that may aid in reducing patient dose.

## Concluding Remarks

Cardiologists, interventional radiologists and radiographers should be aware of the potential for x-ray induced skin injuries from fluoroscopic procedures. They must always adopt procedures which minimise the dose to their patients and themselves.

Further Information:

Radiation Safety Unit  
1/115 Victoria Parade  
Fitzroy 3065

Ph: (03) 9412 7563  
Fax: (03) 9412 7568

**Table 1**

Reported cases of skin injuries following fluoroscopy

Patient Sex and Age, country	Procedure	Nature of Injury	Fluoroscopic Exposure Time and Skin Dose
Female, 53, New Zealand (1996)	coronary angiography followed by coronary angioplasty	skin lesion	101 minutes, 78 cinefluorography runs, 18 Gy
Male, 40, USA	coronary angiography and PTCA followed by second coronary angiography	skin necrosis requiring 12 cm x 10 cm skin graft	unknown, estimated to exceed 120 minutes
Female, ?, USA	RF cardiac catheter ablation	7.5 cm x 12.5 cm second degree burn	unknown
Female, 25, USA	RF cardiac catheter ablation	skin breakdown 3 weeks post procedure	unknown, procedure time of 325 minutes
Female, 34, USA	RF cardiac catheter ablation	draining skin lesion on back 5 weeks post procedure	unknown, procedure time of 190 minutes
Female, 62, USA	balloon dilation of bile duct anastomosis	burn-like back injury on back requiring skin graft	unknown
Female, 61, USA	renal angioplasty	skin necrosis requiring skin graft	unknown, procedure time of 165 minutes

Note: Victorian Department of Human Services received a report of the New Zealand case in May 1996. The USA cases were reported to the Food and Drug Administration in the USA and the data presented in a paper presented by T.B. Shope at the 1995 Annual Meeting of the Radiological Society of North America.

Note: RF is radiofrequency; PTCA is percutaneous transluminal coronary angioplasty

**Table 2**

Typical threshold doses for radiation-induced skin injuries\*

Effect	Typical Threshold Dose (Gy)	Fluoroscopic on time (minutes) to reach threshold dose at a dose rate of 50 mGy/minute	Fluoroscopic on time (minutes) to reach threshold dose at a dose rate of 100 mGy/minute	Time to onset of the effect
Early transient erythema	2	40	20	hours
Temporary epilation	3	60	30	~ 3 weeks
Main erythema	6	120	60	~ 10 days
Permanent epilation	7	140	70	~ 3 weeks
Dry desquamation	10	200	100	~ 4 weeks
Invasive fibrosis	10	200	100	----
Dermal atrophy	11	220	110	> 14 weeks
Telangiectasia	12	240	120	> 52 weeks
Moist desquamation	15	300	150	~ 4 weeks
Late erythema	15	300	150	~ 6-10 weeks
Dermal necrosis	18	360	180	> 10 weeks
Secondary ulceration	20	400	200	> 6 weeks

\* Adapted from Rosenstein M 1996, *Practical Approaches to Dosimetry for the Patient and Staff for Fluoroscopic Procedures*, IRPA, International Congress on Radiation Protection: Proceedings. International Radiation Protection Association.

