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Investment in radiotherapy infrastructure positively affected the economic status of an oncology hospital

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ABSTRACT

Background: Radiotherapy is among the most efficient treatment methods of cancer. However, a radiotherapy base needs a substantial financial investment, especially before the beginning of its operation, and in some cases, in developing countries such a huge investment may cause some financial disturbances for a hospital concerned.

Aim: To assess the influence of investments modernizing the radiotherapy base in the period between 2000 and 2007 on the financial condition of the oncology hospital in the region with population of about 3 million.

Material and methods: Financial reports and medical statistics for the period between 2000 and 2007 from the studied oncology hospital and a recognized staffing model, as well as data on epidemiological situation of the region have been used to calculate the economic effects of financial investment in the radiotherapy base.

Results: The growth of RT therapeutic potential has been driven by two cost-effective investment programmes. The total amount invested in both programmes was PLN 127,191,000.

The number of radiotherapy patients treated in the hospital increased from 2301 in 2000 to 4799 in 2007 with a the same number of five therapeutic machines, although all five of them were replaced over that period. Investments modernizing the radiotherapy base lead to a significant increase in depreciation and operating costs, which adversely affects financial results of the hospital.

Conclusion: Long term trends showed that investments had positive influence on hospital performance shown both in increased income and larger number of patients treated.

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1. Background

The health care sector can always consume more money than is available. It is mostly due to the development in science, clinical practices, and introduction of new technology.¹

Improvement in technologically sophisticated radiotherapy allows to bring new treatment methods to patients. However, the process of preclinical research of new radiotherapy equipment and than its implementation into clinical practice is expensive and requires a very long evaluation, which increases economic cost for the health care system. On the

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Table 1 – The number of radiotherapy treatments in relation to the number of therapeutic machines in the GPCC in 2000–2007.

Year	Number of radiotherapy patients	Total number of therapeutic machines.	Number of purchased therapeutic machines
2000	2.111	5	0
2001	2.557	5	0
2002	3.353	5	0
2003	4.381	5	1
2004	4.794	5	1
2005	5.462	5	1
2006	5.348	5	1
2007	5.701	5	1

other hand, clinical evaluation of sophisticated radiotherapy equipment is problematic from the ethical point of view.^{2,3} One of the issues is that, in practice, it is difficult to construct a clinical trial in which patients will be assigned to an old, i.e. probably less efficient therapeutic machine rather than to a new one. This is how new technologies, like three-dimensional conformal radiotherapy (3DCRT) and intensity modulated radiation therapy (IMRT), were introduced into clinical practice worldwide.⁴ The cost-effectiveness of this new sophisticated radiotherapy machines and tools for one patient could be sometimes questioned, therefore, a careful analysis is required of how it affects a hospital budget. This issue is even more important when a hospital is a major radiotherapy provider in a region, thus being expected to provide a larger number of sophisticated and expensive procedures than smaller providers.

2. Aim

The aim of this study was to evaluate the influence of the investments modernizing the radiotherapy base in the period between 2000 and 2007 on the financial condition of the oncology hospital in the region with population of about 3 million.

3. Materials and methods

The description of radiotherapy service for the studied region was based on information received from the GPCC records, concerning the number of patients and type of radiotherapy treatment applied in the years 2000–2007. The population demand for radiotherapy treatment in the analyzed region was evaluated based on data from the Greater Poland Cancer Registry, which included cancer incidence recorded from 2000 to 2007. Data concerning the amounts of money paid to the hospital were taken from the hospital database and from the National Health Fund (the institution which contracts and reimburses medical procedures). The influence of the modernization of the radiotherapy base on the financial condition of the GPCC was assessed for the period of 2000–2007. These data were retrieved from financial reports – balance sheet, profit and loss statement and unit activity reports, taking into consideration medical statistics.

An inductive approach was used for which status at certain starting point was described and studied allowed for theoretical generalization.⁵ These theories are derived from sociology⁶ and also widely used in the organization and management

theory⁷. In addition, these allow to check whether specific modernization processes in specific conditions could have led to impairment of the financial condition of a health care unit.

