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INFRASTRUCTURE FOR RADIOTHERAPY IN THE NETHERLANDS: DEVELOPMENT FROM 1970 TO 2010

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In 1993 the radiotherapy advisory committee of the Dutch Health Council published its report on the developments of infrastructure for radiotherapy in The Netherlands during the last 10 years and the prognosis for future needs until 2010. Based on demographic trends, the expected incidence of cancer, the role of radiotherapy in the treatment of cancer, and the workload assessment in a model department, two scenarios are presented for the development of infrastructure. According to the committee, the Quality Scenario would be the most appropriate. © 1997 Elsevier Science Inc.

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INTRODUCTION

According to the Dutch Cancer Registry 52,000 new cancer patients (excluding skin cancer patients) were registered in The Netherlands in 1991. Since 1989, the total number of registered tumors has increased annually by 1000. In the same year, about 35,500 people died of this disease (8). This means that cancer, together with heart and vessel diseases, is the leading cause of death in the Dutch population. However, whereas the incidence of heart disease has been gradually decreasing for the past years, the incidence of cancer is steadily rising. In 1991, the crude cancer rates were 401 per 100,000 males and 357 per 100,000 females.

Cancer is a disease that affects those of advanced age; 70% of all new patients are over 60. Because of the present demographic trends showing a dramatic increase of the number of elderly people and a stabilizing birth rate, cancer will become the most frequent lethal disease in the near future. Cancer treatment and care will draw heavily on the health care system and the available means (11–13).

There are several options for the treatment of cancer patients. Radiotherapy has long been recognized as an important treatment modality, together with surgery and chemotherapy. In Western Europe and North America about 45–50% of all new cancer patients are given radiotherapy. This means that almost one out of eight individuals will receive radiotherapy during his or her lifetime. Radiotherapy is applied with curative intent in about half of these patients. In the other half, this treatment aims at improving the quality of the remaining years of life. In both situations, radiotherapy has shown to be effective and relatively cheap. On the other hand, the investments needed for radiotherapy facilities and the manpower involved are substantial, making careful planning a necessary measure.

Planning of facilities in The Netherlands

Already in the early 1970s, the health care authorities in The Netherlands saw the need to learn how radiotherapy was utilized in the care of cancer patients. Their aim was to plan new facilities more in accordance with the needs of the population. In 1974, the Dutch Health Council published its first report on the use of radiotherapy, pointing out that the expected growth of the number of cancer patients would lead to a substantially higher demand for this type of treatment. In the years that followed, the number of facilities increased, but not sufficiently (5).

In 1984, the Council published a second report, which thoroughly analyzed the use of radiotherapy in The Netherlands and discussed its future development (6). The Council concluded that there was considerable underconsumption of radiotherapy, partly caused by a serious shortage of facilities in the radiotherapy centers. Therefore, it presented an estimate of the true need for radiotherapy up

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Table 1. Comparison of actual development of radiotherapy parameters from 1983–1990 and forecast for 1990 (according to the 1984 committee)

	Survey 1983	Survey 1990	Forecast 90
New cancer patients (excl. skin cancer)	46,850	52,200	52,600
New irradiation patients (incl. skin cancer)	20,100	27,700	33,000
% new irradiation patients	38	47	55
Treatment sessions	434,400	476,300	630,000
Sessions per treatment	18	15,6	18
Megavoltage units	38	53	81
Sessions per year per unit	11,140	8,900	7,800
Radiotherapists	83	102	155
New patients per radiotherapist per year	242	268	215
Physicists	30	41	60
New patients per physicist per year	670	675	550
Radiotherapy technicians	314	398	720
Sessions per radiotherapy technician per year	2,500	2,000	1,600

to the year 2000, urging the government to increase the capacity for treatment. In 1987, the National Scenario Committee on Cancer came to a similar conclusion. As a result of these studies, the government published a plan to increase the number of facilities by almost 50% in 1995 (reaching a total of 76 linear accelerator units). In 1990, the Health Council was again requested to analyze the situation of radiotherapy and to present a new forecast for the period from 1995 up to 2010. This report presents the results of this analysis.

The actual situation in 1990

In 1990, 27,700 new patients were irradiated in 19 centers and two subcenters. These data became available as the result of a survey of all departments, conducted by the Dutch Health Council Committee. Comparison of these and other parameters with prognostic estimates of previous committees, especially those of the Health Council Committee of 1984, resulted in striking differences (Table 1). Although the number of megavoltage units had increased from 39 in 1984 to 53 in 1990, this had not been sufficient to catch up with the increase of cancer patients. In 1990, there was a shortage of at least seven accelerators and almost one-third of the centers had serious waiting list problems. The actual number of 53 accelerators in 1990 was still far removed from the forecast of 1984 (81 linacs). Between 1984 and 1990, the percentage of new cancer patients who actually received radiotherapy rose from 38 to 47. Because manpower had not increased at the same rate during that period, the workload for radiotherapists, physicists, and technicians still exceeded the normal standards as recommended by the committee in 1984.

