The costs of providing radiotherapy treatment, particularly palliative treatment, for cancer patients extends into the wider community. Social service agencies may provide support and the voluntary and charitable organisations are also likely to be active in support of both cancer patients and their families.

Education

The Working Party notes that consumer booklets, pamphlets and videos about radiotherapy have been produced by both formal and informal agencies including voluntary and support groups, and appear to be readily available from Cancer Councils and hospitals in each State and Territory. The information focuses on describing the various treatments available, what is entailed in the treatment and possible side effects, questions that consumers should ask their medical practitioners and the location of treatment services.

However, the Working Party believes that where there is still a level of unawareness of the benefits of radiotherapy for cancer treatment among doctors, then it is likely that consumers may be unaware of their treatment options. Consumers must have access to information that discusses treatment options including radiotherapy.

One way to do this is to ensure that hospitals, doctors' rooms and health centres where cancer patients are treated are provided with materials that provide general information about different cancers, treatment centres in each State, the PATS scheme and sources of further information. Consumer statements in plain English and in other languages are widely accepted in other areas of health care and provide access to knowledge that might otherwise be controlled by professional, but not always well informed, gatekeepers to the system.

Further, establishment of a system of regional multimodal assessment centres should be a priority. This structure could provide a focus for the provision of consumer information and the opportunity for exchange, particularly in relation to treatment options. Such an environment providing multidisciplinary information is likely to be better for the patient than the traditional one-to-one exchange which characterises the usual form of patient-doctor interchange.

Continuity of care following radiotherapy treatment needs to be enhanced. Quality management and thus continuing quality care may not occur for some patients, indicating a need for more structured community processes and the development of guidelines for the coordination of community based care.

Patient education about care after treatment is not as readily available as information about the treatment process itself. Service providers should be responsible for providing comprehensive information to all people undergoing radiotherapy which describes in detail the possible side effects of the treatment together with recommendations for the management of side effects such as fatigue. This information should be prepared in easy to read booklets and include general information about multidisciplinary primary care providers such as GPs and community based nurses who can provide quality continuing care during and after the radiotherapy treatment.

While there is consumer information available for cancer patients about treatment options including radiotherapy, there are still gaps in this information.

Decision making about treatment can be adversely affected if the referring doctor and the patient have a limited understanding of treatment options.

Recommendations:

- **Consumer information should be developed which specifically focuses on treatment options available to patients to assist their decision making.**
- **Plain English consumer education booklets about care after treatment should be developed and provided to all patients undergoing radiotherapy.**
- **Primary care guidelines in a multidisciplinary framework should be developed for post-radiotherapy management, particularly for GPs and district nurses.**

8. Workforce, education and training requirements

As discussed in Chapter 6, the low referral rate for radiation oncology in Australia in comparison with overseas rates is seen as a major reason for its under-utilisation in this country. The reasons are manifold and include the lack of recognition of the role of radiation therapy in cancer treatment and the shortage of radiation oncologists, radiation oncologist trainees and radiation oncology physicists.

Education of the medical profession and the establishment of an academic base in radiation oncology are seen as important elements in addressing the situation. Educating consumers will also raise the level of awareness about treatment options including radiotherapy.

These and related issues are discussed in this chapter. In addition, summary data are presented from annual surveys of the radiation oncology workforce undertaken by the Faculty of Radiation Oncology of the RACR and from surveys conducted by the ACPSEM.

The radiotherapy workforce

There are many different categories of staff involved in the delivery of radiotherapy services. The results of the latest survey undertaken by the RACR in 1994 of the different categories of personnel in radiotherapy are presented in Table 8.1.

There has been an increasing desire among patients to be kept informed and involved in their treatment. As a result there is an expanding role for those involved in continuing and supporting care including social workers, community nurses, domiciliary carers, physiotherapists, pharmacists, dietitians and counsellors.

The Working Party recognises this expanding role for a range of support personnel and acknowledges their importance in the care of the cancer patient in a multidisciplinary context. However, in this report the discussion of workforce issues has been confined to four major categories of personnel involved in the delivery of radiotherapy treatment: radiation oncologists, radiation therapists (formerly therapy radiographers), medical physicists and oncology nurses.

Table 8.1
Workforce categories and numbers in radiation oncology departments in Australia as at 30 June 1994

Category of personnel	State						
	NSW/ ACT	VIC	TAS	SA	WA	QLD	Total
Radiation oncologists	32(6)	29	3	8(2)	6(1)	21	99(9)
Trainee radiation oncologists	21	8	0	4	3	5	41
Resident medical officer and other medical staff	7.5	5	2	1	3	5	23.5
Radiation therapists	195	140.5	22	47.8	51	104.3	560.6
Medical physicists	36.5	19	4	6	3	14	82.5
Biomedical engineers	16	5	3	4	0	5	33
Mould room technicians	22	6.3	0	1	1	0	30.3
Nursing staff	39.5	21.3	9	9	8	31	117.8
Clerical staff	72	42.6	9.6	13.3	14.3	52	203.8
Data managers	8.4	2.5	1	0	.5	2	14.4
Social workers	11	2.5	1.5	2.4	1.0	0	17.4

Source: Faculty of Radiation Oncology, RACR

Radiation oncologists

Workforce

In 1993, the Medical Workforce Data Review Committee (MWDRC) released an interim report on the radiation oncology workforce (MWDRC 1993). At that time the Review Committee reported that a number of problems required resolution before a confident assessment of the number of specialists required could be made. These problems included: the lack of objective criteria against which to assess the adequacy of supply; the limited information available on issues such as changes in the number of training positions available and variation in training arrangements; the differing perceptions of key stakeholders as to the adequacy of current supplies; and numerous factors in the workplace which can affect the availability of service provision.

In an attempt to address these problems, the MWDRC developed a framework for analysing the supply and requirements for medical specialist workforces. The framework contained a number of factors including training arrangements, current workforce analysis, factors affecting overall workforce contribution and availability of services, measures of requirements, perceptions of adequacy of workforce numbers, changes in technology and a range of factors affecting demand for specialist services (MWDRC 1994).

In 1994, MWDRC finalised its report on the radiation oncology workforce, concluding that *there will be an undersupply of radiation oncologists until the year 2004, and the targets set by AHMAC in 1989 cannot be met* (MWDRC 1994).

The standard by which the required number of radiation oncologists was calculated was seven per million population. This number was originally proposed by the WHO in the early 1980s and was subsequently endorsed in 1989 by AHMAC (AHMAC 1989). In its 1994 report, the MWDRC found that the current number of EFT radiation oncologists was 5.8 per million of population. The report concluded that on current projections of cancer incidence and population changes, the number of radiation oncologists required by the year 2014 will be 12 per million of population (MWDRC 1994).

The results of RACR surveys about numbers of radiation oncologists are summarised in Table 8.2, and show that in 1994 there were 99 radiation oncologists (with nine vacant positions). Comparison of RACR survey results about numbers of radiation oncologists with those recommended by the MWDRC and the AHMAC report show a significant shortfall in radiation oncologist positions (Table 8.3). This shortfall is exacerbated by positions being unfilled.

In determining the number of radiation oncologists required, the use of numbers of population tends to understate the real position because it does not take into account increasing cancer incidence and the increasing complexity of treatment for cancer.

This increasing incidence rate can be best accommodated by using the ratio of radiation oncologists to new referrals. One proposed ratio is that there be one radiation oncologist for every 250 new referrals (Morgan 1993, Dept Health NSW 1995). Using the number of new referrals recorded in 1994, this equates to a requirement for 131 positions. This figure is comparable to that described in Table 8.3, with all showing a considerable shortage of radiation oncologists.

Table 8.2
Number of radiation oncologists in Australia, 1988–1994

State	1988 Filled/vac	1990 Filled/vacant	1992 Filled/vaca	1994 Filled/vacant
Qld	16/3	21/0	21/0	21
NSW/ACT	26/2	24/2	29/5	32(6)
Victoria	20/0	19/5	21/0	29
Tasmania	2/2	2/2	3/1	3
South Australia	8/0	7/1	8/1	8(2)
Western Australia	5/2	5/1	6/1	6(1)
Total	76/9	78/11	88/7	99
No/million population	4.6	4.6	5.0	5.5

Source: Faculty of Radiation Oncology, RACR

Table 8.3
Comparison of the actual number of radiation oncologists in Australia in 1994 with those recommended by Government bodies

State	Filled/vacant*	AHMAC recommendation (7.0 per million)**	MWDRC recommendation (7.5 per million)***
Qld	21	22	24
NSW/ACT	32(6)	45	48
Victoria	29	32	35
Tasmania	3	4	4
South Australia	8(2)	11	12
Western Australia	6(1)	12	13
Total	99(9)	126	136
No/million	5.5	7.0	7.5

* RACR Survey 1994
** 1989 AHMAC Working Party
*** MWDRC 1993

Education and training

The provision of sufficient trainee positions is essential for radiation oncologist numbers to rise. In 1989 the AHMAC Working Party on Radiation Oncology recommended the immediate provision of 21 new trainee positions (to a total of 58 positions). The 1994 MWDRC report recommended that the number of training posts be increased from 44 to 55 in 1996, and to 60 by the year 2004. The MWDRC considered that this increase will ensure that there are sufficient radiation oncologists for the period 2004-2014. Current levels and MWDRC projections are presented in Table 8.4.

Table 8.4
Number of trainee radiation oncologists in Australia, 1988–1994

State	1988 Filled/vacant	1990 Filled/vacant	1992 Filled/vacant	1994 Filled/vacant	MWDRC 1999	MWDRC* 2004
Qld	5/1	3/1	5/0	5	11	13
NSW/ACT	14/1	19/2	22/0	21	19	21
Victoria	10/0	4/3	10/0	9	14	14
Tasmania	0/0	0/0	0/0	0	1	2
South Australia	3/0	3/0	4/0	4	5	5
Western Australia	3/0	3/0	3/0	2	5	5
Total	35/2	32/6	44/0	41	55	60

* MWDRC consultancy report 1994 recommendations
Source: Faculty of Radiation Oncology, RACR

Trainees in radiation oncology are required to have one year of general post-intern experience before acceptance into an accredited training program of four year's duration. All trainees must occupy a training post for four years.

In 1993, the MWDRC identified the following impediments to training in radiation oncology:

- current pressures on practising radiation oncologists make it difficult for them to give the attention which they believe the training of new radiation oncologists deserves;
- trainees are under strong clinical pressure themselves and this may well impede the completion of training posts;
- the available radiation oncology workforce does not permit the development of an academic structure which would enable either improved attention to teaching or critical analysis of results;
- the relative ignorance of the role and benefits of radiotherapy among the rest of the medical profession has contributed to some of the problems.

The MWDRC (1994) recommended that the RACR should take steps to improve the productivity of training posts, in terms of completion times, so that the average traineeship is completed in five years. The College has already acted to improve the pass rate by introducing a monthly day-release scheme, a pre-exam course for Australian and New Zealand candidates, and part-time training to encourage female graduates.

Despite these steps, many problems remain. The Working Party believes that there are major deficiencies in the understanding of cancer management in the medical profession, beginning with the education of undergraduates. The reasons for this vary from university to university but include: the dominance of the traditional disciplines within medical schools; a lack of focus on oncology as a defined subject; the lack of appropriate teachers; and the progressive dispersal of undergraduate medical students from the major centres where radiation oncology and to some extent medical and surgical oncology tend to be concentrated. Instruction in cancer is often given by non-cancer specialists and may lead to misunderstanding of concepts. The consequences of the lack of appropriate undergraduate education in cancer are that cancer patients may be treated by a less appropriate method and/or have their prospects of a successful outcome compromised.

A survey of new medical graduates has been undertaken to determine their levels of knowledge about cancer, their level of exposure to clinical instruction and their rating of instruction in different aspects of cancer in order to assess a perceived need for curriculum changes (Smith, WT et al. 1991). The results of the survey revealed disturbing variation in experience and a lack of important knowledge about cancer among graduating students. There were substantial differences in knowledge, experience in and rating of teaching between the medical, surgical, radiographic and palliative components of cancer care. The respondents displayed a considerable lack of knowledge about radiotherapy treatment options. Over half of the medical graduates from Australian universities do not enter a department of radiation oncology during a six-year course of tuition (Tattersall et al. 1993).

To examine this further, Tattersall et al. (1993) surveyed Australian oncologists and 'teachers' in the undergraduate cancer curriculum at all Australian medical schools. The same questions of knowledge were asked of the recent graduates, in addition to seeking their views about the type and duration of teaching desirable in undergraduate cancer education. The survey showed that educators are not well informed about cancer epidemiology and had differing views about treatment goals and options. The results highlighted the need for an integrated cancer curriculum.

It is clear that attitudes instilled in undergraduate medical education flow through to later practice. Although medical schools cannot be expected to cover every facet of patient care, they must accept the responsibility for establishing the knowledge base and attitudes on which postgraduate skills and thus patient care depend.

The Working Party is aware that cancer teaching in Australian universities is under review and has received a significant impetus from studies quoted. At a time when curricula are under review in many schools, the Working Party believes that the universities should be encouraged to develop further their focus on oncology and to ensure that appropriate instruction is given by specialists in the field.

The shortage of radiation oncologists results in high individual workloads, detracting from the quality of training that can be delivered.

The shortage of radiation oncology trainees also results in high individual workloads, placing the trainees under high clinical pressure, and reducing the productivity and attractiveness of training posts.

The limited academic base of radiation oncology in Australia hampers teaching at both the undergraduate and postgraduate levels.

The relative ignorance of the medical profession concerning radiotherapy results in a significant number of potential trainees being either unaware of the discipline, or preferentially attracted elsewhere.

Recommendations:

- **The way in which cancer management is taught in undergraduate and postgraduate medical education should be reviewed. In particular, medical schools should be asked to address the issue of undergraduate education about cancer when reviewing their curricula.**
- **Increased radiation oncologist positions and trainee positions should be established as a matter of urgency, in line with Medical Workforce Data Review Committee findings.**

Radiation therapists

Workforce

Radiation therapists (formerly known as therapy radiographers) are primarily concerned with treatment planning and treatment delivery. The Australian Institute of Radiography (AIR) has published recommendations on radiation therapist staffing levels in departments of radiation oncology (AIR 1988) and these have recently been reviewed by the AIR Radiation Therapy Advisory Panel (AIR submission to AHTAC 1995). RACR survey results on the number of radiation therapists in Australia are presented in Table 8.5.

Table 8.5
Number of radiation therapists in Australia, 1988–1994

State	1988 Filled/vacant	1990 Filled/vacant	1992 Filled/vacant	1994 Filled/vacant
Qld	70/6	82/6	94/3	104.3/2.2
NSW/ACT	124/13	113/34	137/29	195/5.5
Victoria	101/19	125/5	121/0	140.4
Tasmania	17/3	21/0	19/1	22
South Australia	40/3	38/3	39/3	47.8
Western	38/0	37/3	37/0	51/1
Total	390/44	416/51	447/36	561.6/8.7

Source: Faculty of Radiation Oncology, RACR

The AIR considers that the current number of radiation therapists in Australia is adequate, although the distribution of radiation therapists varies around the country and this may result in local shortages or oversupply. In addition, the growing complexity of radiotherapy technology and more complex quality assurance and safety standards are adding to the time needed for radiation therapists to deliver treatment. Minimum standards for numbers of radiation therapists may need to be increased, so that quality assurance and safety standards are not compromised in the face of increasing pressure to maintain current patient throughput levels. The minimum staffing numbers recommended by AIR are in accordance with standards in England and Canada (AIR representation to Working Party). Not all Australian units meet these minimum figures.

The Institute has been collecting workforce data with the aim of predicting shortages, and these data are used to make recommendations to universities about student intakes. This is complicated by the need to predict staff requirements before new radiotherapy centres become operational. The AIR is yet to consider necessary increases in numbers of trainees to meet future expansion and increase in radiotherapy facilities (AIR representation to Working Party).

Education and training

Radiation therapists qualify by undertaking a three-year undergraduate course and a professional development year.

Factors controlling the numbers of radiation therapists in training include tertiary education sector budgetary processes and the numbers of positions allocated in hospitals for the post-degree professional year. The AIR Accreditation and Education Board assesses the standards of courses offered in tertiary institutions and AIR is represented on university course advisory committees (AIR representation to Working Party).