4. Results

The growth of RT therapeutic potential was driven by two cost-effective investment programmes. The first of them was implemented in the period of 2000–2006 for a total amount of PLN 70,518,000 and was funded in a large part by the state budget. The other programme, carried out in 2004–2007, involved the investment of PLN 56,673,000, including PLN 30,908,000 coming from the Greater Poland Cancer Centre's own resources and PLN 25,765,000 from EU funds. The total amount invested in both programmes was PLN 127,191,000. Focusing investment activity on radiotherapy was dictated by both therapeutic needs and very high profitability of this particular type of medical service. The Greater Poland Cancer Centre maintained its financial liquidity throughout the period of 2000–2007. In each of these years, the Centre recorded positive balances, with the exception of 2007 when depreciation of newly activated tangible assets soared rapidly to almost PLN 16 million. But already in the following year of 2008, owing to a large extent to the increase in the material base of radiotherapy and income from radiotherapy services amounting to PLN 30 million, the accounts of the hospital were closed with a positive balance.

The Greater Poland province is a region of 70,000 km² situated in the western part of Poland with administrative capital in Poznan and inhabited by 3,200,000 people. Approximately 12,800 new cases of cancer are expected per year, which corresponds well with cancer registry data. More than 6400 patients may need radiotherapy treatment depending on the case mix, and this number was quite stable throughout the study period, considering size of the population studied. A potential change during the study period could be caused by the implementation of a screening program, but this effect had direct impact neither on the procedure cost nor on the reimbursement. In 2007, 5701 out of potential 6400 radiotherapy patients were treated in the GPCC (Table 1). The total number of patients recruited to radiotherapy in GPCC was constantly increasing from 2050 in 2000 to 4799 in 2007, and it affected the equipment and personnel workload. The number of patients treated on one accelerator increased from 410 in 2000 to 960 in 2007. The proportion of conformal radiotherapy which applied more sophisticated techniques (3DCRT, IMRT)

Table 2 – Proportion of income associated with the value of radical radiotherapy procedures in general value of procedures during 2000–2007.

Year	Value of reimbursement of all radiotherapy procedures in thousands of PLN	Value of reimbursement of conformal (3DCRT, IMRT) radiotherapy procedures in thousands of PLN	Percentage of the value of conformal radiotherapy in the value of all radiotherapy procedures
2000	40,416	7833	19.4%
2001	45,356	8024	17.7%
2002	53,851	8525	15.8%
2003	59,201	9042	15.3%
2004	64,661	10,296	15.9%
2005	80,674	16,905	21.0%
2006	91,249	20,990	23.0%
2007	105,871	25,297	23.9%

Source: Own study based on GPCC's reports.

in the reimbursed value of all radiotherapy procedures provided in the studied period grew from 19.4% in 2000 to 23.9% in 2007 (Table 2). (Table 3).

The investigated period also saw a significant share of radiotherapy in generating institutional income, from 19.4% in 2000 to 23.9% in 2007 (Table 2) achieved with an increase in workload of clinical staff in radiotherapy. The number of radiation oncologists (residents excluded) increased by 33% from 2000 to 2007 (Table 4). However, the value of reimbursement obtained from the refunding institution increased by 230% in the same period, which shows the increase in work efficiency of the radiotherapy staff.

The purchase of equipment and its use had a significant impact on the economic status, especially in radiotherapy where initial costs of therapeutic machines were high in comparison to other medical disciplines. The changes in the share of accelerators in the total value of medical equipment and appliances in the hospital in 2000–2007 are presented in Table 5.

These data show a very strong increase in the value of accelerators, from 31.5% to 43.1%, that took place in the years 2002–2005 (Table 5).

The year 2004 marked the beginning of a widening gap between the growth rate of investment in accelerators and the growth rate of investment in other appliances and medical equipment, which is presented in Fig. 1.