## APPENDIX III

## Research With Human Volunteers - Projects Approved

Licensee	Work location	Project Title
Austin Hospital	PET centre	Influence of ageing on neuropsychological function and neuroimaging in healthy individuals.
Austin Hospital	PET centre	C-11 flumazenil PET study in psychiatry and epilepsy patients.
Austin Hospital	PET centre	A positron emission tomography (pet) and event-related count correlational count of auditory hallucinations in schizophrenic patients.
Austin Hospital	PET centre	Cerebral metabolic and activation PET (positron emission tomography) studies in Parkinson's disease before and after pallidotomy.
Austin Hospital	PET centre	Studies of the ischaemic penumbra in acute stroke using PET and F-18 fluoromisonidazole.
Alfred Hospital and Baker Medical Research Institute	Baker Medical Research Institute	Determination of arginine transport and nitric oxide synthase activity in the human forearm.
Alfred Hospital and Baker Medical Research Institute	Baker Medical Research Institute	The effects of aromatase inhibition on forearm vascular reactivity, noradrenaline kinetics and cardiovascular responses to stress in men.
Geelong Hospital	University Department of Medicine	A phase III study of intermittent cyclical tiludronate in the treatment of established post-menopausal osteoporosis.
Monash Medical Centre	Body Composition Laboratory	Assessment of DEXA derived fat-free mass as an index of survival in dialysis patients.
Monash Medical Centre	Body Composition Laboratory	Body fat and Leptin levels in Indian, Chinese and Anglo-Celtic populations.
Monash Medical Centre	Monash Medical Centre	Long-term follow-up of children with congenital or acquired eventration of the diaphragm.
Monash Medical Centre	Cardiac Catheterisation Laboratory	Regional coagulation and platelet activity in mitral valve disease and atrial fibrillation.
Royal Melbourne Institute of Technology	Royal Melbourne Hospital, Essendon Campus	Body composition, metabolic and hormonal responses of post-menopausal women to varied compared with unvaried strength training.
Royal Children's Hospital	Department of Child Development and Rehabilitation	Inhalation pneumonitis and respiratory failure in cerebral palsy.
Royal Melbourne Hospital	Rheumatology Department	Symptomatic osteoarthritis in twins: a study of aetiopathogenesis based on the Australian twin registry.
Royal Melbourne Hospital	Bone Densitometry Unit	A longitudinal study of the skeletal effects of exercise during growth in females.
University of Melbourne (Dept. of Physiology)	Department of Physiology	Influence of glucose availability on glucose metabolism during exercise.
University of Melbourne (Dept. of Physiology)	Department of Physiology	Adrenergic regulation of glucose metabolism during exercise.

## APPENDIX IV(a)

Numbers of Operator Licences as at 27/9/96												
CATEGORY	IRRADIATING			SEALED			UNSEALED			ENDORSED		
	Status			Status			Status			Status		
	A	P	T	A	P	T	A	P	T	A	P	T
Radiologists	188	1	1	-	-	-	-	-	1	47	-	-
Medical Imaging Technologists	1446	12	7	-	-	-	1	-	-	1	-	-
Radiation Oncologists	1	-	-	1	-	-	-	-	-	30	-	1
Radiation Therapists	53	-	1	1	-	-	-	-	-	183	-	1
Nuclear Medicine Specialists	-	-	-	-	-	-	22	1	-	1	-	-
Nuclear Medicine Technologists	-	-	-	-	-	-	116	3	1	14	-	-
General Practitioners	481	2	9	-	-	-	-	-	-	-	-	-
Dentists	1846	4	1	-	-	-	-	-	-	-	-	-
Chiropractors	276	2	1	-	-	-	-	-	-	-	-	-
Dermatologists	7	-	-	-	-	-	-	-	-	-	-	-
Ophthalmologists	-	-	-	21	-	-	-	-	-	2	-	-
Other Medical Specialists	27	-	14	-	-	-	8	1	2	-	-	-
Dental Therapists	194	-	1	-	-	-	-	-	-	-	-	-
Testers	31	-	1	1	-	-	-	-	-	21	-	-
Service Technicians	173	-	1	34	-	6	-	-	-	17	-	1
Research (Human Subjects)	21	1	3	2	-	-	10	-	1	3	1	-
Veterinary Surgeons	517	3	-	-	-	-	-	-	1	13	-	-
Industrial Radiographers	118	-	11	4	-	1	-	-	-	144	-	-
Consultants	-	-	-	-	-	2	-	-	2	9	-	1
Dental Hygienists	35	1	-	-	-	-	-	-	-	-	-	-
Cardiologists	22	-	14	-	-	-	-	-	-	-	-	-
Borehole Loggers	-	-	-	38	-	-	-	-	-	9	1	-
Moisture/density Gauge Operators	-	-	-	231	21	22	-	-	-	-	-	-
Other Paramedical	11	-	-	1	-	-	6	-	-	-	-	-
Radiologist/Nuclear Medicine Specialist	-	-	-	-	-	-	-	-	-	3	-	-
<b>Subtotal</b>	<b>5447</b>	<b>26</b>	<b>65</b>	<b>334</b>	<b>21</b>	<b>31</b>	<b>163</b>	<b>5</b>	<b>8</b>	<b>595</b>	<b>2</b>	<b>4</b>
<b>TOTALS</b>	A status: 6539;			P status: 54;			T status: 108.					