Medical physicists in radiation oncology

Workforce

The ACPSEM has published detailed descriptions of the role of the physicist in radiation oncology (ACPSEM 1989, ACPSEM 1995). The role includes, but is not limited to, equipment quality assurance, dosimetry, provision of radiation beam data, advice on radiation oncology, involvement in the planning and treatment of complex external beam treatments, involvement in the quality assurance of external beam treatment planning, evaluation of the accuracy of treatment planning and treatment techniques, planning and delivery of brachytherapy treatments, calibration of external beam and brachytherapy sources, commissioning of new equipment, provision of scientific and technical advice for the selection of equipment, provision of advice and training on radiation protection and safety, and research and development.

Both the RACR and ACPSEM regularly conduct surveys of staffing levels of medical physicists working in radiotherapy. The results of these surveys are typified by the ACPSEM data shown in Table 8.6, which indicates a consistent shortfall between the actual staffing levels and the levels recommended by the ACPSEM.

Table 8.6
Number of medical physicists in radiation oncology in Australia in 1990 and 1994

	1990		1994	
State	Actual	Recommended	Actual	Recommended
Qld	10	11.5	17	21.5
NSW/ACT	25.5	33.5	39.5	54
Victoria	5	10.5	19	33
Tasmania	3	5.5	4	6.5
South Australia	5	6	7.5	10
Western Australia	4.5	6	5	8
Total	53	73	92	133

Source: Australasian College of Physical Scientists and Engineers in Medicine

The ACPSEM survey reveals that for 1990–1994, the shortfall in the number of medical physicists in radiation oncology employed in hospitals, as compared with the number recommended by ACPSEM, increased from 20 to 41. ACPSEM commented that approximately one-third of the 92 physicists are inexperienced (having less than four years relevant work experience) and must therefore be considered to be trainees. Therefore the real shortfall, as seen by ACPSEM, is 70 qualified radiation oncologist physicists, which equates to 50 per cent of the required positions.

Although these ACPSEM levels have not so far been ratified by government in Australia, it is noted that they are consistent with staffing levels recommended by the professional organisations in Europe and North America (Institute of Physical Sciences in Medicine 1989, European Federation of Organisations for Medical Physics 1991, Inter-Society Council for Radiation Oncology 1991). This suggests that a significant number of radiation oncology physics training positions are required in Australia.

Education and training

In Australia, there is no formal training requirement for employment as a medical physicist. Most hold a basic science degree with a major in physics and then obtain on-the-job clinical training in a hospital. A Master of Science degree is available in medical physics and ACPSEM actively encourages trainees to undertake this course (ACPSEM representation to the Working Party).

The lack of distinction between a physicist and a trained and qualified medical physicist is regarded as a major problem by the Working Party and is an indication of a serious deficiency in the training of medical physicists generally. Although an undergraduate physics degree provides core skills, a medical physicist also requires considerable additional training to acquire specialised knowledge and expertise in medical technology and the clinical process. This lack of appreciation of the distinction between a physicist and a medical physicist has resulted in a significant number of medical physics positions in Australia being filled by persons with limited or no experience or training in medical physics (ACPSEM submission to AHTAC 1995).

Although such personnel usually receive some in-service training, particularly at the larger centres, this is generally of an ad-hoc nature and provides no guarantee whatsoever of an adequate standard of professional competence. This a considerable concern, as medical physicists in radiation oncology play a key role in the delivery of radiotherapy through the maintenance of stringent standards of radiation dose delivered to patients. As successful radiotherapy depends upon the accurate quantity and placement of radiation delivery, failure to maintain an adequate dose standard is potentially very serious and can result in compromised treatments, or fatal incidents.

There have been a number of incidents reported in the literature overseas that demonstrate consequences of such inadequacies in medical physics standards and training (Leveson & Turner 1993, Haywood 1993). These incidents have all been reported from overseas, with none being reported to date in Australia.

The almost total lack of any practical competency standard governing the employment of medical physicists is also a matter of some concern to the Working Party. While ACPSEM conducts an accreditation scheme in linear accelerator commissioning, this covers only a portion of the skills required of a medical physicist working within radiation oncology, and has so far been recognised only under Radiation Control Legislation in NSW.

The Working Party recognises that a number of Australian universities offer postgraduate courses in medical physics and that these courses may well substantially satisfy the academic component of an accreditation system. However, no formally designated medical physics training positions exist within teaching hospitals to provide the practical component of training for such an accreditation system.

There are no national standards for training, accreditation or employment of medical physicists.

No formally designated medical physics training positions exist within Australian teaching hospitals.

The practical competency standards governing the employment of medical physicists are inadequate.

Although the Working Party is not in a position to independently verify the legitimacy of ACPSEM recommended staffing levels, their consistency with recommended levels overseas gives them credence. This suggests that an increase in medical physics training positions is required.

Recommendations:

- **The staffing requirements of medical physicists in radiation oncology, including the required number of training positions, should be independently reviewed.**
- **There should be a national minimum qualification standard for medical physicists working in radiation oncology.**
- **A national accreditation system for the medical physics profession should be introduced.**
- **Medical physics training positions should be introduced to enable an approved practical training program to be carried out under the accreditation system.**

Radiation oncology nurses

Workforce

The only data available to the Working Party relating to the number of nurses involved in the delivery of radiotherapy services in Australia are those reported in the regular RACR surveys. In 1994 there were 117 nursing staff employed directly in radiotherapy units while many others were involved in the care of radiotherapy patients (Table 8.1).

Education and training

Specific courses in chemotherapy administration are established at most hospitals.

Although there are no specific formal training courses for radiation oncology nurses in Australia, the Peter MacCallum Cancer Institute in Victoria does conduct a short introductory course in radiation oncology nursing and electives in radiation biology and radiotherapy delivery are available as part of graduate diploma courses in oncology nursing (Royal College of Nursing submission to AHTAC 1995).

In the broader perspective, education about the nursing care for patients undergoing radiation therapy is required by general nurses as well as radiation oncology nurses. Many of the elderly patients undergoing long-term therapy are visited daily by community nurses who have little training in the management of such patients. As the numbers of patients being treated on an outpatient basis increases, the College of Nursing has urged that educational programs be developed to meet the needs of the relevant health professionals.

Beaufils (1994) discusses the emergence and the role of the radiation oncology nurse professional. She notes that there has been a lack of recognition of the impact that the radiation oncology nurse has on the quality of care not only by physicians, radiation technicians and administrators, but also by nurses themselves, because until recently there has not been sufficient documentation identifying the scope of practice and associated standards for nursing care in radiation oncology.

Education for oncology nurses is generally provided as in-service by hospitals with an emphasis on chemotherapy nursing. District and community based nurses are responsible for much of the aftercare of radiotherapy patients, particularly the elderly.

There is insufficient recognition of the important role played by radiation oncology nurses in the treatment of cancer patients.

Recommendations:

- **Oncology education for nurses should include all treatment modalities. Nurses working with oncology patients need accessible and flexible study options in oncology nursing that include consumer perspectives, treatment options and aftercare management.**
- **There should be increased recognition of oncology nurses, including a widely accepted definition of their role and a national program for professional development.**

Funding arrangements for the oncology workforce

All radiation oncology trainee posts are in publicly funded institutions and most depend on State funded registrarships. The RACR has unfilled, fully accredited positions which are unfunded but would accommodate the increased numbers suggested by the MWDRC.

In the case of medical physicists and radiation therapists, the responsibility for their training rests with individual universities, all of which set their own student intakes. This situation makes planning for appropriate numbers in the workforce difficult as the health authorities are the employers.

Recommendation:

- **There should be greater coordination between State and Commonwealth bodies in determining the funds available for training.**

9. Future developments in radiotherapy

Technical and clinical developments occur continually in radiation oncology, as in most fields of medical endeavour. Advances over past decades have established the place of radiotherapy in cancer management. Future developments in the field are likely to further improve the effectiveness and efficiency of the technique. In this chapter there is a discussion of some technical and clinical advances that are already changing radiotherapy practice, as well as others that are likely to have this effect in the future.

Technical advances

The main technical advances likely to change the way radiotherapy is delivered include the following.

- **Multileaf collimators and independent jaws**, both of which improve the definition of the field of irradiation. They are computer controlled so they also decrease set-up time and ensure the reproducibility of the treatment being given. The specificity they provide is essential for the use of new techniques such as stereotactic radiosurgery and 3D conformal radiotherapy (described below).
- **On-line portal imaging (OLPI)**, a new computer based technique for verifying that the correct area is being treated. It will replace manual photographic methods, resulting in considerable savings in film costs and staff time. OLPI also has the potential to reduce treatment times and hence increase the number of patients treated.
- **Record and verify systems**, which are now routinely fitted to linear accelerators to check parameters of treatment delivery such as X-ray or electron energy, field size and collimator angle, and match this information with patient particulars before treatment can begin. Record and verify systems form a valuable part of quality assurance procedures in radiation oncology. Equipment manufacturers have expanded their record and verify systems into patient record and management systems which include facilities for patient scheduling on treatment machines or planning, appointment systems for follow-up and billing schedules for consultations, simulation, planning and treatment.
- **Three dimensional (3D) planning systems**, which are likely to eventually replace the current two dimensional systems. The 3D systems more clearly and easily outline the tumour volume for calculation of the dose distribution within the treatment volume. Dose-volume histograms can be constructed to compare different arrangements of radiation beams to determine which treatment plan is the most appropriate. Three dimensional planning systems have only recently been approved in the USA (Smith, AR et al. 1995) and they are not widely available in Australia. However, they are essential for planning treatment in new techniques such as stereotactic radiosurgery and in conformal radiotherapy.

- Using **CT scans** to replace the simulator in a technique known as CT simulation or CT-sim. A number of 2D CT cuts are taken and the images manipulated by computerised technology to form either a 3D reconstruction of the region of interest or, alternatively, a digitally reconstructed radiograph (DRR) which can be processed and become available as a normal X-ray, in the same way as a normal simulator film for planning. A CT-sim is the ideal way to create 3D pictures for accurately outlining tumour volumes for stereotactic radiosurgery and conformal radiotherapy, but due to cost implications is not likely to replace the standard simulator. In most instances, CT-sim will be used in addition to a normal simulator.

Clinical advances

A number of new clinical techniques, such as treatment given in multiple daily fractions, are being used already in Australia, but have not yet become standard treatment. Others, such as stereotactic radiosurgery have shown promising initial results but their long-term efficacy has not yet been determined.

- **Multiple daily fractions (MDF)** aim to improve local control and survival by treating to higher total doses without producing an increase in the long-term complications seen with conventional fractionation given to the same total dose (Lichter et al. 1995, Peters & Aug 1994), particularly in advanced tumours which usually respond poorly to conventional radiation schedules.

  The use of MDF regimens to improve clinical outcomes is based upon the fact that tumours behave like acutely responding normal tissues and have a greater repair capacity than late responding normal tissues. Smaller fractions are given more often, leading to an increase in acute reactions in the tumour. However, due to the greater tolerance of late responding normal tissues, there is no increase in late complications, even if the total dose is increased. If the overall treatment time is also shortened, there is less opportunity for tumour cells to regenerate during the treatment, giving a higher likelihood of control.

  Unfortunately the MDF regimens used have not always been based on sound radiobiological principles, and there is disagreement about the most effective degree of fractionation. Peters and Ang (1994) have defined the different regimens and discussed the area in some detail. There are a number of publications reporting the effectiveness of MDF, but few of these are randomised phase III studies. The available evidence for two types of fractionation are described below: hyperfractionation, in which size of dose per fraction is reduced, the number of fractions increased and the overall time about the same; and accelerated fractionation, in which the overall time of treatment is reduced, and the number of fractions, total dose and size of dose per fraction either unchanged or reduced.

  Hyperfractionation: prospective randomised Phase III clinical trials have been conducted for head and neck cancer and for bladder cancer. The EORTC trial in head and neck cancer found that hyperfractionation increased the overall five-year loco-regional control rate from 40 to 59 per cent (p=0.02) with T3 tumours accounting for most of the improvement. Survival was also increased (p=0.08) and there was no difference in late treatment related morbidity. Other studies have confirmed this finding (Horiot et al. 1992).

Accelerated fractionation: the only phase III trial is the CHART (Continuous Hyperfractionated Accelerated Radiation Therapy) regimen for advanced head and neck and lung cancers (Saunders & Dische 1990). The trial is comparing CHART treatment which consists of small frequent doses with conventional radiotherapy. Interim results indicate that for NSCLC survival is improved among CHART patients, but for head and neck cancers no difference in morbidity or survival has emerged (Saunders et al. In press).

- **3D conformal radiotherapy** is a method of achieving a *boost* dose of radiotherapy to a well defined area and has application to almost any site in the body. Treatment aims to deliver radiation to the tumour volume while sparing critical structures such as the spinal cord and surrounding normal tissues. The treatment fields are specifically designed to *conform* to the tumour volume and a multileaf collimator is required. Accurate delineation of the treatment volume using CT scanning and reconstruction using a 3D planning system are also required.

  The initial results for prostate cancer and some other sites show a significant improvement in local disease control and overall survival.

- **HDR brachytherapy** has been discussed elsewhere. Its potential uses parallel those of conformal radiotherapy as both aim to deliver a *boost* dose to a small tumour volume while sparing surrounding critical structures and normal tissues. HDR brachytherapy has additional uses in radical treatment of gynaecological malignancies and also in the palliation of obstructing lesions in carcinoma of the oesophagus or bronchus. In the latter situations, a single dose treatment may provide effective relief of symptoms in elderly or frail patients (perhaps also with metastatic disease) who would not normally be considered even for a short course of external beam radiotherapy (Brady et al. 1993).

- **Stereotactic radiosurgery** is a term used to describe the closed-skull destruction of a stereotactically defined intracranial target with a single high dose of ionizing radiation. The goals of radiosurgery are to define and deliver a clinically significant dose of irradiation within a small 3D intracranial target volume, and avoid a clinically significant radiation dose beyond the target volume. Treatment is directed at the desired area by movement of the linear accelerator through four or five non-coplanar arcs centred on that area. A 3D planning system is required, together with meticulous attention to detail, particularly as the brain and surrounding structures are very susceptible to damage.

  Although initially used for small arteriovenous malformations in areas unsuitable for surgical ablation, the indications for treatment with stereotactic radiosurgery have increased and now include pituitary tumours, meningiomas, acoustic neurinomas, ependymomas, medulloblastomas, malignant gliomas, pinealomas, crainiopharyngiomas, paediatric brain tumours and, more recently, brain metastases (Loeffler et al. 1995).

  Radiosurgery techniques are now expanding into stereotactic radiation therapy. This combines the biological advantages of fractionated external beam irradiation with the precise focal irradiation of stereotactic radiosurgery. It requires an easily relocatable head frame so that treatment arcs can be reproduced and sensitive structures avoided.

Stereotactic radiation therapy may provide an alternative approach to conventional radiation therapy where malignant and benign intracranial neoplasms are less than 3 cm.

There is a recent AIHW document about radiosurgery (AIHW 1994).

- **Intra-operative radiotherapy**, which involves external beam treatments being given during surgery. The AIHW has recently made recommendations about this, and concluded that there is evidence of significant effect on local tumour control for some cancers, but the quality of the data on the efficacy of the technique is poor and there is no established curative role for this technology yet (Patterson & Hailey 1994).
- **Combined hyperthermia and radiotherapy** is a method which has been applied to deep seated tumours. Phase II and III clinical trials are currently underway in Europe for recurrent and advanced rectal cancer, and advanced cervical and bladder cancers (Fieldamann 1995).
- **Research and development into alternative treatment strategies** is occurring in the areas of apoptosis (programmed cell death), gene therapy and immunotherapy. Gene therapy, in which a radiation-responsive element is coupled to a selected gene and introduced into the DNA of cancer cells, is being tested in vitro. If developed, radio-labelled monoclonal antibodies could have a large impact on cancer treatment by destroying tumour cells safely and specifically. These are still at the stage of early clinical trials and several obstacles to effective therapy have been identified, but encouraging initial results have been produced.