Tables 4 and 5 show the economic parameters for the hospital. Table 6 shows the depreciation costs for the whole hospital

in the years 2000–2007 and Table 5 financial results in terms of income and costs.

5. Discussion

In this study, authors investigated the potential influence of investment in radiotherapy infrastructure on the hospital budget in the region with population of 3.2 million, where the studied hospital was a major radiotherapy provider. In 2000–2007, the investment activity was mainly connected with the purchase and installation of sophisticated medical equipment, especially for radiotherapy. It led to the hospital's financial loss (negative balance sheet result) in 2007, which occurred in the last year of the study period.

In the last three years of the investigated period, there was a clear divergence between the increase in the value of accelerators and the increase in the value of all hospital medical equipment, i.e. in 2005–2007 the value of all hospital medical equipment grew faster than the value of accelerators (Fig. 1). This process influenced the economic results but cannot be explained based on the results revealed in the present study.

Among many investment undertakings carried out by the Greater Poland Cancer Centre in the period of 1999–2007, two major investment programmes were of particular importance: "Enlargement of the Greater Poland Cancer Centre" and "Improvement of Standards of and Access to Specialist Cancer Treatment (Radiotherapy) in the Wielkopolska Region".

The first of those programmes related to modernization of the existing and construction of new hospital infrastructure, including buildings and technical installations. The infrastructure was aimed to be used mostly for the purposes of radiotherapy as well as other areas of cancer treatment. In the years 2000–2003, the programme was – at the end of the day – financed by funds from the state budget allocated to the hospital through government, regional or local administration units. In 2004–2006, under new regulations, the hospital was obliged to contribute in the financing of the project. The share of external and internal sources in covering investment costs under the programme "Enlargement of the Greater Poland Cancer Centre" in the whole period of 2000–2006 is shown in Table 7. Table 7 shows, among other things, that total investment made in 2000–2006 to implement the whole programme was PLN 70,518,000, including the state budget contribution of

Table 3 – Expenses on key objectives under the Radiotherapy Development programme (in thousands of PLN).

Key project objectives	Investment
Radiotherapy Ward	28,268
CT	525
Radiotherapy Department	11,478
Accelerator	294
CT	1732
Accelerator	12,495
Mould Room	166
Treatment planning systems	1539
Beds	176
Total	56,673

Table 4 – Number of all employees, all physicians and radiotherapy physicians employed in GPCC in the years 2000–2007.

Year	Number of all employees	All physicians	Radiotherapy physicians
2000	597	90	15
2001	589	86	15
2002	564	87	15
2003	575	77	19
2004	581	81	18
2005	611	85	21
2006	662	94	21
2007	734	101	20

Table 5 – Initial cost of medical equipment compared to radiotherapy accelerators in 2000–2007.

Year	Medical equipment in the hospital	Proportion of accelerators in all hospital
2000	29,999	45.0%
2001	38,326	32.2%
2002	43,802	31.5%
2003	50,880	52.6%
2004	73,023	45.6%
2005	84,675	46.1%
2006	105,954	37.6%
2007	119,563	43.1%

Table 6 – Depreciation costs for hospital in 2000–2007.

2000	2001	2002	2003	2004	2005	2006	2007
4,553,605 PLN	4,563,695 PLN	5,073,758 PLN	6,447,290 PLN	8 295 726 PLN	11, 620,358 PLN	13,013,930 PLN	15,809,957 PLN

Table 7 – Overall investment in the enlargement of the Greater Poland Cancer Centre in 2000–2006 (in thousands of PLN).

Years	Sources of financing		Overall investment
	External	Own	
2000	8172	0	8172
2001	13,311	0	13,311
2002	6944	0	6944
2003	12,301	0	12,301
2004	12,926	89	13,015
2005	12,854	349	13,203
2006	3416	157	3573
Total	69,923	595	70,518

Source: Own study based on the Greater Poland Cancer Centre' accounting records.

PLN 69,923,000 and the Greater Poland Cancer Centre's contribution in the last three years of the programme of PLN 595,000.