Table 2. Number of patients and treatments in an average radiotherapy department, based on 1500 newly registered patients per year

1500	New patients	
1350	Irradiated new patients	INP = 0,90 × NP
1540	Irradiated patients	IP = 1,14 × INP*
1690	Radiation (megavolt) treatments	RT = 1,10 × IP†
163	Brachytherapy treatments	BT = 0,10 × IP

NP = New patients.
INP = Irradiated new patients.
IP = Irradiated patients.
RT = Radiation treatments.
BT = Brachytherapy treatments.
* Including repeat treatment patients referred in previous years.
† Total repeat treatment factor 1,14 × 1,10 = 1,25.

Table 3. Distribution of workload per tumor category in Dutch radiotherapy departments based on 1,500 new patients per year

Tumor	% Irradiated new patients	Number of radiation treatments
Breast	22–28	423
Lung	18–24	338
Urogenital	8–14	203
Digestive tract	6–11	118
Hematologic	5–9	101
Gynaecologic	4–8	135
Head and neck	3–7	101
Skin	2–5	101
Others	6–10	170
Total	100	1690

Organizational aspects of radiotherapy

The committee reviewed the indicators and standards currently in use to define the workload in radiotherapy centers. To formulate more precise standards, a mathematical model was developed based on empirical data derived from some radiotherapy departments in The Netherlands. This model allows detailed calculation of the expected number of patients, planning and treatment procedures, and mouldroom activities in a typical or average

Table 4. Workload for megavoltage irradiation per model department (1,500 new patients)

Activity	Workload		Time (h)	
	Total no.	Per treatment	Total	Per treatment
Treatment plans	2,285	1,4	3,672	2,2
Mouldroom	1,792	1,1	3,466	1,9
Simulations	2,854	1,7	3,675	2,0
CT-sessions	365	0,2	182	0,5
Treatment sessions	30,167	17,9	5,723	3,1
Treatment fields	73,955	44	—	—

radiotherapy department in which 1500 new patients are seen per year.

On the basis of this model, the need for manpower and equipment can be calculated for any given case mix of cancer patients. In addition, this model can be an important instrument to optimize the quality of care and the use of resources in radiotherapy (Tables 2, 3, and 4).

Estimated future need for radiotherapy

The committee used the following data to arrive at a forecast of the future need for radiotherapy: a) the current demographical trends, b) the expected incidence of cancer for the next 15 years, c) the percentage of new cancer patients receiving radiotherapy (ratio), and d) the workload as calculated for the model department. The numbers of required equipment and personnel (N) can be derived from the formula $NK = population \cdot incidence \cdot ratio$, wherein K varies per category.

Table 5 shows the forecast of the growth of the Dutch population as calculated by the National Office for Statistics.

An important factor for the incidence of cancer is the expected relative increase of the older age groups, due to the postwar baby boom from 1945 to 1955.

For this forecast of the number of cancer patients, data since 1989 were used from the National Cancer Registry (8) and more detailed, age-specific incidence rates since 1975 from the Cancer Registry in the South East District of The Netherlands (3). The committee calculated a total incidence of 361 cases per 100,000 for 1995 and 430 cases per 100,000 for 2010 (Table 6). Skin cancer was excluded because the accuracy and reliability of these data were considered as being too low.

The percentage of new cancer patients who need radiotherapy was estimated by the 1984 committee to be between 50 and 55%, whereas the surveys showed a percentage of 38% in 1983 and of 47% in 1990 (6). The percentage of 38%, reported for 1983, was mainly based on the cancer registry in a small part of the country and the annual reports of a limited number of departments. The percentage of 47% in 1990 was based on a complete national registry and a much more detailed survey of all departments in the country. Probably, the latter percentage can be considered much more reliable.