A status = approved licence

P status = licence to be issued pending payment

T status = applications not yet approved - temporary status

Notes: Endorsed licences are licences which permit use of more than one category of irradiating apparatus, sealed source, and unsealed source on the one licence.

## APPENDIX IV(b)

Numbers of Registrations as at 27/9/96						
CATEGORY	IRRADIATING			SEALED		
	A	P	T	A	P	T
Radiology (Hospital)	516	-	-	-	-	-
Radiology (Private)	484	3	2	-	-	-
CT Scanner	95	3	3	-	-	-
Linear Accelerator	24	-	-	-	-	-
Radiotherapy	12	-	-	32	-	-
Dermatology	5	-	-	1	-	-
Ophthalmology	-	-	-	18	-	-
Dental	1913	8	4	-	-	-
Chiropractor	94	-	-	-	-	-
Medical (GP)	121	-	2	-	-	-
X-ray Analysis	100	-	-	-	-	-
Irradiation Cell	-	-	-	3	-	-
Borehole Logging	2	1	-	63	-	-
Radiation Gauge	8	-	-	428	11	2
Moisture Meter	-	-	-	167	4	-
Industrial Radiography	84	1	-	42	-	-
Veterinary	352	1	3	7	-	-
Calibration	-	-	-	130	-	1
Teaching	15	-	1	108	-	-
Other Industrial	40	-	-	210	-	-
Research	7	-	-	25	3	1
Other Medical	5	-	1	5	-	-
Mammography	138	-	3	-	-	-
OPG	209	4	1	-	-	-
Medical Cyclotron	1	-	-	-	-	-
Bone Mineral Densitometry	28	-	-	-	-	-
Mobile Image Intensifier	43	2	1	-	-	-
Condenser Discharge Mobile	88	-	-	-	-	-
Laboratory Irradiator	-	-	-	6	-	2
Lithotripter	2	-	-	-	-	-
Veterinary	4	-	-	-	-	-
Therapy Simulator	3	-	-	-	-	-
Cabinet X-ray Equipment	20	-	1	-	-	-
GC-Electron Capture Detector	-	-	-	13	4	2
<b>Subtotals</b>	<b>4413</b>	<b>23</b>	<b>22</b>	<b>1258</b>	<b>22</b>	<b>8</b>
<b>TOTALS</b>	<b>A status: 5671;</b>	<b>P status: 45;</b>	<b>T status: 30.</b>			

A status = approved licence

P status = licence to be issued pending payment

T status = applications not yet approved - temporary status

## APPENDIX IV(c)

Numbers of Management Licences on System as at 27/9/96															
CATEGORY	IRRADIATING			SEALED			UNSEALED			ENDORSED			TRANSPORT		
	Status			Status			Status			Status			Status		
	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T
Sales	43	1	5	60	1	2	19	-	-	11	1	-			
Industrial	-	-	-	-	1	-	10	-	-	-	-	-			
Hospital	-	-	-	-	-	-	22	-	-	-	-	-			
Pathology	-	-	-	-	-	-	12	-	-	-	-	-			
Education and Research	-	-	-		-	-	32	2	-	-	-	-			
Research (Humans)	6	-	1	1	-	-	5	-	-	1	1	-			
Radiotherapy	-	-	-	-	-	-	2	-	-	-	-	-			
Nuclear Medicine	-	-	-	-	-	-	33	-	-	-	-	-			
Other Medical	-	-	-	-	-	-	1	1	-	-	-	-			
Government Department	-	-	-	-	-	-	18	-	-	-	-	-			
Veterinary	-	-	-	-	-	-	7	-	-	-	-	-			
Other Laboratory	-	-	-	-	-	-	5	-	-	-	-	-			
Transport													16	-	-
Transport (Low Level Waste)													7	-	-
<b>Subtotals</b>	<b>49</b>	<b>1</b>	<b>6</b>	<b>61</b>	<b>2</b>	<b>2</b>	<b>166</b>	<b>3</b>	<b>-</b>	<b>12</b>	<b>2</b>	<b>-</b>	<b>23</b>	<b>-</b>	<b>-</b>
<b>TOTALS</b>	<b>A status: 311;</b>			<b>P status: 8;</b>			<b>T status: 8.</b>								

A status = approved licence

P status = licence to be issued pending payment

T status = applications not yet approved - temporary status

Notes: Endorsed licences are licences which permit use of more than one category of irradiating apparatus, sealed source, and unsealed source on the one licence.