How will these developments affect radiotherapy practice?

The technical and clinical advances described above are not presently part of standard radiotherapy treatment but they are likely to eventually change the way radiotherapy is practised in Australia. They will make delivery of the treatment more accurate and facilitate changes in clinical practice which may increase rates of local control and cure. CT scanning has already improved practice by giving anatomical information for treatment planning which was previously constructed by hand. Three dimensional treatment planning allows more precise targeting of tumours and sparing of adjacent tissues, allowing trials of whether increasing the dose delivered to target tissue improves efficacy without increasing the complication rate.

Most of these new techniques are interdependent, and this may impede their rate of adoption within Australia. For example, while the initial results of 3D conformal radiotherapy in several cancer sites suggest that this treatment should be available in Australia, the need for new, highly complex equipment such as a multileaf collimator, CT scanning and 3D reconstruction of the tumour volume, and the fact that conformal radiotherapy is a time consuming procedure requiring additional expertise, means that it is not likely to be widely used for some time.

Other techniques, such as radiosurgery and stereotactic radiation therapy, are being adopted enthusiastically because they offer the possibility of cure in cancers for which treatment has always been palliative. However, they have not yet been rigorously trialed and it is too early to assess their efficacy.

New clinical practices such as MDF treatments in external beam irradiation and HDR treatments in brachytherapy are growing in use all the time. MDF is an area that holds a great deal of promise for improving the effectiveness of current radiotherapy regimens. At present the use of sound radiobiological and other complex data are necessary for determination of the appropriate fractionation schedule. Even so, the data currently available suggest that MDF treatment may well become the 'gold standard' for radiation treatment in a number of tumour sites, and this will have a significant impact on the provision of radiotherapy services in Australia. The increasing role of brachytherapy in cancer management, the reduced bed stay costs involved and the greater patient convenience all suggest that HDR will have an important role in the future.

Recommendation:

- **New technical and clinical developments should be evaluated rigorously before they become widely used.**

Conclusions

It is clear from this discussion that radiotherapy is a dynamic area, with constant innovation and adoption of new techniques. The Working Party is aware that this degree of change will alter the nature and structure of services, and has limited itself to forecasting radiotherapy services for the short term. Technical and clinical advances will improve the efficacy and reduce the complications of radiotherapy and increase its role in cancer management. It is therefore very important that current problems which contribute to the under-use of radiotherapy as a treatment for cancer, such as inadequate medical education, staff shortages and low referral rates, are addressed and resolved as soon as possible.

It is necessary to consider the effect that changes in practice will have on consumers as well as on the specialty itself. This consideration must include the families and social support networks of people with cancer. The Working Party considers that access to services should be improved by the implementation of recommendations in this report, while acknowledging that education of both consumers and providers about the potential benefits of radiotherapy remains a critical aspect of access. The establishment of multimodality clinics will be a vital component of improvements to consumers' access to information and the facilitation of partnerships in decision making about treatment. Clinics suggest that the principle of case management, particularly for complex illness, may better define treatment options as well as enhance the continuity of care between primary and tertiary providers. There should be an increased emphasis on participation to encourage a focus on people rather than institutions. It is also important that the distribution of resources for radiotherapy allow facilities to meet expressed need while maintaining high quality, responsive services.

The Working Party has satisfied itself that radiotherapy in Australia maintains a high standard of safety, and considers that its applications are appropriate. It believes that patient outcomes are as efficacious with radiotherapy as alternative treatments for a number of cancers, and has made recommendations for further studies. Outcome data should contribute to more definitive cost-effectiveness evidence. As radiotherapy and other modalities for the treatment of cancer evolve, the collection, analysis, interpretation and dissemination of evidence should be an integral component of service provision.

Appendix 1

Terms of reference of the Working Party

The Working Party was given the following terms of reference by the Australian Health Technology Advisory Committee (AHTAC):

- to investigate the safety, efficacy, appropriate applications and impact on patient outcomes of beam and isotope radiotherapy;
- to compare patient outcomes with those of alternative treatments;
- to ascertain the cost and estimate cost effectiveness;
- to investigate and report on the cost implications of equipment proliferation and treatment availability; and
- to recommend appropriate indications for use and estimate appropriate levels of availability and proliferation.

Membership of the Working Party

The membership of the Working Party that prepared this report was convened by the Australian Health Technology Advisory Committee (AHTAC) and comprised:

Ms H Lapsley	Chairperson, expertise in health economics
Dr M Boyer	expertise in medical oncology
Prof G Clunie	expertise in surgery
Dr D Hailey *	AHTAC member, expertise in health technology assessment
Ms H Keleher	nominee of the Consumers' Health Forum
Dr B Mason	expertise in radiation oncology
Dr G Morgan	expertise in radiation oncology
Dr D Waggett	AHTAC member, expertise in medical physics and biomedical engineering.

* member until March 1995

Appendix 2

Reports, inquiries and recommendations on radiation oncology services in Australia 1982–1995

1	1982	SA	Prof R C Bennett. Cancer Services Enquiry at the Royal Adelaide Hospital.
2	1982	QLD	Dr C C Wark. Report of Committee to the Minister for Health—Review of Future Requirements of the Queensland Radium Institute.
3	1983	NSW	Dr F R Trinker. Report on the Radiotherapy Oncology Services in New South Wales.
4	1983	AHMAC	Dr B J Kearney. Chairman, Super Speciality Services Working Party—Standing Committee of the Health Ministers' Conference—Draft Guidelines for Cancer Treatment Services.
5	1984	DeptHealth	Prof D G Penington. Committee of Inquiry into Rights of Private Practice in Public Hospitals. AGPS Canberra, 1984. Annexure 9 pp A130–135.
6	1984	SA	Dr D R Wigg. Radiation Oncology in South Australia—a report to the Inter-hospital Radiation Oncology Service Committee in South Australia.
7	1985	SA	Prof G Andrews. Cancer Services Survey by the Health Commission of South Australia (including a Radiotherapy Working Party).
8	1985	VIC	Prof R R H Lovell. Report of the Ministerial Committee to Review Cancer Services in Victoria.
9	1985	NSW	Dr C MacArthur. Review of Trinker Report (1983)—NSW Health Department Internal Review.
10	1985	TAS	Dr K Mowatt & Dr D Waggett. Report to Minister of Health. Radiotherapy Services in Tasmania.
11	1986	NSW	State Oncology Advisory Committee (NSW). Basic Requirements for the Radiotherapy Component of a Cancer Centre.
12	1987	AHMAC	Guidelines for Cancer Treatment Services. B J Kearney. Report of the Super Speciality Services Subcommittee of the Australian Health Ministers' Advisory Council.
13	1987	VIC	Prof A O Langlands. Report to the Health Department Victoria—The Peter MacCallum Clinic.
14	1987	SA	Dr T F Sandeman. External Review of Services in Radiation Oncology in South Australia for the Anti-Cancer Foundation of the Universities of South Australia.
15	1988	AIR	Therapy Radiographer Services Subcommittee—Report of the Draft Guidelines for Cancer Treatment Services [Published in *The Radiographer*, 1988, 35:95–105].
16	1988		Dr D R Wigg. Radiation Oncology in Australia—An Increasing Crisis [Published in *Australasian Radiology*, 1988, 32: 24–37].
17	1988	WA	Prof B Armstrong. Report to the Chief Executive Officer, Sir Charles Gairdner Hospital on the Development and Implementation of a Comprehensive Cancer Centre.
18	1988	RACR	Submission to the AHMAC Working Party on Radiation Oncology.
19	1989	AHMAC	Dr B T Collopy. Report of the Working Party on Radiation Oncology to the Health Ministers' Advisory Council.
20	1989	AHMAC	Response by States and Territories to the Report of the AHMAC Working Party on Radiation Oncology.
21	1989	ACPSEM	Position Paper: Scientific and Technical Staff in Radiation Oncology Departments [Published in *Austral Phys & Eng Sci Med* 1989 12:48–54]
22	1989	AIH	National Health Technology Advisory Panel. High Energy Radiotherapy Equipment.
23	1989	AIH	National Health Technology Advisory Panel. Automated Afterloading Brachytherapy
24	1990		Dr R A A Fox. Survey of Therapy Physics Workload in Australasia. [Published in *Austral Phys & Eng Sci Med* 1990; 13:42–44]
			Cancer (Radiotherapy) Services Strategy Plan
25	1990	VIC	Health Department Victoria. Royal Adelaide Hospital Working Party. Projected Requirements (to 1995) for Radiation Oncology Facilities in
26	1990	SA	the South Australian Public Sector
			A Strategic Plan for Adult Cancer Services in Western Australia
27	1990	WA	Health Department. (Draft) Quality Assurance in Radiation Oncology. Prepared by Diagnosis Pty Ltd
28	1991	VIC-SA	Radiotherapy Strategic Plan for New South Wales
29	1991	NSW	Health Department. Radiation Oncology Task Force. Royal Adelaide Hospital
30	1991	SA	Booz-Allan & Hamilton. Stereotactic Radiosurgery.
31	1991	AIH	National Health Technology Advisory Council.
32	1991	TAS	Prof A O Langlands. Report to the Department of Health, Tasmania on Cancer Treatment Services in Tasmania, with particular reference to Radiation Oncology
33	1993	WA	Health Department of Western Australia. Radiation Oncology Advisory Committee. Present and Future Requirements for major Radiation Oncology Equipment in Western Australia
34	1993	DHHLGCS	Medical Workforce Data Review Committee—Annual Report. AGPS Canberra, 1993
35	1993	SA	Dr D R Wigg. Radiation Oncology Strategic Plan 1994–1998
36	1994	DHHLGCS	Medical Workforce Data Review Committee. Refinement of Analysis of the Supply of and Requirements for Radiation Oncology Services. Prepared by Diagnosis Pty. Ltd.
37	1994	AIH	Intra-Operative Radiotherapy.
38	1994	DHSH	Better Health Outcomes for Australians: National Goals, Targets & Strategies. AGPS
39	1994	Federal Parliament	Senate Inquiry. Breast Cancer Screening and Treatment in Australia.
40	1995	Federal Parliament	House of Representatives Inquiry. Management and Treatment of Breast Cancer
41	1995	NSW	Health Department. Strategic Plan for Radiotherapy Services in New South Wales 1995 - 2000
42	1995	DHHLGCS	Medical Workforce Data Review Committee—Annual Report (1994). AGPS Canberra, 1995

Summary of reports and inquiries

1. Cancer Services Enquiry at the Royal Adelaide Hospital (1982)

This report was undertaken at the request of the board of Royal Adelaide Hospital to advise on cancer services at the hospital.

Recommendations were divided into radiotherapy, medical oncology and surgery with major deficiencies being identified in the first two areas. There were staff (medical, physics and radiographers) and equipment shortages and recommendations were made to rectify these. Creation of a separate department of medical oncology with a full–time director was recommended. The surgical specialties for management of oncology were, in general, considered adequate.

The report made a number of statements designed to facilitate the development of a comprehensive cancer service at Royal Adelaide. In addition, as this was the only public hospital radiation oncology service in South Australia, it was suggested that an Inter-hospital Cancer Services Committee be formed to advise on all matters of policy for provision of a radiation oncology service to all hospitals in South Australia.

A separate report from the Chief Therapy Radiographer at the Peter MacCallum Institute, Melbourne, dated 2 February 1982 related to numbers of radiographer staff and their duties.

Since this report there have been an additional five reports in South Australia (Numbers 6, 7, 14, 25 and 31).

2. Wark Report: Review of Future Requirements of the Queensland Radium Institute (1982)

This report was a confidential numbered document to the then Minister for Health. The report was designed to document the need for upgrading of existing facilities and to plan for the future development of radiation oncology in Queensland. The report was to ascertain the possible future requirements for the Queensland Radium Institute (QRI) over the ensuing five to ten years and the long-term planning of radiotherapy for Queensland.

Recommendations of the report areas follows:

- Replacement of certain items of equipment (documented) immediately.
- Completion of the redevelopment of the Herston QRI site and upgrading of the Mater Sub-centre.
- A major centre be established at either the Mater or Princess Alexandria Hospital with two linear accelerators by 1985–1986 with the capability to expand to three or four.
- A centre at Townsville to be investigated.
- The QRI Board be reconstituted; the Health Act be repealed and replaced by a new Act to cover Oncology; the QRI to continue to be responsible for the planned provision of radiotherapy services in Queensland.
- Training programs for radiotherapists, physicists, engineers, radiographers and oncology nurses be the responsibility of the QRI to provide for future expansion.

3. Trinker Report on the Radiotherapy Oncology Services in New South Wales (1983)

This report was commissioned by the then Minister of Heath for New South Wales. The terms of reference were:

- To determine the need for radiotherapy services as part of an integrated oncological service in New South Wales.
- To evaluate current radiotherapy services including evaluation of staff and equipment of radiotherapy services in New South Wales.
- To detail specific plans to ensure the delivery of effective radiotherapy services in the metropolitan areas of Sydney over the next 10 years with particular detail to the nature and type of equipment required.
- The financial implications of the planned development of services listed in section 3 of the report.

This report drew to a large extent on the Norman Report of 1974 entitled *Radiotherapy Units of the NSW Health Commission – A Review Project of the NSW Public Service Board's Scientific Advisory Committee*. The fragmentation of radiotherapy services, shortage of radiotherapists and equipment that had been in use for 14–17 years were all identified as problems. The fragmentation was to be corrected by having three radiotherapy units in Sydney seeing 2,500 patients each for the year 2000.

4. AHMAC Draft Guidelines for Cancer Treatment Services (1983)

The Draft was released in late 1983, although the final report was not published until 1986. Part of the reason for this was the deficiencies contained in the draft, due largely to the fact that the original Working Party did not contain any members with any clinical experience in the delivery of cancer services.

5. Penington Inquiry into Rights of Private Practice in Public Hospitals (1984)

This report contained 40 recommendations. In Annexure 9 entitled *Radiation Oncology – Special Issues*, attention is focused on the increase in cancer incidence; the value of radiotherapy; its cost effectiveness compared with surgery; and staffing problems.

6. Radiation Oncology in South Australia (1984)

This document was prepared for the Inter-hospital Radiation Oncology Services Committee (suggested by report no. 1, Bennett Report) and was a review of the radiation oncology services up to 1984 to be used as a reference document for further discussion.

The lack of a simulator, computerised planning equipment, automated afterloading brachytherapy, equipment for construction of blocks, moulds and immobilisation devices, beam data acquisition system or secondary standard dose meters were all identified as being necessary if the department was to have a full complement of basic equipment. This was in addition to medical and para-medical staffing shortages.

The report was detailed and evaluated a number of areas such as clerical and nursing staff, gynaecological insertions, radiotherapy beds, radiotherapy library and cancer registry.

7. Cancer Services Survey (Health Commission of SA) (1985)

There were 12 recommendations which largely centred on resolving the problems of providing information on radiotherapy to hospitals and to the hospital records for patients accommodated outside Royal Adelaide Hospital during treatment and arrangements for their subsequent follow-up by radiation oncologists from the hospital. A cancer registry was proposed and priorities for purchase of several items of radiotherapy equipment and increases in numbers of staff, including an additional two radiation oncologists were outlined.

The Working Party did not recommend the establishment of an Advisory Committee as suggested by the Bennett Report (see no.1), but that a State Radiation Oncology Advisory Committee be maintained to advise the South Australian Health Commission.

8. Lovell Inquiry: Review of Cancer Services in Victoria (1985)

The intention of this inquiry was to report on cancer services in general. The terms of reference of the inquiry were:

- To determine guidelines for the provision of accessible, effective and economic comprehensive cancer services in Victoria.
- To review the provision of therapeutic and palliative cancer services, including those privately conducted.
- To determine the requirements for:
  - i) the major modalities of cancer management (surgery, radiotherapy, chemotherapy);
  - ii) palliative services in provision of a comprehensive cancer service in Victoria.
- To make recommendations on the development of an accessible, effective and economic cancer service in Victoria over the coming decade, with particular reference to organisation, accommodation, equipment, laboratory provision and staffing.
- To estimate the cost of implementing the recommendations.