Nevertheless, it was difficult to explain the difference between the expected and the observed ratio between

Table 5. Forecast of the Dutch population (×1,000)

	1995	2000	2005	2010
Men	7,558	7,551	7,884	7,940
Women	7,758	7,966	8,118	8,202
Total population	15,316	15,717	16,002	16,142
>45 year	5,540	6,016	6,511	7,048
>45 as % of total population	36	38	40	43

Table 6. Forecast of number of new cancer patients (skin cancer excluded)

	1995	2000	2005	2010
Men	29,400	31,700	33,700	37,900
Women	25,900	27,700	28,400	31,500
Total population	55,300	59,400	63,100	69,400
Incidence/100,000	361	378	394	430

newly diagnosed cancer patients and irradiated patients. A survey of the literature on this item provided no satisfactory explanation for various reasons (Table 7). The main reason concerns the definition of the irradiation patient. In most departments, a cancer patient was registered as a new irradiation patient in every calendar year that he or she was irradiated. This means that a new cancer patient could be registered more than once as a new irradiation patient for a given type of cancer. Another problem is that cancer patients are sometimes only registered as radiotherapy patients if they have been irradiated during the treatment of their primary tumor. If they are irradiated for the first time long after their initial registration as a cancer patient, for example, for a relapsed tumor or metastasis, they are not always registered as irradiated patients. It is clear that these phenomena can strongly influence the ratio between cancer patients and patients referred for radiotherapy. Because the National Cancer Registry counts patients only once as new irradiation patient for a given type of cancer, irrespective of the year of treatment, the committee advised the centers to register irradiation patients from now in line with this and to use the term old irradiation patients for those patients who have a second and following treatment. This will lead to a better correlation between the figures of the cancer registries and those of radiotherapy departments, whereas in the workload calculation of radiotherapy departments, the numbers of new and old irradiation patients can simply be added to a total number of irradiated patients and irradiation treatments.

Patients who are referred to a radiotherapy department but who are not irradiated after the first consultation are sometimes not counted at all in the workload calculation of the radiotherapy department. The committee calculated that about 10% of patients who are seen by a radiotherapist in a model department, will not be irradiated. Therefore, they should be counted as newly registered patients but not as irradiated patients.

For the calculation of the workload of a model department, the committee used the detailed data available from the survey of the Dutch departments and the recommendations of the 1984 committee (available in the 1993 Health Council Report on Radiotherapy).

In 1990, there were 21 departments of radiotherapy in The Netherlands. Two of them belong to specialised cancer centers in Amsterdam and Rotterdam. Seven departments are in university hospitals, five are freestanding facilities, and seven are departments in general hospitals.

Table 7. Application of radiotherapy for new cancer patients in The Netherlands and elsewhere (1, 2, 4, 6, 7, 9, 10, 14)

Country	Year	% Referred for radiotherapy	Source
The Netherlands (4)	1983	35	Annual reports radiotherapy depts.
	1984	50–55	Health Council, planning estimate
	1990	47	Survey of data from radiotherapy depts.
Australia (1, 7, 14)	1986	36	Survey depts.
	1990	44	Survey district
UK (14)	1979	45	Survey radiotherapy depts.
	1988	53	Planning estimate
Canada (2)	1975	48	Survey
	1987	54	Planning estimate
USA (10, 14)	1983	46	Survey
	1985	50–60	Capacity planning
	1990	57	Estimate

The number of newly registered patients varied from 273 to 3868, whereas in 14 of the 21 departments this number ranged from 1000 to 2000. The average number was about 1500 new patients per year. Based on the data of this survey we could calculate the numbers presented in Table 2.

Two scenarios for the period 1995–2010

Two scenarios were developed and presented by the Health Council Committee on Radiotherapy, called the Reference Scenario and the Quality Scenario (Tables 8 and 9).

In the first scenario the forecast for the needed radiotherapy capacity was based on the simple extrapolation of the existing practice to the future, without taking into account major developments in indications, fractionation, treatment planning, and irradiation technology. In the second scenario, these developments and their consequences for the daily routine in an average department were taken into account, both for the facilities as well as for personnel. In the Quality Scenario, the percentage of cancer patients who need radiotherapy will not stabilize at 47% as in the Reference Scenario, but will rise from 47% in 1995 to 50% in 2010. In addition, the repeat treatment factor is expected to rise from 1.25 to 1.35.

DISCUSSION

The diffusion of facilities for radiotherapy in The Netherlands is controlled by a Health Care Facilities Act, which means that the number of megavoltage units, the personnel, and the budget are restricted by license procedures. As a result of these procedures, appropriate and efficient use of the infrastructure can be promoted, but a realistic long-term planning of facilities is still required. More than 20 years of experience with the planning of future radiotherapy needs has been built up by consecutive advisory committees of the National Health Council. In 1993, the third report was published in which the future

Table 8. Reference scenario for capacity planning radiotherapy infrastructure 1995–2010

	1995	2000	2005	2010
New cancer patients (skin cancer excluded)	55,300	59,400	63,100	69,400
% irradiated patients	47	47	47	47
New irradiated patients (skin cancer excluded)	25,400	27,300	29,000	31,900
New irradiated patients (skin and benign lesions included)	26,700	28,600	30,400	33,500
Irradiation treatments (repeat treatment factor 1,25)	33,400	35,700	38,000	41,800
Megavoltage sessions	567,800	606,900	646,000	710,000
Accelerators	66	71	76	83
Radiation oncologists	129	138	146	162
Physicists	51	55	58	64
Technicians	587	625	665	731