**APPENDIX V****Summary of Radiation Safety Testing - May 1985 to September 1996**

Type	Total	No. Inspected	No. Not inspected	% Inspected
61 (Hospital)	516	401	115	78
62 (Private Radiology)	489	213	276	44
63 (CT Scanners)	101	34	67	34
64 (Linear Accelerators)	24	6	18	25
65I (Radiotherapy X-ray)	12	1	11	8
65S (Radiotherapy Sources)	32	3	29	9
66I (Dermatology X-ray)	5	2	3	40
66S (Dermatology Sources)	1	1	0	100
67 (Ophthalmology)	18	9	9	50
68 (Dentists)	1925	1038	887	54
69 (Chiropractors)	94	79	15	84
70 (General Practitioners)	123	108	15	88
71 (X-ray Analysis)	100	20	80	20
72 (Irradiation Cells)	3	1	2	33
73 (Borehole Logging)	66	11	55	17
74I (Gauges X-ray)	8	1	7	13
74S (Gauges Sources)	441	193	248	44
75 (Nuclear Moisture Gauges)	171	108	63	63
76I (Industrial Radiography X-ray)	85	34	51	40
76S (Industrial Radiography Sources)	43	16	27	37
77I (Vets X-ray)	356	164	192	46
77S (Vets Sr-90)	7	5	2	71
78S (Calibration Sources)	131	8	123	6
79I (Teaching X-ray)	16	2	14	13
79S (Teaching Sources)	108	2	106	2
80I (Other Ind X-ray)	40	19	21	48
80S (Other Ind Sources)	210	24	186	11
81I (Research X-ray)	7	2	5	29
81S (Research Sources)	29	1	28	3
82I (Other Med X-ray)	6	4	2	67
82S (Other Med Sources)	5	3	2	60
83 (Mammography)	141	93	48	66
84 (OPG)	214	91	123	43
85 (Medical Cyclotron)	1	0	1	0
86 (Bone Mineral Densitometer)	28	10	18	36
87 (Mobile Image Intensifiers)	46	12	34	26
88 (Condenser Discharge Mobile)	20	7	13	35
89 (Laboratory Irradiator)	8	5	3	63
90 (Lithotripter)	2	1	1	50
92 (Veterinary Dental)	4	1	3	25
93 (Therapy Simulator)	3	0	3	0
94 (Cabinet X-ray Equipment)	21	10	11	48
95 (GC-Electron Capture Detectors)	19	0	19	0
Totals	5679	2743	2936	48

NB: This list only applies to units registered (or for which applications have been made) at the time of preparation of this summary. It does not take account of units that were inspected and have subsequently been de-registered through being sold, dismantled, destroyed or placed in storage.

## APPENDIX VI

### Papers Related to Biological Effects Associated with Power Frequency Electromagnetic Fields and Radiofrequency Radiation Considered in the Past Year

#### 1. Cell Studies

Balcer-Kubiczek EK and Harrison GH. Neoplastic transformation of C3H/10T1/2 cells following exposure to 120 Hz modulated 2.45 GHz microwaves and phorbol ester cancer promoter. *Radiation Research* 1991 **126**: 63-72.

Libertin CR, Panozzo J, Groh KR et al. Effects of gamma rays, ultraviolet radiation, sunlight, microwaves and electromagnetic fields on gene expression mediated by human immunodeficiency virus promoter. *Radiation Research* 1994 **140**: 91-96.

Scaiano JC, Cozens FL and McLean J. Model for the rationalization of magnetic field effects in vivo. application of the radical-pair mechanism to biological systems. *Photochemistry and Photobiology* 1994; **59**: 585-589.

Trillo MA, Ubeda A, Blanchard J et al. Magnetic fields at resonant conditions for the hydrogen can affect neurite outgrowth of PC12 cells. *Bioelectromagnetics* 1996 **17**: 10-20.