The recommendations covered areas such as medical oncology, palliative care and bone marrow transplantation extensively. Those relating to radiotherapy included the redevelopment of the Peter MacCallum Hospital complex and creation of a second principal centre in the South Eastern Metropolitan region, together with newly created associated centres being developed in conjunction with the two principal centres.

In the report several standards were defined. These were: three megavoltage machines per million of population; 500 new courses of treatment per machine per year; and seven radiation oncologists per million of population, with a workload of 215 new cases per annum.

In addition, it concluded that *distance from a treatment centre is the major factor contributing to the lesser use of radiotherapy amongst patients from non–metropolitan regions compared with patients from metropolitan regions.*

The minimum requirements for a radiation oncology department were defined. These have been repeated in Reports 11, 12, 18 and 24. These are :

- two linear accelerators
- one simulator
- one superficial X-ray unit, if appropriate
- one computer planning system with CT scanner interface
- one CT scanner
- one automatic afterloading facility
- brachytherapy facilities

A principal radiotherapy centre should have a minimum of four linear accelerators and include at least one ultra-high energy unit. A principal centre should also have a second simulator to cope with the extra workload.

The expansion of radiotherapy services in Victoria in the 1990s has largely been along the lines suggested by the Lovell Report.

9. NSW Health Department Review of Trinker Report (1985)

This was an internal review by New South Wales Health of the Trinker Report. The review also evaluated the current staffing and equipment levels and as a by-product a committee was set up by the then Minister for Health, which provided funding for four dual energy linear accelerators. Although three eventuated, the money allocated ran out and the fourth machine was not installed and was eventually provided through private funds.

10. Radiotherapy Services in Tasmania (1985)

This report was undertaken because of the imminent separation of radiotherapy services from Victoria with the enactment of the Tasmanian Cancer Services Act on 1 July 1986. Prior to this time the provision of radiation oncology services in Tasmania had been under the administrative control of the Peter MacCallum Institute in Melbourne, although the running costs were met by the Tasmanian Government.

11. NSW State Oncology Advisory Committee Report on Basic Requirements for the Radiotherapy Component of a Cancer Centre (1986)

This document was prepared for the NSW State Oncology Advisory Committee of the NSW Health Department by a committee of the Heads of Departments of Radiation Oncology in New South Wales. It appears that this document gave input from the New South Wales Health Department to the AHMAC Guidelines for Cancer Treatment Services (Report no 12)

The recommendations were essentially the same as those in the Lovell Report regarding basic equipment but were expanded to include mould room and workshop requirements and to attempt to define adequate staffing numbers in all spheres, from radiation oncologists to mould room technicians, secretarial staff, social workers and porters. This document was accepted and endorsed by the New South Wales Health Department as part of the plan by the Oncology Advisory Committee to upgrade radiotherapy services in New South Wales to internationally acceptable levels with respect to equipment and staffing in line with the need for upgrading outlined in the Trinker Report (no 3).

12. AHMAC Guidelines for Cancer Treatment Services (1987)

These guidelines were prepared by the AHMAC Super Specialty Services Subcommittee. The purpose of the guidelines was to produce a document that was broadly based and useable for health services planning, to assist in the rational provision of hospital based super specialty services, and to provide for equity of access to such services throughout Australia.

The guidelines addressed bed and staff requirements, distribution of services, paediatric care, oncology department design, radiotherapy equipment guidelines and safety issues associated with chemotherapy and radiotherapy. The guidelines also referred to issues in cancer care such as prevention, research and evaluation.

The usefulness of the document has largely been for health planners by providing a 'standard' to apply for costings of cancer treatment services.

13. Langlands Report Victoria (1987)

A copy of this report has not been obtained and comment is therefore not possible.

14. Review of Radiation Oncology in SA (1987)

This report was undertaken for the Anti-Cancer Foundation of the Universities of South Australia by Dr T F Sandeman, a senior radiation oncologist from the Peter MacCallum Institute, Melbourne.

The terms of reference were:

- Identify any present shortcomings in major equipment with particular reference to the need for providing superficial X-ray therapy services at the Royal Adelaide Hospital.
- Identify any items of major equipment which require immediate replacement, or replacement within the next five years and comment upon any staffing implications.
- Comment and make recommendations upon the methods of funding radiotherapy equipment.
- Comment and make recommendations upon the relationship of the Foundation with the Radiotherapy Department of the Royal Adelaide Hospital, with particular reference to the responsibility of the Foundation in providing funds for equipment and journals, and particularly the role in providing resources for research as distinct from routine services.

Recommendations included replacement of machines and increase in workforce numbers.

15. Australian Institute of Radiography Draft Guidelines for Cancer Treatment Services (1986)

The report was published by the Australian Institute of Radiography in response to the AHMAC Draft Guidelines for Cancer Treatment Services (Report no 4).

Prior to this document there were no established standards for staffing levels for therapy radiographers in departments of radiation oncology, although the recommendations were too late to be incorporated into the final AHMAC document (Report no 12).

Staffing Levels for 2,000 new courses of treatment were estimated at between 46 and 54 depending on the use of superficial/orthovoltage. This equated to a five machine department (400 new courses per annum or a total of 500 courses per annum, including a 25 per cent re-treatment rate). These related in round figures to 9–10 per megavoltage machine.

These numbers are at variance with the 'per million' staffing levels proposed in the AHMAC Report. The latter makes no allowance for a progressive increase in cancer incidence or other variables, such as re-treatment rate or the complexity of treatments given (eg intracavitary, stereotactic radiosurgery, paediatrics).

16. Wigg, DR 'Radiation Oncology in Australia. An Increasing Crisis' (1988)

This article was the first comprehensive report on radiation oncology equipment, staffing and treatment levels undertaken in Australia. The findings can be summarised as follows:

- Patients treated: only 36 per cent of newly diagnosed cancer patients receive radiotherapy in Australia, compared with 50 to 55 per cent in Europe, UK, Canada and the USA. This figure also varied considerably between States, from a low of 25 per cent in Queensland to 43 per cent in New South Wales.
- Radiation oncologists: there were a total of 74.5 FTE or 4.8 per million compared with a recommended 7 per million or a total of 108.
- Trainee radiation oncologists: there were 36 trainees or 2.3 per million. To correct the deficiency in numbers of specialist radiation oncologists at least an additional 21 training positions should be created immediately.
- Therapy radiographers: there were 364 positions available. The 1987 AHMAC Guidelines recommendations of 22 to 25 per million of population merely describes the current position with no provision for current understaffing in New South Wales or the low referral rates. Using the AIR recommendations (Report no 15) a deficit of 170 exists.
- Megavoltage units: there were 44 treatment units in operation with 30 per cent being Cobalt-60 units. An increase to referral rates of 55 per cent would need an extra 23 accelerators working at the same high rates (500 courses of treatment per year).

17. Comprehensive Cancer Centre at the Sir Charles Gairdner Hospital, WA (1988)

This report was to the Chief Executive Officer of the Sir Charles Gairdner Hospital by a Committee to Advise on the Development and Implementation of a Comprehensive Cancer Centre. This was a self-initiated committee from the Sir Charles Gairdner Hospital. The brief was:

- to identify the need for improvements in cancer care at the Sir Charles Gairdner Hospital and the need for a comprehensive cancer centre;
- to research the benefits that have been gained as a consequence of the development of comprehensive cancer centres elsewhere in the world;
- to outline a plan for the development of a comprehensive cancer centre at the Sir Charles Gairdner Hospital.

Many of the recommendations related to para-medical services such as psycho-social support, management of lymphoedema, dietitians, and replacement of equipment and of medical oncology services. The report was seen as relating only to SCGH and not to Western Australia as a whole.

18. RACR Submission to the AHMAC Working Party on Radiation Oncology (1988)

This submission suggested the following:

- a radiation oncology unit should provide high quality facilities for a population base of 500,000 (within 100km);
- to achieve the internationally accepted level of seven radiation oncologists per million of the population by 1995, an additional 15 posts for radiation oncologists and an additional 21 posts for trainee radiation oncologists were required immediately;
- an estimated 98 megavoltage machines would be required in 1995;
- to treat the 20 per cent of patients denied radiotherapy in 1988 an additional 25 machines would be needed immediately;
- to achieve a 55 per cent treatment rate and a level of six machines per million population by 1995 an additional 38 linear accelerators would be required;
- 35 of the megavoltage machines currently in use would need replacing by 1995;
- the total number of new/replacement megavoltage machines required by 1995 was therefore 98, at an estimated cost of $100 million; and
- sufficient numbers of therapy radiographers, medical physicists, biomedical engineers and other support staff were also needed.

19. AHMAC Report of the Working Party on Radiation Oncology (1989)

The Working Party's objective was to develop guidelines on the appropriate establishment of new radiation oncology facilities having regard to the Super Specialty Sub-Committee's Guidelines for Cancer Treatment Services and Wigg's report, *Radiation Oncology in Australia: An Increasing Crisis*. The terms of reference were:

- the current and future need for radiation oncology services;
- the minimum catchment population per radiation oncology facility;
- the need for comprehensive cancer services;
- the optimal geographic location of facilities;
- the need for adequate undergraduate and postgraduate training facilities;
- cost effective provision of services; and
- maintaining the current public-private mix of patients.

The Working Party concluded that major deficiencies exist in the provision of radiotherapy services in Australia with regard to the quality and quantity of equipment and the numbers of staff and recommended that:

- A planned program of re-equipment be undertaken immediately by Governments at both State and Federal level to ensure that by 1995 there are at least 25 additional machines. The level of equipment required will need to be consistently reviewed in the light of population growth, ageing and the increased level of referrals and as additional capacity and staff are made available.

- The basic minimum requirement in equipment for a radiation oncology unit should be:
  - two megavoltage machines of which one should be a machine of 6 Mev or greater, with an electron capability (the other machine may be an isocentric cobalt-60 unit operating at 100 cmc SSD)
  - simulator for planning
  - CT assisted computer planning facilities
  - superficial/orthovoltage machine
  - facilities for construction of patient immobilisation devices, custom made blocks and tissue compensators
  - dosimetry equipment for machine quality control
  - computerised database system for evaluation of treatment outcome.

- Brachytherapy facilities for gynaecological and interstitial treatments should be available at least in close proximity if not within the Department.

- The minimum population to be served by a Department should be 500,000. In isolated areas this may be reduced but, in any case, formal attachment to a larger metropolitan department is essential.

- There is a need for at least 130 radiation oncologists by 1995 and the immediate provision of 21 new Radiation Oncology training positions is recommended. The number of positions should thereafter be kept under review, with a number of these positions to be considered supernumerary and intended solely to correct the identified shortfall.

- To ensure sufficient therapy radiographers can be attracted to the profession, consideration be given to a new career structure and a move to a Federal award, or alternatively to the payment of a significant loading, for therapeutic radiographers who have the responsibility of the operation of high technology computerised equipment such as dual energy machines and to take account of the new educational requirements.

- There is a need for detailed studies comparing the effectiveness of radiotherapy in the treatment of a specific cancer with another modality.

- Radiation oncology facilities should establish comprehensive quality assurance programs which will also require additional funding.

By way of commentary, the Working Party on Beam and Isotope Radiotherapy notes that the major recommendation that new training positions for radiation oncologists be established was not effectively acted upon, so that by 1993 only an additional seven positions had been created (due solely to an increase in number of departments) and the Medical Workforce Data Review Committee Annual Report of 1993 therefore recommended that there should be an increase of 14 in the number of training posts for the speciality.

20. Response of States to AHMAC Working Party on Radiation Oncology (1989)

The report was considered by the AHMAC Executive in June 1989 and again in October 1989. The response to AHMAC from the States was made on the basis of the low cancer incidence rate of 3,000 per million of population used in the report which was not increased before applying expected equipment and staffing needs to those required in 1995. This was, in fact, the cancer incidence in Australia in 1980 whereas the true cancer incidence for 1995 will be around 4,000 to 4,500 per million.

21. ACPSEM Position Paper on Staffing in Radiation Oncology (1989)

This paper was produced under the chairmanship of Dr A Beddoe (Royal Adelaide Hospital) and was no doubt initiated by the AHMAC Guideline for Cancer Treatment Services (Report no 12). Numbers of physicists, dosimetrists, physics technicians and maintenance technicians were recommended for several sized departments, based on similar guidelines for staffing from several overseas countries. The levels suggested were considerably higher than those in the final AHMAC Report (no 12).

22. National Health Technology Advisory Panel: High Energy Radiotherapy Equipment (1989)

This report examined the considerations involved in the choices of high energy equipment as compared to lower energy linear accelerators or cobalt units. The paper considered clinical efficacy and cost factors and was intended as a stimulus for further discussion.

23. National Health Technology Advisory Panel: Automated Afterloading in Brachytherapy (1989)

This report provides an evaluation of a remote automated afterloading technique for brachytherapy with particular reference to its cost effectiveness and clinical efficiency. The panel concluded that its use in Australia is desirable for low dose rate brachytherapy in view of its perceived occupational health benefits to medical, nursing and other staff. Also the technology could provide benefits through allowing high dose rate therapies and increased levels of nursing care, although these were less certain.

24. Survey of therapy physics workload in Australasia (1990)

This survey showed that actual staffing levels were considerably lower than the numbers suggested in Report no 20.

25. Cancer (Radiotherapy) Services Strategy Plan, Victoria (1990)

This plan was developed by Health Department Victoria in response to the need for the expansion of radiotherapy services in Victoria. Key elements of the strategy plan were:

- an increase in the number of megavoltage machines from nine to at least 19 by 1996;
- redevelopment of the Peter MacCallum Institute (PMCI);
- distribution of machines around the PMCI/Melbourne University axis with nine machines (PMCI five, Geelong two and Heidelberg Repat. two) and the Alfred/Monash University axis with eight machines (Alfred four, Box Hill two and Monash two) together with a further two in the private sector.

26. Projected Radiation Oncology Requirements to 1995 in SA (1990)

The terms of reference for this study were specifically to address the projected requirements to 1995 for radiation oncology facilities in South Australia. The study noted that a substantial investment would be required to rectify existing deficiencies and particularly to plan for the inevitable demand. The recommendations were:

- Future projections be based on a 50 per cent referral rate.
- A Radiation Oncology Committee be formed to assist in future plans.
- The RAH site be limited to five megavoltage machines.
- Consideration be given to a second radiation oncology site in Adelaide.
- Adequate numbers of training and specialists posts to be funded.
- Option A which provides for 460 courses/machine/annum) be adopted.
- AHMAC guidelines for Radiation Oncology be adopted in the public and private sector.
- Adequate transport and accommodation be provided for patients.
- Inpatient accommodation should be sufficient to reduce the need for transport between hospitals during treatment.
- Country clinics should be implemented.

This report also documented under Options A, B & C, that it is more cost effective to increase the number of machines operating at 'normal' working hours than to run a lesser number of machines at extended hours. This was also documented in a study at Westmead Hospital by the Health Economics Research group.

27. Strategic Plan for Adult Cancer Services in WA (Draft) (1990)

Following the Armstrong Report (no 17) the WA Health Department attempted to tackle the problem and this report was their input to the debate (as a draft report so that alterations could be made before a final draft was issued).

The Report contained 26 recommendations and included a number of Appendixes relating to requirements for megavoltage radiotherapy machines and their siting, coordination with medical oncology, labour force requirements and proposals to upgrade radiation oncology services at SCGH.

In effect this document suggested that a Comprehensive Cancer Centre be established at Sir Charles Gairdner Hospital with a Director who would also manage the State Cancer Service.

28. Quality Assurance in Radiation Oncology - Diagnosis Pty Ltd (1991)

This report of 161 pages followed recommendation number 7 of the 1989 AHMAC report which stated that *radiation oncology facilities should establish comprehensive quality assurance programs which will also require additional funding.*

The terms of reference were:

- develop outcome measures suitable for the application of radiation oncology services throughout Australia;

- identify data requirements which will provide tools relevant to the assessment of treatment modalities, quality of care, efficiency and cost-effectiveness of radiation oncology services;
- develop data collection instruments;
- undertake a pilot study which examines the relationship between resource inputs, treatment modalities and outcomes of radiation oncology treatment provided in public and private clinics in Victoria and South Australia; and
- develop quality assurance and utilisation review mechanisms.