In 2004, the Greater Poland Cancer Centre launched the other investment programme called "Improvement of Standards of and Access to Specialist Cancer Treatment

(Radiotherapy) in the Wielkopolska Region". That project, as the name suggests, was targeted exclusively at radiotherapy. Implemented until 2007, it was financed – all the way through – from two sources only, namely: the European Union funds and the hospital's own resources. According to the

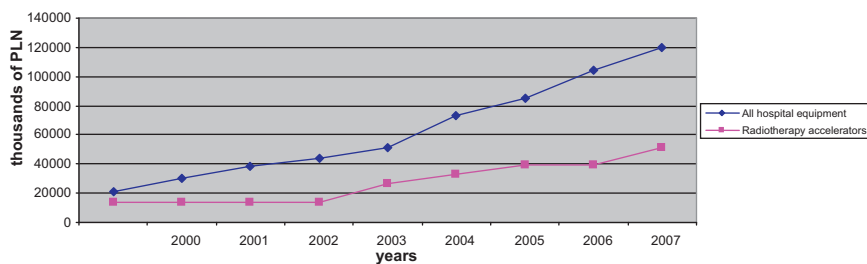
**Fig. 1 – Trends in changing the value of all medical equipment in the hospital and value of accelerators in 2000–2007 (in thousands of PLN).**

Table 8 – Financial results of the hospital in terms of income and costs.

Year	Income in thousands of PLN		Cost in thousands of PLN		Financial result in thousands of PLN	
	Hospital	Radiotherapy only	Hospital	Radiotherapy only	Hospital	Radiotherapy only
2000	43,936	18,159	43,557	11,456	379	6703
2001	49,236	22,039	49,133	11,163	103	10,876
2002	57,002	25,697	56,711	15,294	291	10,403
2003	63,257	30,023	62,935	15,170	322	14,853
2004	69,274	37,379	68,965	17,136	309	20,243
2005	84,224	47,594	83,838	19,472	386	28,122
2006	95,783	46,109	95,721	21,085	62	25,024
2007	109,347	53,013	120,545	25,050	-11,198	27,963

financing agreement, the EU funds accounted for 75%, while the hospital's own contribution for the remaining 25% of the investment. It is worth noting at this point that external contribution was awarded as a refund of costs previously incurred by the hospital. Overall costs of that programme amounted to PLN 56,673,000, including PLN 30,908,000 from the Greater Poland Cancer Centre's own resources and PLN 25,765,000 from the European Regional Development Fund. The specification of key expenses under the programme "Improvement of Standards of and Access to Specialist Cancer Treatment (Radiotherapy) in the Wielkopolska Region".

With a financial burden so heavy, the hospital Management had to apply a careful economic calculation to prevent the institution from losing its financial liquidity in any of the years to come and to ensure a return on the investment as soon as possible. Both investment undertakings were successful. The hospital maintained its financial liquidity over those difficult four years. Despite the fact that in 2007, mainly due to a sudden increase in depreciation costs which reached the level of nearly PLN 16 million causing the hospital to record an exceptional negative balance, the very next year the result was positive again, owing largely to the increase in the income from radiotherapy procedures exceeding PLN 33 million.

The hospital, like every other economic entity, when choosing the direction of its investments should be guided by their effectiveness and strive to maintain positive financial standing. The negative financial result in 2007 was caused to the greatest extent by the effects of modernization that was carried out, particularly in the radiotherapy infrastructure, as shown by the increased value of radiotherapy accelerators (Table 5). However, implementation of new buildings, equipment and medical appliances results in the increase of depreciation costs, which was revealed in the authors study, systematically from 2004 to 2007 by 90% of total increase and it had an influence on the final financial result of the hospital. In 2007, depreciation costs were almost twice as high as in 2004. The additional factor to consider was the increase of operating costs connected with extensive use of modern and thus more expensive equipment which used more consumables and required more labor (Table 8).