#### 2. Animal Studies

Bakos J, Nagy N, Thuroczy G and Szabo LD. Sinusoidal 50Hz, 500  $\mu$ T magnetic field has no acute effect on urinary 6-sulphatoxy melatonin in Wistar rats. *Bioelectromagnetics* 1996; **16**: 377-380.

Gledhill M. Comments on "Effects of 60 Hz electric and magnetic fields in the development of the rat cerebellum" by Sona et al. *Bioelectromagnetics* 1995; **16**: 143-144.

Kowalczyk CI, Robbins L, Thomas JM and Saunders RD. Dominant lethal studies in male mice after exposure to a 50 Hz magnetic field. *Mutation Research* 1995. **328**: 229-237.

Margonato V, Nicolini P, Conti R et al. Biologic effects of prolonged exposure to ELF electromagnetic fields in rats. II: 50 Hz magnetic fields. *Bioelectromagnetics* 1995; **16**: 343-355.

Prato FS, Kavaliers M and Carson JLL. Behavioural evidence that magnetic field effects in the land snail *Cepaea nemoralis* might not depend on magnetite or induced electric currents. *Bioelectromagnetics* 1996 **17**: 123-130.

#### 3. Epidemiology

Beale IL and Pearce NE. Psychological and physical correlates of 50 Hz magnetic field exposure in humans living near extra high voltage transmission lines. Paper presented at the 17th Bioelectromagnetics Society annual meeting.

Bracken MB, Belanger K, Hellenbrand K et al. Exposure to electromagnetic fields during pregnancy with emphasis on electrically heated beds: association with birthweight and intrauterine growth retardation. *Epidemiology* 1995; **6**: 263-270.

Coogan PF, Clapp RW, Newcomb PA, Wenzel TB et al. Occupational exposure to 60-Hertz magnetic fields and risk of breast cancer in women. *Epidemiology* 1996; **7**: 459-464.

Fear NT, Roman E, Carpenter LM, Newton R and Bull D. Cancer in electrical workers: an analysis of cancer registrations in England 1981 - 7. *Br J Cancer* 1996; **73**: 935-939.

Gurney VG, Muelle BA, Davis S et al. Childhood brain tumour occurrence in relation to residential power line configurations, electric heating source and electric appliance use. *Am J Epidemiol* 1996; **143**: 120-128.

Heineman EF, Gao Y-T, Dosemeci M and McLaughlin JK. Occupational risk factors for brain tumors among women in Shanghai, China. *JOEM* 1995; **37(3)**: 288-293.

Infante-Rivard C. Electromagnetic field exposure during pregnancy and childhood leukemia (letter to the editor). *The Lancet*, July 15, 1995; **346**: 177.

Miller AB, To T, Agnes DA, Wall C and Green LM. Leukemia following occupational exposure to 60Hz electric and magnetic fields among Ontario electric utility workers. *Am J Epidemiol* 1996; **144**: 150-160.

Pearson RL and Wachtel H. Childhood cancer risk in relation to residential environmental and lifestyle factors that are associated with wire codes. Paper presented at the 17th Bioelectromagnetics Society annual meeting.

Preston Martin S, Navidi W, Thomas D et al. Los Angeles study of residential magnetic fields and childhood brain tumours. *Am J Epidemiol* 1996; **15**: 105-119 and 133-4.

Reif JS, Lower KS and Ogilvie GK. Residential exposure to magnetic fields and risk of canine lymphoma. *Am J Epidemiol* 1995; **141(4)**: 353-359.

Robert E, Harris JA, Robert O and Selvin S. Case-control study on maternal residential proximity to high voltage power lines and congenital anomalies in France. *Paediatric and Perinatal Epidemiology* 1996; **10**: 32-38.

Savitz DA and Ananth CV. Residential magnetic fields, wire codes, and pregnancy outcome. *Bioelectromagnetics* 1994; **15**: 271-273.

Wertheimer N, Savitz DA and Leeper E. Childhood cancer in relation to indicators of magnetic fields from ground current sources. *Bioelectromagnetics* 1995; **16**: 86-96.

#### 4. Dosimetry

Cheng J, Stuchly MA, DeWagter C and Martens L. Magnetic field induced currents in a human head from use of portable appliances. *Phys Med Biol* 1995; **40**: 495-510.