The recommendations in the report were:

- the proposed data collection instrument be established in a single facility for a trial period of 18 months;
- a project advisory structure, to include staff with epidemiological and statistical expertise, be established which is similar to that established in the first phase of the study;
- the issue of responsibility for the collection of data be explored in consultation with the relevant clinical colleges and associations including the RACR, the AAPROP, the RACS, the RACP and the RACGP;
- the costs of data management be recognised as a cost of all medical treatment; and
- the feasibility and associated costs of the establishment of dosimetric quality control similar to that which was developed by the EORTC be explored in the next stage of the study.

The report was never activated, no doubt partly because of the feeling that it may lead to an Australian 'Patterns of Care' study and also because the suggestion that the costs of data collection be added to the Medicare fee could flow on to all other areas of medical and surgical practice.

29. Radiotherapy Strategic Plan for New South Wales (1991)

The plan proposed to increase the number of megavoltage machines from 24 in 1990 to 30 in 1996 and also detailed replacement needs for antiquated equipment. A working party (no. 28) has since been formed to develop the radiotherapy plan for 1995 and 2000. It is notable in the plan that the Department recognises the need to identify and address the problem of transport.

30. Booz-Allan & Hamilton, Radiation Oncology Task Force, Royal Adelaide Hospital (1991)

Although a copy of this report has not been received and no comment can be made, it is noted that similar reports about radiation oncology were made by Booz-Allan and Hamilton at a number of other hospitals, in conjunction with an overall assessment of operating costs at each hospital. For radiation onclogy the general thrust of the recommendations was to reduce staffing levels below numbers which were in line with accepted standards of appropriate clinical practice.

31. Stereotactic radiosurgery in Australia: proposals for nationally funded centres, AIHW (1991)

This AHTAC report was in response to proposals from a number of hospitals for nationally funded centres for stereotactic radiosurgery. The AHTAC concluded that the technology should be considered a superspecialty service and that its degree of use in Australia at present did not warrant national funding.

32. Cancer Treatment Services in Tasmania (1991)

The terms of reference for this study were:

- To review the State's cancer treatment services with particular reference to radiation oncology in the context of the move to regionalisation.
- To review the Government and Regional Health Board's administrative structures responsible for cancer treatment services, again with particular reference to radiation oncology.
- To take account of concerns raised in the community, employees and unions relating to cancer services.
- To recommend an appropriate organisation of radiation oncology services which would serve as a model for the development of Statewide cancer services.

Much of the document and the recommendations are related to administrative details, rather than matters of levels of staff and equipment as seen in most other reports on radiation oncology.

33. Requirements for Radiation Oncology Equipment in WA (1993)

This report was prepared by the Radiation Oncology Advisory Committee consisting of the department heads at Royal Perth Hospital (RPH) and Sir Charles Gairdner Hospital (SCGH), several medical administrators and a nominee of the Cancer Foundation of Western Australia. In the introduction it is stated that there were many objections to the Armstrong Report (see no 17) which was seen as covering development of cancer services at SCGH and not for the state as a whole and that this would be to the detriment of services at RPH which managers approximately one third of cancer patients in Western Australia.

In October 1991 a Radiation Oncology Advisory Committee was formed with the approval of the State Health Executive. The first meeting took place on 1 April 1993.Recommendations were:

- Priority 1 New Linear Accelerator RPH
- Priority 2 Replacement of Simulator RPH
- Priority 3 Replacement of planning computer RPH
- Priority 4 Remote automatic brachytherapy for SCGH
- Priority 5 Patient database for SCGH
- Priority 6 Replacement linear accelerator SCGH
- Priority 7 Replacement of Cobalt at RPH (linear accelerator) by 1997.

34. Medical Workforce Data Review Committee Annual Report (1993)

The Medical Workforce Data Review Committee (MWDRC) was established by AHMAC following recommendations of the Commonwealth Inquiry into Medical Education and the Medical Workforce (the Doherty Inquiry).

The Annual Report for 1993 highlighted the relative deficiencies in the number of training posts in dermatology (35) and radiation oncology (44). The only other specialities with less than 150 trainees were rehabilitation medicine (60) and ophthalmology (95). Other areas of perceived need were orthopaedic surgery, ENT, O & G, geriatrics and rehabilitation medicine.

The MWDRC findings were that there was currently an undersupply which could be addressed by a modest increase in funded training positions. The MWDRC's preliminary conclusions were that:

- there should be an increase of 14 in the number of training posts;
- the issue of productivity of training be addressed to reduce the average training period from seven to five years.

35. Radiation Oncology Strategic Plan for SA 1994–1998 (1993)

This report was prepared by Dr D R Wigg, Director of Radiation Oncology at Royal Adelaide Hospital against the background that the Health Commission of SA had no policy regarding radiation oncology services for the future. His recommendations were:

- Appoint an additional radiation oncologist.
- Replace linear accelerator 3, now 15 years old.
- Increase the numbers of therapy radiographers by at least six to comply with AIR guidelines, with further increases needed with increases in numbers treated.
- Create a second sub-centre with two linear accelerators at either Flinders Medical Centre/Repatriation or at Queen Elizabeth Hospital, with other associated equipment and adequate levels of staffing.
- Replace and/or provide a second simulator with CT at RAH.
- Remote automated afterloading brachytherapy for RAH.
- Replacement orthovoltage machine at RAH, now 30 years old.
- Extra radiation oncology beds to avoid costs of transporting patients from other hospitals for treatment (estimated at $300,000 per year).
- Development of country clinics—not possible at present due to lack of specialist radiation oncologists.

36. Refinement of the analysis of the supply of and the requirements for radiation oncology services, Diagnosis Pty Ltd for MWDRC (1994)

The terms of reference of this inquiry were to:

- assess the level of the balance between supply of and requirements for radiation oncology services;
- estimate the future balance of supply and requirements for these services;
- identify key strategies which could address any identified current or possible future imbalance between supply of and demand for radiation oncology services;

The conclusions of the report were:

- The number of training posts accredited by the RACR for training of radiation oncologists should be increased to 55 in 1996 and to 60 by 2004.
- There will be an undersupply of radiation oncologists until 2004. The target of 130 radiation oncologists by 1995 set by the AHMAC Working Party in 1989 cannot be met since the maximum number which will be in the workforce in 1995 is 115.
- By the year 2014 the number of radiation oncologists required will be 12 per million of the population. This contrasts with the eight ot ten per million recommended by AHMAC in 1989.
- Based on the distribution of cancers treated by radiation oncology in each State, there is currently an excessive number of training posts in NSW and the ACT and a clear shortage in both Queensland and Victoria.
- The evidence that radiation oncology is more effective than other modalities for treating cancer is inconclusive. Direct comparisons between modalities are of little assistance if the real question is determining the optimal combination of modalities.
- The limited survey of radiation oncologists, medical oncologists and surgeons found a lack of agreement among the three specialties about the proportion of cancers considered appropriate for radiotherapy treatment.

The first three recommendations were adopted verbatim into the 1994 MWDRC report, including suggestions that the RACR make every effort to ensure that trainees complete their training in the shortest possible time.

37. Intraoperative radiotherapy - IORT (1994)

This report was prepared by the AIHW because of a proposal from a Sydney hospital to establish an IORT unit. The report concluded that the main issue was the extent to which a largely experimental technique should be funded by the State, given the number of cases treated. If the unit was established the report recommended that systematic collection of clinical and economic data be undertaken with a particular focus on quality of life issues.

38. Better Health Outcomes for Australians (1994)

Cancer was one of four major key areas identified in which improvements in outcome would benefit Australians. Several of the points made follow:

- the most acute shortage of cancer treatment services is in radiotherapy;
- most medical and nursing students graduate without exposure to specialist cancer treatment services;
- access to radiotherapy for rural patients could be improved by suitable hostel services in major metropolitan areas;
- appropriately funded regular visits by radiation oncologists to rural centres is needed to improve access to specialist consulting services;
- better evidence is needed about the benefits and cost-effectiveness of multidisciplinary centres for cancer treatment compared with more decentralised care.

39. Senate Breast Cancer Report (1994)

The Senate Committee heard evidence of the shortages of radiotherapy services, examined the MWDRC report on the shortage of radiation oncologists and examined the supply of radiotherapy facilities.

Recommendations which relate to radiation oncology were:

- that supply of radiation oncology services be regularly monitored by the National Breast Cancer Centre;
- that the geographic location of radiotherapy facilities be improved so that women living in areas outside the metropolitan areas can obtain equitable access to these services;
- that the level of travel and accommodation assistance be improved for women living in areas outside metropolitan centres who require radiotherapy treatment.

40. House of Representatives Breast Cancer Report (1995)

Recommendations in this report which relate to radiotherapy were:

- that greater exposure of medical undergraduates to Radiation Oncology Departments be provided by medical schools as a matter of urgency;
- that the AHTAC immediately address the distribution of radiotherapy units and the required number of radiation oncologists and technical staff; and
- that governments standardise and broaden travel and assistance schemes.

41. NSW Health Department Radiotherapy Working Party (1995)

The working party was proposed by the Minister for Health in March 1994 following extensive media coverage of the claim by a surgeon at Penrith that women were being forced to have mastectomy for breast cancer, due to the absence of radiation oncology west of Westmead and the long waiting lists for radiotherapy at Westmead.

The final report was released just before the State election in March 1995 and included:

- details of the proposed expansion of radiation oncology facilities to increase the number of linear accelerators in NSW/ACT public hospitals from 21 in 1995 to 30 in 2000 and increase the number in all hospitals from 28 in 1995 to 39 in 2000; and
- a proposal to examine support requirements for rural cancer patients and their carers in accessing radiotherapy treatment (also proposed in the 1991 plan but not carried out);

42. 1994 MWDRC Annual Report (1995)

This report contained the recommendations for radiation oncology given in the full report by Diagnosis Pty Ltd.

Appendix 3

Projected megavoltage machine requirements for Australia and individual States for 1995, 2000 and 2005

Method

The number of megavoltage linear accelerators needed for radiotherapy treatment is not a static number per million of population (as described in previous reports). Although the number of newly diagnosed cancer patients who can be treated per year per machine is static, the number of newly diagnosed cancer patients needing treatment will increase due to increases in cancer incidence and in the population. These two latter factors have been estimated and the appropriate numbers of machines have been determined for each State individually and separately for Australia.

Cancer incidence

The cancer incidence (and population figures) for the years 1980 to 1991 (inclusive) were provided by the National Cancer Statistics Clearing House of the Australian Institute of Health & Welfare, Canberra. For each State and for Australia, the crude cancer incidence rate per million of population was calculated by dividing the total number of cancers recorded for a year by the population in that year (in millions). The cumulative change in cancer incidence was calculated by adding or subtracting the yearly change between successive years and an average annual change in crude cancer incidence was derived. This average figure was then extrapolated from the base level of cancer incidence to arrive at an estimation of the crude cancer incidence rate for 1995, 2000 and 2005.

Population

The projected population numbers were derived from the Series D Projections of the ABS publication *Projections of the populations of Australia States and Territories 1993 to 2041 - Catalogue No. 3222.0* for the years 1995, 2000 and 2005.

New cancer patients per machine

The number of attendances for megavoltage treatment per machine have been set by the Commonwealth for the purpose of Medicare rebates and HPG Funding at 8,280 per annum. At an average of 17 attendances per course of treatment, this equates to 487 new courses of treatment per machine per year. Assuming a re-treatment rate of 25 per cent, the 487 new courses of treatment consist of 390 newly diagnosed cancer patients and 97 patients (or 25 per cent of 390) who require a second course of treatment. The absolute numbers of newly diagnosed cancer patients were determined using the projected crude cancer incidence figures and the projected population figure derived by the above methods. This was then divided by 390 to give the estimated number of megavoltage machines required.

Assumptions

The number of new courses of treatment per machine per year used to determine the number of megavoltage machines has varied between reports. The 1987 AHMAC Report suggested 440 new cancer patients per machine per year by reducing the 500 new courses per year by a 20 per cent re-treatment rate and 10 per cent being treated on other than megavoltage. This was four per million of population although the Lovell Report of 1985 suggested three per million of population. The HDV Plan of 1990 recommended 500 new course per machine and three per million of population. The New South Wales Plan of 1991 adopted the 1987 AHMAC Report recommendations of 440 new cases per machine. In the plan, the throughput assumptions were derived from mean data from radiotherapy facilities in New South Wales for 1993. There were 19 attendances per course; an eight hour working day; 4.1 attendances per hour and 234 working days per annum. A 20 per cent re-treatment rate was also assumed. Using these figures the number of courses of treatment is 404.

Reduction of the numbers of newly diagnosed patients by 10 per cent due to treatment on other than megavoltage equipment (namely, orthovoltage or brachytherapy) as suggested by the 1987 AHMAC Report is no longer tenable. The use of orthovoltage only to treat newly diagnosed patients has decreased sharply as many of the newer departments do not have an orthovoltage/superficial machine and rely on electron beam for treatment of skin malignancies. Nowadays, skin cancers are also treated by plastic surgeons or dermatologists and when radiotherapy is used it is more likely to be electron beam therapy on a megavoltage accelerator. Likewise, brachytherapy for gynaecological or other cancers is invariably used to give a *boost* (or highly localised dose), so that these patients receive the majority of their treatment with megavoltage beams with brachytherapy as an additional or supplementary dose.

As there are a number of estimates of expected machine utilisation rates and there will be a variation between departments depending on the complexity of the treatments required, it would seems reasonable to adopt the Commonwealth figures of 8,280 attendances per year. This is a total of 487 courses of treatment per year. With a 20 per cent re-treatment rate this gives a figure of 390 newly diagnosed cancer patients and 97 (20 per cent of 390) patients re-treated (or receiving a second course) per machine per year.

In determining megavoltage machine requirements, the cancer incidence data from the Northern Territory were effectively ignored due to the small numbers which would accrue to either South Australia or Queensland. The cancer incidence in the Northern Territory for 1988 was only 1,406 per million, or a total number of 219 new cancers. While this may represent under-reporting particularly in Aboriginal communities, the proportion of the population over 65 years was only 2.7 per cent in 1991. No allowance has been made for *cross-border* patient transfer. It is accepted that New South Wales patients may have treatment in the Australian Capital Territory or travel to Melbourne from the Riverina and that northern New South Wales patients travel to Brisbane for treatment. These transfers have been allowed for in the machine numbers in the NSW Radiotherapy Plan, which includes the Australian Capital Territory, but no allowance has been made for this for Queensland or Victoria.