Interestingly, the study revealed that a significant increase in the number of patients treated in the study period (which corresponds to a larger volume of service provided) was achieved by more extensive use of the same number of therapeutic machines (Table 1). However, it is worth noticing

that beginning with 2003, each year one old accelerator was replaced with a new one equipped with IMRT and other functionalities (Table 1). From a purely economic point of view, such approach was not justified by the expected increase of radiotherapy service volume which could be reimbursed (purchased) by the National Health Fund. The new and more sophisticated accelerators enabled to provide more accurate treatments, which, however, required more work-intensive therapy planning and more time dedicated at each machine for patient irradiation. These were not set off by the epidemiological need and economical incentive of more patients to be treated.⁹ Therefore, additional measures had to be undertaken in order to pay back the money used for radiotherapy base modernization.

The hospital itself has some properties of a regular market entity. In some health care systems, more sophisticated medical procedures are covered by higher reimbursement, so that they do not affect strongly the economic performance. In European countries major providers of health services are based on public money and usually a public health care unit plays partly a role of an economic enterprise with special public duty for which market economy has limited significance.⁸ These two contradicted aims are differently accomplished in different EU countries.

Due to the above-mentioned fundamental constraints, it is difficult to study performance of a hospital with no regard to the function it performs for the community. According to the functional theory of social and economic systems, every change causes general disturbances in the functioning of a given organization.¹⁰ If behind this thesis lies the belief that such an institution as a hospital is a system composed of many different elements, among which prevails a relative equilibrium, then, in consequence, every change of any of these elements at least periodically destabilizes the whole system. The more important are the functions in the structure of the system the element subject to a change fulfils, the more serious are the consequences for the whole system. This would explain why the change consisting of modernization of the radiotherapy base in the studied hospital caused consequences that impacted the economic position of the whole institution. The main cause of the balance sheet loss in 2007 recorded in the hospital was – as determined earlier – the occurrence of the so-called rolling costs, being a consequence of the use of modern treatment appliances and expressed by the increase in depreciation and operating costs.

In the study region, the radiotherapy service was insufficient in order to serve the population.⁹ Therefore, the investment in radiotherapy equipment was justified from the epidemiological point of view. This brought two consequences: improved quality of the service, measured by the increased proportion of more sophisticated conformal radiotherapy, and, directly, by a very significant increase in the number of radiotherapy patients. The increase in the number of patients with a constant number of accelerators can be explained by a better performance of new equipment and higher “up” time but is also linked with the more challenging possibilities which modern equipment offers to staff. Such investments, while not bringing immediate financial profits, were rational and necessary in the long-term perspective. On the other hand, the suspension of expenditures on modernization of radiotherapy would lead to hospital's losing its credibility in the increasingly competitive and Europe wide market of medical services.¹¹⁻¹³

In all medical disciplines, investment normally has to be associated with better clinical results, larger volumes of service provided or better quality of service. In oncology, it is not easy to evaluate the influence of the cost increase and related improvement of clinical results, because they can only be seen after many years; usually more than five. The quality of service is associated with the quality of management systems (like ISO) and clinical audits.¹⁴⁻¹⁷ The implementation of ISO and clinical audits requires additional workload and the more sophisticated equipment is in use, the more extensive – thus costly – quality assurance procedures are required.^{18,19}

The modernization strategy of health care units includes not only innovation driven by the idea of securing better economical status of a hospital but also to ensure proper quality level of medical services provided.²⁰ Moreover, hospitals in which – as in the GPCC – radiotherapy is used also have to fulfil specific conditions associated with a safe use of ionizing radiation. To meet these requirements, hospitals have to allocate certain costs to maintain radiological safety.

6. Conclusion

Investments modernizing the radiotherapy infrastructure led to a significant increase in depreciation and operating costs of the hospital, which temporarily worsened its financial results.

More sophisticated radiotherapy enabled to provide more accurate treatments, which while requiring more time to be dedicated for each patient, triggered more effective use of resources and allowed for more patients to be treated.

Long term trends showed that investments had positive influence on hospital performance which was manifested on the financial level by increased income and on the community level by increased number of patients treated.

Conflict interest

None declared.

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