Tofani S, Ossola P, d'Amore G and Gandhi OP. Electric field and current density distributions induced in an anatomically-based model of the human head by magnetic fields from a hair dryer. *Health Physics* 1995; **68(1)**: 71-79.

#### 5. Reviews and Editorials

Feychting M and Ahlbom A. Childhood leukemia and residential exposure to weak extremely low frequency magnetic fields. *Environmental Health Perspectives (Suppl 2)* 1995: 59-62.

Moulder JE and Foster KR. Biological effects of power-frequency fields as they relate to carcinogenesis. *PSEBM* 1995; **209**: 309-324.

Reiter RJ. Melatonin suppression by static and extremity low frequency electromagnetic fields: relationship to the reported increased incidence of cancer. *Reviews in Environmental Health* 1994; **10**: 171-186.

#### 6. Other

Henshaw DL, Ross AN, Fewes AP and Preece AW. Enhanced deposition of radon daughter nuclei in the vicinity of power frequency electromagnetic fields. *Int J Radiat Biol* 1996; **69(1)**: 25-38.

#### 7. Radiofrequency Radiation

Buffler PA. Cellular telephones and health. *Epidemiology* 1996 **7**: 219.

Cleary SF, Liu L-M and Merchant RE. Glioma proliferation modulated *in vitro* by isothermal radio-frequency radiation exposure. *Radiation Research* 1990; **121**: 38-45.

Hocking B. Non ionising electromagnetic radiation (letter to the editor). *Australian family physician* 1994; **23(7)**: 1388-1389.

Lai H and Singh NP. Acute low intensity microwave exposure increases DNA single strand breaks in rat brain cells. *Bioelectromagnetics* 1995; **16**: 207-210.

## ABBREVIATIONS

<b>AIR</b> Australian Institute of Radiography	<b>JSAC</b> Joint Specialist Advisory Committee (of the RACP and RACR)
<b>ALARA</b> As Low As Reasonably Achievable	<b>kBq</b> kilobecquerel (1 kBq = 1,000 Bq)
<b>AMA</b> Australian Medical Association	<b>kV</b> kilovolt
<b>ANSTO</b> Australian Nuclear Science and Technology Organisation	<b>MBq</b> megabecquerel (1 MBq = 1,000,000 Bq)
<b>ANZAPNM</b> Australian and New Zealand Association of Physicians in Nuclear Medicine	<b>mG</b> milligauss, a unit of magnetic flux density
<b>ARL</b> Australian Radiation Laboratory	<b>MRI</b> magnetic resonance imaging
<b>Bq</b> becquerel, a unit of radioactivity (1 Bq = 1 disintegration per second)	<b>NHAC</b> National Health Advisory Committee of NHMRC
<b>CT</b> computed tomography	<b>NHMRC</b> National Health & Medical Research Council
<b>DEXA</b> dual energy X-ray absorptiometry	<b>NIR</b> non-ionizing radiation
<b>DHS</b> Department of Human Services	<b>NRPB</b> National Radiation Protection Board (UK)
<b>DSA</b> digital subtraction angiography	<b>NSQAC</b> National Specialist Qualification Advisory Committee
<b>EMF</b> electromagnetic field	<b>OHSA</b> Occupation Health and Safety Authority
<b>GBq</b> gigabecquerel (1 GBq = 1,000,000,000 Bq)	<b>OR</b> odds ratio
<b>ICNIRP</b> International Commission on Non-Ionizing Radiation Protection	<b>PET</b> positron emission tomography
<b>ICRP</b> International Commission on Radiological Protection	<b>PMCI</b> Peter MacCallum Cancer Institute
	<b>PTCA</b> percutaneous transluminal coronary angioplasty

**RAC**

Radiation Advisory Committee

**RACGP**

Royal Australian College of General Practitioners

**RACP**

Royal Australasian College of Physicians

**RACR**

Royal Australasian College of Radiologists

**RF**

radiofrequency

**RSU**

Radiation Safety Unit, Dept. of Human Services

**RVEEH**

Royal Victorian Eye & Ear Hospital

**TGA**

Therapeutic Goods Administration

**TLD**

thermoluminescent dosimeter

**UMWVC**

University of Melbourne Werribee Veterinary  
Clinic

**V/m**

volts/metre

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