New South Wales

	Population (Millions)	Cancers registered	Crude incidence per million	% change in incidence
1980	5.17527	15,105	2918	
1981	5.234889	15,446	2950	+ 1.09
1982	5.303580	15,614	2944	- 0.20
1983	5.352959	16,403	3064	+ 4.07
1984	5.402729	16,815	3112	+ 1.56
1985	5.464512	18,410	3369	+ 8.26
1986	5.531526	19,199	3470	+ 2.99
1987	5.605269	19,897	3533	+ 1.81
1988	5.699285	20,146	3534	+ 0.02
1989	5.771946	20,476	3547	+ 0.36
1990	5.826850	20,920	3590	+ 1.21
1991	5.902411	22,097	3744	+ 4.26

Cumulative Increase = 25.42% 0R Average Annual Increase = 2.31%

Extrapolation of cancer incidence by average annual increase of 2.3%

1980	2918	1993	3921
1981	2985	1994	4011
1982	3053	1995	4104
1983	3124	1996	4198
1984	3195	1997	4295
1985	3269	1998	4393
1986	3344	1999	4498
1987	3421	2000	4598
1988	3500	2001	4704
1989	3580	2002	4812
1990	3663	2003	4920
1991	3747	2004	5035
1992	3833	2005	5150

Megavoltage machine requirements:

	Population	Incidence	Cancers	50% treated	55% treated
1995	6,110,500	4011	24,509	31	35
2000	6,419,500	4598	29,517	38	42
2005	6,754,300	5150	34,785	45	49

Victoria

	Population (millions)	Cancers Registered	Crude Incidence per million	% change in incidence
1982	3.992870	13,091	3278	
1983	4.035702	13,033	3229	-1.49
1984	4.076492	13,747	3372	+ 4.42
1985	4.120068	13,960	3388	+ 0.47
1986	4.160856	13,857	3363	- 1.71
1987	4.207689	14,443	3432	+ 3.06
1988	4.260306	14,762	3465	+ 0.96
1989	4.321484	15,174	3511	+ 1.32
1990	4.379822	15,791	3605	+ 2.67
1991	4.416320	16.540	3745	+ 3.88

Cumulative increase = 13.58% or Annual Average Increase = 1.5%

Extrapolation of cancer incidence by average annual increase of 1.5%

1982	3278
1983	3327
1984	3377
1985	3427
1986	3479
1987	3531
1988	3584
1989	3638
1990	3692
1991	3748
1992	3804
1993	3861
1994	3919
1995	3978
1996	4037
1997	4098
1998	4159
1999	4222
2000	4285
2001	4349
2002	4414
2003	4480
2004	4547
2005	4615

Megavoltage machine requirements

	Population	Incidence	Cancers	50% treated	55% treated
1995	4,502,000	3919	17,643	23	25
2000	4,679,400	4285	20,051	26	28
2005	4,866,500	4615	22,459	29	31

Queensland

	Population (millions)	Cancers registered	Incidence per million	% change in incidence
1982	2.424586	7,477	3083	
1983	2.482282	8,097	3261	+ 5.77
1984	2.523859	8,688	3442	+ 5.55
1985	2.571218	9,165	3564	+ 3.54
1986	2.624595	9,678	3687	+ 3.45
1987	2.675313	10,128	3785	+ 2.67
1988	2.742945	9,727	3546	- 6.31

Cumulative increase = 14.65% or Average annual increase = 2.44%

Extrapolation of cancer incidence by average annual increase of 2.4%

		1993	4001
		1994	4098
1982	3083	1995	4196
1983	3156	1996	4297
1984	3232	1997	4400
1985	3310	1998	4505
1986	3389	1999	4613
1987	3471	2000	4724
1988	3554	2001	4838
1989	3639	2002	4954
1990	3727	2003	5072
1991	3816	2004	5194
1992	3908	2005	5319

Megavoltage machine requirements:

	Population	Incidence	Cancers	50% treated	55% treated
1995	3,256,400	4196	13,664	18	19
2000	3,581,700	4724	16,920	22	24
2005	3,917,600	5319	20,838	27	29

Western Australia

	Population (millions)	Cancers registered	Crude incidence per million	% change in incidence
1982	1.338899	3,570	2666	
1983	1.369050	3,665	2677	+ 0.41
1984	1.391237	3,710	2667	- 0.41
1985	1.418564	4,103	2892	+ 8.47
1986	1.459019	4,185	2868	- 0.82
1987	1.490059	4,398	2951	+ 2.89
1988	1.54392	4,625	2995	+ 1.49
1989	1.594745	4,692	2942	- 1.76
1990	1.633825	5,005	3063	+ 4.11
1991	1.636783	5,383	3288	+ 7.34

Cumulative increase = 21.72% or Average annual increase = 2.4%

Extrapolation of cancer incidence by average annual increase of 2.4%

		1993	3460
1982	2666	1994	3543
1983	2729	1995	3628
1984	2795	1996	3715
1985	2862	1997	3805
1986	2931	1998	3896
1987	3001	1999	3989
1988	3073	2000	4085
1989	3147	2001	4183
1990	3222	2002	4283
1991	3300	2003	4386
1992	3379	2004	4491
		2005	4599

Megavoltage machine requirements:

	Population	Incidence	Cancers	50% treated	55% treated
1995	1,722,300	3628	6249	8	9
2000	1,863,000	4085	7610	10	11
2005	2,013,100	4599	9258	12	13

South Australia

	Population (millions)	Cancers registered	Incidence per million	% change in incidence
1980	1.308397	4,285	3274	
1981	1.318769	4,417	3349	+ 2.29
1982	1.331108	4,552	3419	+ 2.09
1983	1.345775	4,633	3442	+ 0.67
1984	1.360048	4,896	3599	+ 4.56
1985	1.371197	4,610	3362	- 6.58
1986	1.382550	4,561	3298	- 1.9
1987	1.393813	5,074	3640	+ 10.3
1988	1.407984	5,193	3688	+ 1.31
1989	1.424647	5,434	3814	+ 3.41
1990	1.430121	5,579	3901	+ 2.28
1991	1.447172	5,830	4028	+ 3.25

Cumulative increase = 21.68% or Average annual increase = 1.97%

Extrapolation of cancer incidence by average yearly increase of 2%

1980	3274	1993	4235
1981	3339	1994	4319
1982	3406	1995	4406
1983	3474	1996	4494
1984	3543	1997	4584
1985	3614	1998	4675
1986	3687	1999	4769
1987	3760	2000	4864
1988	3836	2001	4961
1989	3912	2002	5060
1990	3990	2003	5161
1991	4070	2004	5264
1992	4152	2005	5369

Megavoltage machine requirements:

	Population	Incidence	Cancers	50% treated	55% treated
1995	1,475,500	4406	6500	8	9
2000	1,519,600	4864	7391	9	10
2005	1,561,000	5369	8381	11	12

Australian Capital Territory

	Population (millions)	Cancers registered	Crude incidence per million	% change in incidence
1982	0.233045	456	1956	
1983	0.238983	487	2037	+ 4.14
1984	0.245112	523	2133	+ 4.71
1985	0.251389	526	2092	- 1.92
1986	0.258910	543	2097	+ 0.23
1987	0.263156	560	2128	+ 1.47
1988	0.273318	586	2144	+ 0.75

Cumulative increase = 9.38% Average annual increase = 1.56%

Extrapolation of cancer incidence by an average annual increase of 1.6%

1982	1956	1994	2354
1983	1986	1995	2391
1984	2017	1996	2428
1985	2048	1997	2466
1986	2080	1998	2505
1987	2113	1999	2544
1988	2146	2000	2584
1989	2179	2001	2624
1990	2213	2002	2665
1991	2248	2003	2707
1992	2283	2004	2750
1993	2318	2005	2794

Megavoltage machine requirements

	Population	Incidence	Cancers	50 % treated	55% treated
1995	309,100	2391	739	1	1
2000	337,500	2584	872	1	1
2005	368,100	2794	1028	1	1.5

Tasmania

	Population (millions)	Cancers Registered	Crude incidence per million	% change in Incidence
1980	0.423590	1224	2396	
1981	0.427224	1213	2839	- 3.30
1982	0.429845	1228	2856	+ 0.59
1983	0.432805	1337	3089	+ 8.15
1984	0.437760	1301	2971	- 3.82
1985	0.442828	1358	3066	+ 3.19
1986	0.446473	1385	3102	+ 1.17
1987	0.449135	1455	3239	+ 4.41
1988	0.448414	1512	3371	+ 4.07
1989	0.451138	1634	3621	+ 7.41
1990	0.456633	1732	3792	+ 4.72
1991	0.466908	1758	3765	- 0.71

Cumulative increase in incidence = 25.88% Average yearly increase = 2.35%

Extrapolation of cancer incidence by an average annual increase of 2.3%

1980	2936	1993	3970
1981	3004	1994	4064
1982	3075	1995	4159
1983	3147	1996	4257
1984	3221	1997	4357
1985	3297	1998	4460
1986	3375	1999	4564
1987	3454	2000	4672
1988	3535	2001	4781
1989	3618	2002	4890
1990	3703	2003	5002
1991	3790	2004	5117
1992	3879	2005	5234

Megavoltage machine requirements

	Population	Incidence	Cancers	50% treated	55% treated
1995	478.200	4159	1988	3	3
2000	494,100	4672	2308	3	3
2005	508,300	5234	2659	3	4

Australia

	Population (millions)	Cancers registered	Incidence per million	% change in incidence
1982	15.184247	46,119	3037	
1983	15.393472	47,799	3105	+ 2.23
1984	15.579391	49,812	3197	+ 2.96
1985	15.788312	52,697	3337	+ 4.37
1986	16.01835	53,554	3343	+ 0.17
1987	16.251636	56,041	3448	+ 3.14
1988	16.531939	56,770	3433	- 0.43

Cumulative increase = 12.46 % or Average annual increase = 2.08 %

Extrapolation of cancer incidence by average yearly increase of 2.1%

1982	3037	1994	3897
1983	3100	1995	3979
1984	3165	1996	4062
1985	3232	1997	4147
1986	3300	1998	4235
1987	3369	1999	4323
1988	3440	2000	4414
1989	3512	2001	4507
1990	3586	2002	4601
1991	3661	2003	4698
1992	3738	2004	4797
1993	3817	2005	4898

Megavoltage machine requirements

	Population	Incidence	Cancers	50% treated	55% treated
1995	18,028,100	3979	71734	92	101
2000	19,084,500	4414	84239	108	119
2005	20,194,300	4898	98912	127	140

Current and projected machine numbers for States and Australia

	1994 Current	1995 Projected	2000 Projected	2005 Projected
NSW	25	31–35	38– 42	45–49
Victoria	16	23–25	26– 28	29–31
Queensland	12	18–19	22–24	27–29
WA	8–9	10–11	12–13	
SA	8	8–9	10–11	12–13
Tasmania	2	3–3	3–3	3–4
ACT	2	2	2	2
Estimated Numbers:		93–100	111–121	130–141
Australia	75	**97–101**	**108–119**	**127–140**

Population data for Australia

	1988	1990	1992	1995	2000
NSW & ACT	5,943,200	6,109,350	6,275,500	6,541,250	6,842,800
Victoria	4,260,300	4,365,775	4,471,250	4,655,500	4,853,000
Queensland	2,742,900	2,846,700	2,950,500	3,146,750	3,445,100
SA & NT	1,563,800	1,602,650	1,641,500	1,709,750	1,781,600
WA	1,543,900	1,618,950	1,694,000	1,843,250	2,062,300
Tasmania	448,400	456,950	465,500	480,000	489,200
AUSTRALIA	**16,531,900**	**17,000,37**	**17,498,250**	**18,376,500**	**19,474,000**

Estimates of population and cancer incidence

	Population (million)	Cancer incidence (per million)	Newly diagnosed cancer patients per year
1982	15.2	3,011	45,750
1983	15.4	3,130	48,150
1984	15.6	3,175	49,750
1985	15.8	3,325	52,500
1988	16.5	3,500	57,750
1990	17.0	3,625	61,625
1992	17.5	3,775	66,065
1994	18.0	3,950	71,100
1996	18.5	4,150	76,775
1998	19	4,375	83,125
2000	19.5	4,525	88,240

Appendix 4

Acronyms and abbreviations

AAPROP	Australian Association of Private Radiation Oncology Practices
ABS	Australian Bureau of Statistics
ACPSEM	Australasian College of Physical Scientists and Engineers in Medicine
AHMAC	Australian Health Ministers' Advisory Council
AHTAC	Australian Health Technology Advisory Committee
AIHW	Australian Institute of Health and Welfare
AIR	Australian Institute of Radiography
AMA	Australian Medical Association
AN-DRG	Australian National Diagnosis Related Groups
BHOOC	Better Health Outcomes Overseeing Committee
CHART	continuous hyperfractionated accelerated radiation therapy
CT	computed tomography
DCIS	ductal carcinoma in situ
DHHLG	Department of Health, Housing and Local Government
DHSH	Department of Human Services and Health
DMLA	dual modality linear accelerator
DRR	digitally reconstructed radiograph
EORTC	European Organisation for Research and Treatment of Cancer
FIGO	International Federation of Gynaecology and Obstetrics
FRO	Faculty of Radiation Oncology, Royal Australasian College of Radiologists
HDR	high dose rate
IUCC	International Union Against Cancer
LDR	low dose rate
MBS	Medicare Benefits Schedule
MDF	multiple daily fractions
MRI	magnetic resonance imaging
MWDRC	Medical Workforce Data Review Committee

NHMRC	National Health and Medical Research Council
NPBY	national patient benefit year
NSCLC	non-small cell lung cancer
OLPI	on-line portal imaging
PATS	Patient Accommodation and Travel Scheme
PCS	Patterns of Care Study
PDR	pulsed dose rate
PIVOT	Prostate Cancer Intervention Versus Observation Trial
QALY	quality adjusted life years
QCHOC	Quality of Care and Health Outcomes Committee
RACR	Royal Australasian College of Radiologists
RTOG	Radiation Therapy Oncology Group
SAHC	South Australia Health Commission
SCLC	small cell lung cancer
SPLA	single photon linear accelerator
TURP	transurethral resection of prostate

Appendix 5

Glossary

Adjuvant chemotherapy	The use of either chemotherapy or hormone therapy following surgery (usually within six weeks) to eradicate micrometastatic cancer.
Afterloading	Loading of the radioactive isotopes for brachytherapy into position after surgery.
Atelectasis	Collapse of a lung or of a portion of a lung.
Brachytherapy	The use of isotopes inserted into i) tissue (interstitial) or ii) body cavities (intracavitary) to deliver radiation to a limited volume.
Carcinoma	A malignant tumour arising from epithelial cells. Carcinomas spread by local infiltration and by invading blood vessels and lymphatisc, they may also spread to distant sites such as lung, liver, lymph nodes and bone. (See metastasis.)
Chemotherapy	The use of medications (drugs) to kill cancer cells.
Clinical trial	Research conducted with the patient's permission to understand the underlying disease process and/or methods to treat it.
Cobalt-60	A radioactive isotope of cobalt used as a source of radiation (in the form of gamma rays) to treat some forms of cancer.
Combined modality treatment	The integration of two or more forms of treatment to combat the cancer, ie radiation and surgery, radiation and chemotherapy or surgery, radiation and chemotherapy.
Cost benefit	In this form of evaluation attempts are made to measure both the costs and consequences of alternatives in dollars. The results of such analyses might be stated either in the form of a ratio of dollar benefits, or as a simple sum (possibly negative) representing the net benefit (loss) of one program over another.
Cost effectiveness	In this form of evaluation the incremental cost of a program, from a particular viewpoint, is compared to the incremental health effects of the program, where the health effects are measured in natural units related to the objective of the program, for example cases found, cases of disease averted, lives saved, life-years gained. The results are usually expressed as a cost per unit of effect.
Cost minimisation	In this form of evaluation the consequences of two or more alternatives are examined alongside costs, and are show to be equivalent.

Cost utility	In this form of evaluation the incremental cost of a program, from a particular viewpoint, is compared to the incremental health improvement attributable to the program, where the health improvement is measured in quality adjusted life-years (QALYs) gained. The results are usually expressed as a cost per healthy day or the cost per QALY gained.
Cure	Usually, five-year period after completion of treatment during which time patient exhibits no evidence of disease.
Disease free survival	The time from the primary treatment of the cancer to the first evidence of cancer recurrence.
Effectiveness	This is a measure of the benefit of the technology under average conditions of use in clinical practice. It is influenced by factors such as mix of patients, duration of treatment and the convenience and acceptability of treatment compared with alternative treatments.
Efficacy	This is a measure of the benefit of the technology from clinical trials conducted under ideal conditions.
Electron	The smallest particle of negative electricity. Electrons have a useful property of finite penetration of tissue as opposed to the exponential absorption that occurs with X-rays.
Etiology	The study of causes of diseases.
Fractionation	Dividing the total planned radiation dose into a number of smaller doses (fractions) to be given over a longer period. Consideration is given to biologic effectiveness of smaller doses.
Grade	Assessment of a carcinoma's malignant potential by assessing the histology of the tumour: degree of formation of ducts (differentiation), cellular abnormality (atypia) and the number of cells in division (mitotic rate or mitotic index). It is reported as grade I, II or III, with grade III (high grade) being the worst prognosis.
Gray (Gy)	The modern unit of radiation dosage, equivalent to the deposition of one joule of energy per kilogram of tissue (one Gray equals 100 rad, the formerly used unit of absorbed dose). (See rad.)
Histology	Assessment of cellular features by light microscopy of sections from paraffin embedded tissue.
Hyperplasia	Increased numbers of ductal epithelial cells.
Increment	See fraction.
In-situ carcinoma	Carcinoma confined to ducts or terminal lobules. In approximately 30 per cent of cases, invasive carcinoma will eventually develop.