Table 9. Quality scenario for capacity planning radiotherapy infrastructure 1995–2010

	1995	2000	2005	2010
New cancer patients (skin cancer excluded)	55,300	59,400	63,100	69,400
% irradiated patients	47	48	49	50
New irradiated patients (skin cancer excluded)	26,000	28,500	30,900	34,700
New irradiated patients (skin & benign lesions included)	27,300	29,900	32,400	36,400
Irradiation treatments (repeat treatment factor 1,25–1,35)	35,500	38,800	43,700	49,100
Megavoltage sessions	603,500	698,400	786,600	932,900
Accelerators	71	87	100	124
Radiation oncologists	132	157	174	205
Physicists	55	60	68	80
Technicians	621	740	859	10150

needs up to 2010 were described. Since the previous advisory report of 1984, an accurate forecast of the number of cancer patients was made, but striking differences were observed between the actual facilities present in 1990 and the forecast given in 1984. The number of accelerators; the percentage of patients needing radiotherapy; and the number of physicists, radiotherapists, and technicians in 1990 were all lower than was expected in 1984. This was an incentive to make a more detailed analysis of the organizational aspects of radiotherapy and to calculate the workload for several categories of personnel.

In 1990, about one-third of all departments still had problematic waiting lists, which indicated that there was still a shortage of capacity or that the available capacity was not used efficiently. Although the committee concluded that there was an actual shortage of capacity, it was also assumed that to some extent the previous reports had overestimated the necessary capacity. In particular, the percentage of patients who were referred for radiotherapy was considerably lower than expected. Apart from difficulties in the use of proper definitions for irradiated patients, progress in other modalities of cancer treatment may have led to a decrease in the number of patients who need radiotherapy. On the other hand, there is a strong tendency nowadays to develop organ-saving treatment techniques for several types of cancer, which may lead to an increase in the need for radiation treatment. In addition, if the treatment results of cancer will improve and patients will survive longer, more of them can be expected to need radiotherapy with palliative intent. These were reasons for developing two scenarios for the next 15 years. In the reference scenario, the percentage of referred patients was kept stable at 47, whereas in the quality scenario, a gradual increase up to 50% in 2010 was taken into account.

Because the consequences of other developments such as hyperfractionation, the introduction of more complicated localization and treatment techniques, three-dimensional and inversed planning procedures, and conformal therapy were incorporated in the latter scenario, it is the opinion of the committee that this is the most appropriate scenario for the future.

REFERENCES

1. Australian Institute of Health. High energy radiotherapy equipment. A discussion paper by the National Health Technology Advisory Panel. Canberra; 1989.
2. Bush, R. S. The future horizon for radiation therapy. J. Jpn. Soc. Ther. Radiol. Oncol. 2:1–15; 1990.
3. Coebergh, J. W. W. Incidence and forecast of cancer in the Netherlands. Studies based on cancer registries. Thesis, Erasmus University, Rotterdam; 1991.
4. deJong, B.; Coebergh, J. W. W.; Crommelin, M. A. Radiotherapiegebruik van kankerpatiënten. Med. Contact 47:1389–1391; 1992.
5. Gezondheidsraad, Advies inzake megavolttherapie. Gezondheidsraad: Den Haag; 1974.
6. Gezondheidsraad, Advies inzake radiotherapie. Gezondheidsraad: Den Haag; 1984.
7. Langlands, A. O. Radiation oncology in Australia: The horns of a dilemma. Aust. NZ J. Surg. 60:3–7; 1990.
8. Netherlands Cancer Registry. Incidence of cancer in the Netherlands 1991. Third report of the Netherlands Cancer Registry. Utrecht; 1994.
9. Radiation oncology in integrated cancer management. Report of the Inter-Society Council for Radiation Oncology. American College of Radiology; 1986.
10. Radiation oncology in integrated cancer management. Report of the Inter-Society Council for Radiation Oncology. American College of Radiology, revised edition; 1991.
11. Stuurgroep Toekomstscenario's Gezondheidszorg (STG). Kanker in Nederland, deel 1 en 2. Scenario's over Kanker 1985–2000. Bohn, Scheltema en Holkema, Utrecht; 1987.
12. Stuurgroep Toekomstscenario's Gezondheidszorg. Kanker: signaleerrapport 1990. STG, Rijswijk; 1991.
13. Stuurgroep Toekomstscenario's Gezondheidszorg. Kanker: signaleerrapport 1991. STG, Rijswijk; 1992.
14. Wigg, D. R. Radiation Oncology in Australia. An increasing crisis. Aust. Radiol. 32:24–37; 1988.