Isotope	One of two or more atoms having the same atomic number but different mass number.
Linear accelerator	Produces beams of X-rays or high energy electrons that are focussed on to a tumour within the body. Millions of volts of radiation can be delivered by linear accelerators (linacs).
Linac	See linear accelerator.
Medical oncologist	A specialist medical practitioner who studies and treats cancers using cytotoxic drugs.
Megavoltage	Megavoltage applies to machines delivering X-rays of greater than 1 MV energy. This includes Cobalt-60 apparatus and modern linear accelerators.
Metastasis	The process by which carcinoma cells are disseminated from the tumour origin (primary tumour) to a distant site. Transportation of the cells is generally via lymphatics or blood vessels.
Metastatic cancer	Cancer that has spread to a site distant from the original primary site.
Oncology	The science of treatment of malignant tumours, either with surgery, radiotherapy, chemotherapy or combinations of these modalities.
Orthovoltage	X-rays delivered from generators operating at less than 500 KV and usually in the region of 250–300 KV.
Overall survival	The time from the primary treatment of the cancer to the death of the patient.
Palliation	The alleviation of symptoms due to the underlying cancer.
Prognostic indicators	There are clinical, pathological or biochemical features of the tumour (or patient) which predict outcome.
Progression or disease	The continuing growth of the cancer. Often applicable when discussing treatment failure.
Quality of life	The subjective assessment of lifestyle, especially with regard to symptoms of cancer and/or side effects of treatment.
Rad	An old unit of radiation dose, now superseded by the Gray. 1 Gray = 100 rads.
Radiation oncologist	A medical practitioner who specialises in the treatment with radiotherapy of patients suffering from cancer.
Response to therapy	The disappearance of all detectable cancer for a minimum of one month.

Radiation therapist	A technician who has undergone 2–3 years practical and theoretical training in radiation oncology. This person is responsible for administering radiotherapy to patients under the direction and guidance of a radiotherapist.
Radio-pharmaceuticals	Unsealed radionuclides that are given by intravenous injection.
Staging	The use of clinical examination, imaging (X-rays, bone scans), biochemical and pathologic information to determine the extent of the underlying cancer.
Toxicity	Side effects due to treatment administered.
Tumour	An abnormal growth of tissue which may be localised (benign) or invade adjacent tissues (malignant) or distant tissues (metastases).
Tumour type	The overall histological pattern of a tumour.
Treatment failure	The inability of the cancer therapy (whether surgery, radiation or chemotherapy) to control the primary growth or spread of the cancer.
Teletherapy	Radiation therapy delivered from a distance by a Cobalt-60 unit or a linear accelerator.
X-rays	Electromagnetic radiations with wave lengths in the range of 0.1 to 100 angstroms.

References

Abraham B, d'Espaignet ET & Stevenson C (1995) *Australian Health Trends 1995*, AIHW, Canberra.

AHMAC Health Outcomes Seminar (1993) *AHMAC Sunshine Statement*, Commonwealth Department of Health, Housing, Local Government and Community Services, Canberra.

AHMAC Working Party on Radiation Oncology (1989) *Report to the Australian Health Ministers' Advisory Council.*

Armstrong J, Shank B, Scher H et al. (1991) 'Limited small-cell lung cancer: do favourable short-term results predict ultimate outcome?' *American J Clin Oncol* 14(4): 285–290.

Atterbury VE (1993) 'High dose rate brachytherapy for carcinoma of the cervix' *Current Opin Oncol* 5:1005–1009.

Australian Bureau of Statistics (1995) *Causes of Death, Australia*, ABS, Canberra, Catalogue no 3303.0.

Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM)Topic Group on Radiotherapy staffing (1989) 'Position paper: scientific and technical staffing of radiation oncology departments' *Aust Phys & Eng Sci in Med* 12:48–54.

Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) (1995) *Report to the AHTAC Working Party on Beam and Isotope Radiotherapy. Requirements for Medical Physicists in Radiation Oncology in Australia.*

Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) (1995) *Draft report for the NHMRC. A Code of Safe Practice for External Beam and Sealed Brachytherapy Sources used in Radiation Oncology.*

Australian Institute of Health and Welfare (1989) *Automated Afterloading in Brachytherapy*, AIHW Report no. 23, Canberra.

Australian Institute of Health and Welfare (1994) *Stereotactic Image-guided Surgery. Emerging Health Technology Brief*, p.25.

Australian Institute of Radiography (AIR) Therapy Radiography Services Sub-committee. (1988) 'Report on draft guidelines for cancer treatment services' *Radiographer* 35:95–105

Awan, AM & Weichselbaum RR (1990) 'Palliative radiotherapy' *Hematol/Oncol Clinics N Am* 4(6):1169–1181.

Bagshaw MA, Kaplan ID, Valdagni R et al. (1992) 'Radiation treatment of bone metastases and the biological considerations' *Adv Exp Med & Biol* 324:255–268.

Bagshaw MA (1993) 'Results and new directions in the definitive treatment of prostate cancer with radiotherapy' *Frontiers of Radiation Therapy and Oncology* 27:166–172.

Bagshaw MA, Cox RS & Hancock SL (1994) 'Control of prostate cancer with radiotherapy: long-term results' *J Urology* 152 (5):1781–1785.

Ball D, Bishop J, Smith J, et al (1995) 'A phase III study of accelerated radiotherapy with and without carboplatin in non-small cell lung cancer: an interim toxicity analysis of the first one hundred patient' *Int J Radiation Oncol Biol Phys* 31:267–272.

Barry MJ, Fleming C, Coley CM, et al (1995) 'Should Medicare provide reimbursement for prostate-specific antigen testing for early detection of prostate cancer? Part 3: Management strategies and outcomes' *Urology* 46: 277–289.

Barton M, Boyages J, Crennan E, Fisher RJ et al (1995) 'Radiation therapy for early Hodgkin's disease. Australasian Patterns of Care' *Int J Radiation Oncol Biol Phys.* 31:227–236.

Barton MB, Gebski V, Manderson C. & Langlands AO (1995) 'Radiation therapy: are we getting value for money?' *Clin Oncol* 7: 287–292.

Beauchamp T & Childress J (1989) *Principles of Biomedical Ethics*, Oxford University Press.

Beaufils C (1994) 'The emergence of the radiation oncology nurse professional' *Cancer Forum* 18:174–175.

Biti GP, Cimino G, Cartoni SM et al. (1992) 'Extended-field radiotherapy is superior to MOPP chemotherapy for the treatment of pathologic stage I-IIA Hodgkin's disease: Eight-year update of an Italian prospective randomised study' *J Clin Oncol* 10:378–382

Blitzer PH (1985) 'Reanalysis of the RTOG Study of the palliation of symptomatic osseous metastases' *Cancer* 55:1468–1472.

Boivin J-F, Hutchison GB, Lubin JH and Mauch P (1992) 'Coronary artery disease mortality in patients treated for Hodgkin's disease' *Cancer* 69:1241–1247.

Botti C, Cosimelli M & Impiombato FA (1994) 'Improved local control and survival with the "sandwich" technique of pelvic radiotherapy for resectable rectal cancer' *Dis Colon rectum* 37 (Suppl):S6–S15.

Bourne GR (1991) 'Shades of Gray; A personal view of palliation by radiotherapy' *Australas Radiol* 35:374–378.

Bezjak A, Payne D (1993) 'Radiotherapy in the management of non-small-cell lung cancer' *World Journal of Surgery* 17(6):741–750.

Brady LW, Micaily B, Miyamoto CT, et al. (1993) 'Therapeutic advances in radiologic treatment of cancer' *Cancer* Suppl 72:3463–3469.

Carlson RW, Sikic BI, Gandara DR et al. (1991) 'Late consolidative radiation therapy in the treatment of limited-stage small cell lung cancer' *Cancer* 68:948–958.

Chang LF, Hovath J, Peyton W & Ling S (1994) 'High dose rate afterloading intraluminal brachytherapy in malignant airway obstruction of lung cancer' *Int. J. Radiation Oncol Biol. Phys* 28:589–596.

Chodak GW, Thisted RA, Gerber GS, et al. (1994) 'Results of conservative management of clinically localised prostate cancer' *New Engl J Med* 330:242–248.

Ciezki J & Macklis M (1995) 'The Palliative Role of Radiotherapy in the Management of the Cancer Patient' *Sem Oncol* 22:82–90.

Crook J & Esche BA (1990) 'The Uterine Cervix' in Moss' *Radiation Oncology* JD Cox (ed), Mosby, St Louis.

Cummings BJ (1992) 'Adjuvant radiation therapy for colorectal cancer' *Cancer* 70:1372–1383.

Damstrup L & Skovgaard Poulsen H (1994) 'Review of the curative role of radiotherapy in the treatment of non-small cell lung cancer' *Lung Cancer* 11:153–178.

Denham JW (1995) 'How do we bring an acceptable level of radiotherapy services to a dispersed population?' *Australasian Radiology* 39:171–173.

Department of Health, NSW. (1995) *Strategic Plan for Radiotherapy Services in New South Wales 1995-2000*, Sydney.

Department of Health, Housing, Local Government and Community Services (1993) *Medical Workforce Data Review Committee Annual Report 1993*, AGPS, Canberra.

Department of Human Services and Health (1994) *Better Health Outcomes for Australians*, AGPS, Canberra.

Department of Human Services and Health (1995) *Medical Workforce Data Review Committee Annual Report 1994*, AGPS, Canberra.

Early Breast Cancer Trialists' Collaborative Group (1995) 'Effects of radiotherapy and surgery in early breast cancer - an overview of the randomised trials' *New Engl J Med* 333:1444–1455.

Ennis RD & Peschel RE (1993) 'Radiation therapy of prostate cancer. Long term results and implications for future advances' *Cancer* 72(9):2644–2650.

Epstein BE, Scott CB, Sause WT, et al. (1993) 'Improved survival duration in patients with unresected solitary brain metastases using accelerated hyperfractionated radiation therapy at total doses of 54.4 Gray and greater. Results of Radiation therapy Oncology Group 85-28. *Cancer* 71:1362–1367.

European Federation of Organisations for Medical Physics (1991) *Criteria for the Number of Physicists in a Medical Physics Department*, UK.

Fabian CJ, Mansfield CM, Dahlberg S, Jones SE et al. (1994) 'Low-dose involved field radiation after chemotherapy in advanced Hodgkin's disease. A Southwest Oncology Group randomised study' *Ann Intern Med* 120:903–912.

Fernandez EM, Shentall GS, Mayles WPM, et al. (1995) 'The acceptability of a multileaf collimator as a replacement for conventional blocks' *Radiotherapy & Oncol* 36:65–74.

Fieldamann HJ, Seegenschmiedt MH and Molls M. (1995) 'Hyperthermia - its actual role in radiation oncology' *Strahlentherapie und Onkologie* 5:251-264.

Fielding LP (1995) 'Optimising surgical treatment of rectal cancer' *Lancet* 346:113.

Fisher B, Anderson S, Redmond CK, et al. (1995) 'Reanalysis and results after 12 years of follow-up in a randomised clinical trial comparing total mastectomy with lumpectomy with or without irradiation in the treatment of breast cancer' *New Engl J Med* 333:1456–1461.

Forman W (1994) 'The role of chemotherapy and adjuvant therapy in the management of colorectal cancer' *Cancer* Suppl 74:2151–2153.

Frykholm GJ, Glimelius B & Pahlman L (1993) 'Preoperative or postoperative irradiation in adenocarcinoma of the rectum: Final treatment results of a randomised trial and an evaluation of late secondary effects' *Dis Colon Rectum* 36:564–572.

Garnick MB. 'Prostate cancer: screening, diagnosis, and management' *Annals Internal Med* 118:804–818.

Gerard JP, Coquard R, Fric D, et al. (1994) 'Curative endocavitary irradiation of small rectal cancers and preoperative radiotherapy in T2 T3 (T4) rectal cancer. A brief overview of the Lyon experience' *Eur J Surg Oncol* 20:644–647.

Gillis CR & Hole DJ (1996) 'Survival outcome of care by specialist surgeons in breast cancer: a study of 3786 patients in the west of Scotland' *BMJ* 312:145–148.

Glazebrook GA (1992) 'Radiation therapy: a long term cost benefit analysis in a North American region' *Med Oncol* 4:302–305.

Goddard M & Drummond J (1988) *The Costs of Radiotherapy in Cancer Treatment. Discussion Paper 48*, Centre for Health Economics, University of York.

Gough LR (1994) 'Quality of life as an outcome variable in oncology and surgery' *Aust NZ J Surg* 64:3–11.

Gustafson G, Vicini F, Freedman L, et al. (1995) 'High dose rate endobronchial brachytherapy in the management of primary and recurrent bronchogenic malignancies' *Cancer* 75:2345–2350.

Haie-Meder C, Pellae-Cosset B, Laplancher A, Lagrange JL, Tuchais C, Nogues C & Arriagada R (1993) 'Results of a randomised clinical trial comparing two radiation schedules in the palliative treatment of brain metastases' *Radiotherapy & Oncol* 26:11–116.

Halaris BS, Dattatreyudu N and Anderson LL. (1988) *An Atlas of Brachytherapy* McMillan Publishing Company

Hamilton CS, Denham J W, Joseph D J et al. (1992) 'Treatment and planning decisions in non-small cell carcinoma of the lung: an Australasian patterns of practice study' *Clin Oncol* 4:141–147.

Hanks GE, Krall J M, Horton A L et al. (1994) 'Patterns of care and RTOG studies in prostate cancers long term survival, hazard rate observations, and possibilities of cure' *Int J Radiation Oncol Biol Phys* 28(11) : 39–45.

Hanks GE, Corn BW, Lee WR, et al. (1995) 'External beam irradiation of prostate cancer' *Cancer* 75:1972–1977.

Harvey R (1991) *Making it Better. Strategies for Improving the Effectiveness and Quality of Health Services in Australia.*

Haywood J (1993) 'Radiotherapy Accidents in Europe - A preliminary report' *Scope* 2:45–46.

Health Council of the Netherlands: Committee on Radiotherapy (1993) *Developments in Radiotherapy*, Health Council of the Netherlands, the Hague (publication no. 1993/15).

Hoppe RT, Hanlon AL, Hanks GE & Owen JB (1994) 'Progress in the treatment of Hodgkin's disease in the United States, 1973 versus 1983' *Cancer* 74:3198–3203.

Horiot JC, Le Fur R, N'Guyen T, et al. (1992) 'Hyperfractionation versus conventional fractionation in oropharyngeal carcinoma: final analysis of a randomised trial of the EORTC cooperative group of radiotherapy' *Radiotherapy & Oncol* 25:231–241.

House of Representatives Standing Committee on Community Affairs (1995) *Report on the Management and Treatment of Breast Cancer in Australia*, AGPS, Canberra.

Houts PS, Lipton A, Harvey HA, Matin B et al. (1984) 'Nonmedical costs to patients and their families associated with outpatient chemotherapy' *Cancer* 53:2388–2392.

Institute of Physical Sciences in Medicine (1989) *Policy Statement. Recommended Minimum Staffing Levels for the Medical Physics Support of Radiotherapy, Nuclear Medicine, Diagnostic Radiology and Associated Radiation Protection*, York.

Inter-Society Council for Radiation Oncology (1991) *Radiation Oncology in Integrated Cancer Management*, USA.

Jamrozik K, Byrne MJ, Fitzgerald CJ, et al. (1993) 'Breast cancer in Western Australia in 1989' I. Presentation *Aust NZ J Surg* 63:617–623.

Jelfs P (1995) *Cervical Cancer in Australia*, AIHW Cancer series, no. 3, Canberra.

Jelfs P, Coates M, Giles G, et al. (1996) *Cancer in Australia 1989–1990* (with projections to 1995), AIHW Cancer series no.5, Canberra.

Johansson J-E, Adami HO, Anderson S-O et al. (1992) 'High 10-Year survival rate in patients with early, untreated prostatic cancer' *JAMA* 267(16):2191–2196.

Johnston DH, Bass D, Einhorn LH et al. (1993) 'Combination chemotherapy with or without thoracic radiotherapy in limited stage small-cell lung cancer: a randomised trial of the Southeastern Cancer Study Group' *J Clin Oncol* 11(7):1223–1229.

De Jong B, Crommelin M, van der Heijden LH, et al. (1994) 'Patterns of radiotherapy for cancer patients in south-eastern Netherlands, 1975–1989' *Radiation & Oncol* 31:213–221.

Junor EJ, Macbeth FR & Barrett A (1992) 'An audit of travel and waiting times for outpatient radiotherapy' *Clin Oncol* 4:174–176.

Keleher H & Ellis J (in press) 'Rural people utilising city hospitals: issues for service provision' *Aust J Rural Health* 4 (3).

Kramer S, Hanks GE & Diamond JJ (1983) *Quality of treatment: An Overview of the Patterns of Care Study in Clinical Radiation Therapy in Innovations in Radiation Oncology* (eds Withers HR and Peters LJ) Springer Verlag.

Krook JE, Moertel CG, Gunderson LL, Wieand HS, et al. (1991) 'Effective surgical adjuvant therapy for high-risk rectal carcinoma' *N Engl J Med* 324:709–715.

Kurtz JM, Gelber R, Brady LW, Carella RJ & Cooper JS (1981) 'The palliation of brain metastases in a favourable patient population: A randomised clinical trial by the Radiation Therapy Oncology Group' *Int J Radiation Oncology Biol Phys* 7:891–895.

Lansky SB, Cairns NU, Clark GM, Lowman J, Miller L, Trueworthy R (1979) 'Childhood cancer. Nonmedical costs of the illness' *Cancer* 43:403–408.

Leveson NG & Turner CS (1993) 'An investigation of the Therac-25 accidents' *Computer* July:18–41.

Lichter AS & Haken RK (1995) 'Three dimensional treatment planning and conformal radiation dose deliver' in *Important Advances in Oncology 1995,* (eds De Vita V, Hellman S & Rosenberg SA), JB Lippincott, Philadelphia.

Lichter AS & Lawrence TS (1995) 'Recent advances in radiation oncology' *N Engl J Med* 332: 371–379.

Loeffler JS, Larson DA, Shrieve DC & Flickinger JC (1995) 'Radiosurgery for the treatment of intracranial lesions' in *Important Advances in Oncology*, (eds VT DeVita, Hellman S & Rosenberg SA), JB Lippincott, Philadelphia, pp.141–156.

Ministerial Committee to review cancer services in Victoria (1985) *Lovell Report*, FD Atchinson Government Printer.

Mackillop WJ, Fu H, Quirt CF, et al. (1994) 'Waiting for radiotherapy in Ontario' *Int J Radiation Oncol Biol Phys* 30:221–228.

Mackillop WJ, Bates JHT, O'Sullivan B, et al. (1996) 'The effect of delay in treatment on local control in radiotherapy' *Int J Radiation Oncol Biol Phys* 34(1): 243–250.

Maher EJ, Timothy A, Squire CJ, Goodman a, Karp SJ, Paine CH, Ryall R & Read G (1993) 'The Royal College of Radiologists' Report. Audit: The use of radiotherapy for NSCLC in the UK' *Clin Oncol* 5:72–79.

Mameghan H (1992) 'Recent developments in radiotherapy' *Med J Aust* 156:3–4

Mameghan H, Fisher R, Mameghan J & Brook S (1994) 'Results of external beam radiotherapy in 448 patients with clinically localised adenocarcinoma of the prostate' *Aust NZ J Surg* 64:398–394.

Marsh PJ, James RD & Schofield PF (1994) 'Adjuvant preoperative radiotherapy for locally advanced rectal carcinoma. Results of a prospective, randomised trial. *Dis Colon Rectum* 37:1205–1214.

Mason J, Drummond M & Torrance G (1993) 'Some guidelines on the use of cost effectiveness league tables' *BMJ* 306:570–572.

Mauch P (1982) 'Treatment of metastatic cancer to the bone' in *Principles and Practice of Oncology*, (eds DeVita et al.) JB Lippincott, Philadelphia, pp.1564–1581.

Mazeron JJ & Boisserie G (1993) 'Interstitial brachytherapy: past, present and future' *Cancer Topics* 9:93–95.

McCormick R (1990) 'The Cruzan decision' *Bioethics News* 9:16–24

McCredie M (1995) 'A rising incidence of prostate cancer in Australia: Effect of "Screening" or more disease' *Cancer Forum* 19:7–12.

Medical Research Council Lung Cancer Working Party (1991) 'Inoperable non-small-cell lung cancer: a Medical Research Council randomised trial of palliative radiotherapy with two fractions or ten fractions' *Brit J Cancer* 63(2):265–270.

Minsky BD, Cohen AM, Fass D, Enker WE, Sigurdson E, & Harrison LB (1991) 'Intraoperative brachytherapy alone for incomplete resected recurrent rectal cancer' *Radiotherapy & Oncol* 21:115–120.

Mirimanoff RO (1994) 'Concurrent chemotherapy and radiography in locally advanced non-small cell lung cancer: a review' *Lung Cancer* 11:Suppl. 3 S70–S99.

Mithal NP, Needham PR & Hoskins PJ (1994) 'Retreatment with radiotherapy for painful bone metastases' *Int Radiation Oncol Biol Phys* 29:1011–1014.

Morgan GW, Freeman AP, McLean RG, Jarvie BH & Giles RW (1985) 'Late cardiac, thyroid, and pulmonary sequelae of mantle radiotherapy for Hodgkin's disease' *Int J Radiation Oncol Biol Phys* 11:1925–1931.

Morgan G (1993) 'The problems facing radiation oncology in Australia in the 1990s' *Cancer Forum* 17:3–17.

Morgan G (1994) 'The development of radiation oncology in Australia with particular reference to NSW' Unpublished report.

Myerson RJ, Jeff MM, King ML, et al. (1995) 'Adjuvant radiation therapy for rectal carcinoma: predictors of outcome' *Int J Radiation Oncol Biol Phys* 32:41–50.

Nag S, Owen JB, Farnan N, et al. (1995) 'Survey of brachytherapy practice in the United States: a report of the clinical research committee of the American Endocurietherapy Society' *Int J Radiation Oncol Biol Phys* 31:103–107.

Needham PR, Mithal NP & Hoskin PJ (1994) 'Radiotherapy for bone pain' *J Royal Soc Med* 87:503–505.

Newaishy G A, Kelly C G (1992) 'An audit of survival in small cell lung cancer' *Clin Oncol* 4:362–367.

NSW Department of Health (1995) *Strategic Plan for Radiotherapy Services in New South Wales 1995–2000.*

Non-small Cell Lung Cancer Collaborative Group (NSCLCCG) (1995) 'Chemotherapy in non-small cell lung cancer: a meta analysis using updated data on individual patients from 52 randomised clinical trials' *BMJ* 311:899–909.

Norlen BJ (1994) 'Swedish randomised trial of radical prostatectomy versus watchful waiting' *Can J Oncol* 4 (suppl 1):38–40.

Pantel K, Izbicki J, Passlick B, et al. (1996) 'Frequency and prognostic significance of isolated tumour cells in bone marrow of patients with non-small-cell lung cancer without overt metastases' *Lancet* 347:649–653.

Patchell RA, Tibbs PA, Walsh JW, Dempsey RJ et al. (1991) 'A randomised trial of surgery in the treatment of single metastases to the brain' *N Engl J Med* 322:494–500.

Patterson C & Hailey D (1994) *Intraoperative Radiotherapy*, AIHW, Canberra.

Perez CA, Purdy JA, Harms W, et al. (1995) 'Three-dimensional planning and conformal radiation therapy: preliminary evaluation' *Radiotherapy & Oncol* 36:32–43.

Peters LJ & Ang KK (1994) 'Altered fractionation schemes' in *Radiation Oncology, Technology and Biology*, (eds PM Maunch & JS Loeffler), WB Saunders.

Petterson F, et al. (1988) FIGO *Annual Report on the Results of Treatment of Cervical Cancer*. FIGO, p.20.

Phillips MH, Stelzer KJ, Griffin TW, et al. (1994) 'Stereotactic radiosurgery: a review and comparison of methods' *J Clin Oncol* 12(5):1085–1099.

Pignon J-P, Arriagada R, Ihde D C et al. (1992) 'A meta-analysis of thoracic radiotherapy for small-cell lung cancer' *New Engl J Med* 327(23):1618–1624.

Porter AT, Blasko JC, Grimm PD, et al (1995) 'Brachytherapy for prostate cancer' *CA—A Cancer Journal for Clinicians* 45:165–178.

Price P, Hoskin PJ, Easton D, Austin D, Palmer SG & Yarnold JR (1986) 'Prospective randomised trial of single and multifraction radiotherapy schedules in the treatment of painful bony metastases' *Radiotherapy & Oncol* 6:247–255.

Prosnitz LR, Kapp DS & Weissberg JB (1983) 'Radiotherapy' *N Engl J Med* 309:771–777.

Prosnitz LR, Farber LR, Kapp DS, Scott J et al. (1988) 'Combined modality therapy for advanced Hodgkin's disease: 15-year follow-up data' *J Clin Oncol* 6:603–612.

Quality of Care and Health Outcomes Committee, NHMRC (1995a) *Guidelines for the Development and Implementation of Clinical Practice Guidelines*, AGPS, Canberra.

Quality of Care and Health Outcomes Committee, NHMRC (1995b) *Clinical Practice Guidelines for the Management of Early Breast Cancer*, AGPS, Canberra.

Quality of Care and Health Outcomes Committee, NHMRC (1995c) *Early Breast Cancer: a Consumer's Guide*, AGPS, Canberra.

Recht A & Houlihan MJ (1995) 'Axillary lymph nodes and breast cancer: a review' *Cancer* 76: 1491–1512.

Rees GJG (1985) 'Cost-effectiveness in oncology' *Lancet* 2:1405–1407.

Robinson RG, Preston DF, Schiefelbein M, et al. (1995) 'Strontium 89 therapy for the palliation of pain due to osseous metastases' *JAMA* 274:420–424.

Rosenthal MA, Webster PJ, Gebski VJ, Stuart-Harris RC, Langlands AO & Boyages J (1992) 'The cost of treating small cell lung cancer' *Med J Aust* 156:605–610.

Rotman M, Pajak TF, Choi K, et al. (1995) 'Prophylactic extended field irradiation of para-aortic lymph nodes in stages IIB and bulky IB and IIA cervical carcinomas' *JAMA* 275:387–393.

Royal Australasian College of Radiologists (RACR) (1994) *Submission to the NHMRC Working Party on Beam and Isotope Radiotherapy*.

Royal College of Nursing, Australia (1995) *Submission to NHMRC AHTAC Working Party on Beam and Isotope Radiotherapy.*

Ryan J, Sutton K, & Baigent M (1996) *Australasian Radiology - a History*, McGraw-Hill, Sydney.

Sainsbury R, Howard B, Rider L et al. (1995) 'Influence of clinician workload and patterns of treatment on survival from breast cancer' *Lancet* 345:1265–1270.

Saunders MI & Dische S (1990) 'Continuous hyperfractionated, accelerated radiotherapy (CHART) in non-small cell carcinoma of the bronchus' *Int J Radiation Oncol Biol Phys* 19:1211–1215.

Saunders MI, Dische S, Barrett A, et al. (In press) 'Randomised multi-centre trials of CHART versus conventional radiotherapy in head and neck and small cell lung cancer - an interim report' *British Journal of Cancer.*

Sax S (1990) *Health Care Choices and the Public Purse*, Allen & Unwin, Sydney.

Schaake-Koning C, van den Bogaert W, Dalesio O et al. (1992) 'Effects of concomitant cisplatin and radiotherapy on inoperable non-small-cell lung cancer' *New Engl J Med* 326(8):524–530.

Shaw, EG, Brindle JS, Creagan ET et al. (1992) 'Locally recurrent non-small-cell lung cancer after complete surgical resection' *Mayo Clinic Proceedings* 67:1129–1133.

Smith AR, Gerber RL, Hughes B, et al. (1995) 'Treatment planning structure and process in the United States: A "Patterns of Care" study' *Int J Radiation Oncol Biol Phys* 32:255–262.

Smith RD, Jan S, Shiell A. (1993) 'Options for the efficient expansion of radiation therapy services' *CHERE Discussion Paper Series Number 14.*

Smith TJ, Hillner BE & Desch CE (1993) 'Efficacy and cost-effectiveness of cancer treatment: rational allocation of resources based on decision analysis' *J Nat Cancer Inst* 85:1460–1474.

Smith WT, Tattersall MHN, Irwig LM & Langlands AO (1991) 'Undergraduate education about cancer' *Eur J Cancer* 27:1448–1453.

Sperduto P, Rose M, Jolitz G & Koering S (1994) 'The cost-effectiveness of alternative treatments in prostate cancer' *Int J Radiation Oncol Biol Phys* 30 (Suppl 1):220 (Abstract No. 116).

Steinberg G D, Epstein J I, Piantadosi S, et al. (1990) 'Management of stage D 1 adenocarcinoma of the prostate: the Johns Hopkins experience 1974 to 1987' *J Urology* 144:1425–1432.

Straus DJ (1993) 'Treatment of early stage Hodgkin's disease' *Blood Reviews* 7:34–42.

Tattersall M, Langlands A, Smith W & Irwig L (1993) 'Undergraduate education about cancer - A survey of clinical oncologists and clinicians responsible for cancer teaching in Australian medical schools' *Eur J Cancer* 29A:1639–42.

Tong D, Gillick L, Hendrickson FR (1982) 'The palliation of symptomatic osseous metastases. Final results of the study by the Radiation Therapy Oncology Group' *Cancer* 50:893–899.

Treurniet-Donker AD, van Putten WLJ, Wereldsma JCJ et al. (1991) 'Postoperative radiation therapy for rectal cancer. An interim analysis of a prospective, randomised multicenter trial in the Netherlands' *Cancer* 67:2042–2048.

Ultmann JE & Phillips TL (1987) 'Treatment of metastatic cancer' in *Principles and Practice of Oncology*, (eds DeVita et al.), JB Lippincott, Philadelphia, pp.1564–1581.

Urba WJ & Longo DL (1992) 'Hodgkin's disease' *N Engl J Med* 326:678–687.

Veronisi U, Luini A, Del Vecchio M, et al. (1993) 'Radiotherapy after breast-preserving surgery in women with localised cancer of the breast' *New Engl J Med* 328:1587–1591.

Walker QJ, Salkeld G, Hall J, O'Rourke I, Bull CA, Tiver KW & Langlands AO (1989) 'The management of oesophageal carcinoma: Radiotherapy or surgery?' *Eur J Cancer Clin Oncol* 25:1657–1662.

Wasson JH, Cushman CC, Bruskewitz RC, et al. (1993) 'A structured literature review of treatment for localised prostate cancer' *Archives Family Med* 2:487–493.

Weinshel EL & Peterson BA (1993) 'Hodgkin's disease' *Cancer* 43:325–346.

Weissman DE, Janjan NA, Erickson B, et al. (1991) 'Twice daily tapering dexamethasone treatment during cranial radiation for newly diagnosed brain metastases' *J Neuro-Oncol* 11:235–239.

Whitmore WF (1994) 'Localised prostatic cancer: management and detection issues' *Lancet* 343:1263–1267.

Wigg DR (1988) 'Radiation oncology in Australia: an increasing crisis' *Australas Radiol* 32:24–37.

Willett CG, Tepper JE, Kaufman DS, et al. (1992) 'Adjuvant postoperative radiation therapy for rectal adenocarcinoma' *Am J Clin Oncol* 15:371–375.

Wilt TJ & Brawer MK (1995) 'The Prostate Cancer Intervention Versus Observation Trial: a randomised trial comparing radical prostatectomy versus expectant management for the treatment of clinically localised prostate cancer' *Cancer* 75(7):1963–1968.

Zinzani PL, Fiacchini M, Mazza P, Gherlinzoni F, Bocchia M & Tura S (1991) 'Fifteen-year experience in Hodgkin's disease: Role of combined modality treatment and splenectomy in the incidence of secondary acute leukemia' *Haematologica* 76:305–310