JBR–BTR, 2010, 93: 92-96.

SPECIAL ARTICLE

THE CAPITAL COST AND PRODUCTIVITY OF MRI IN A BELGIAN SETTING*

C. Obyn[1], I. Cleemput[2]

Against the Belgian background of national planning of MRI units and a detailed reimbursement scheme, a study was undertaken to investigate the cost and productivity of MRI units in different investment scenarios and for various operational schedules. This article focuses on capital costs, not operating cost. Using data from a hospital survey and manufacturers, total capital costs per examination were simulated. The survey revealed considerable variation in operational hours, with on average 66 hours per week, resulting in 6 300 examinations per year per unit. Whilst operational hours remained approximately unchanged over the last 8 years, the number of examinations per unit grew by on average 6% per year. Correspondingly, average examination time declined from 45 to 31 minutes. The findings suggest that, mainly due to the increased productivity, capital costs per examination decreased considerably in the examined period. In 2008, the average capital cost per examination is estimated to vary from €23 to €45 for 1.5 Tesla units and from €32 to €62 for 3 Tesla units, assuming an equal examination speed for both types of units.

Key-words: Cost-effectiveness – Magnetic resonance (MR).

The supply of medical imaging services may not only be influenced by the medical know-how of the prescribing physicians and radiologists or by the demand of the patients, but also by other factors such as the reimbursement and national infrastructure planning policies. Concerned about the increase in diagnostic imaging expenditures, health care policy makers aim to use the health care financing and national infrastructure planning policy (if any) to encourage efficient delivery of high quality medical imaging. Financing and planning are used to discourage over- or under-use of services but also to avoid providers giving preference to one technique over another for other reasons than those that can be justified by evidence based medicine.

In Belgium, the number of MRI units is subject to a national supply constraint. End 2008, 92 units were accredited. This is equivalent to 8.6 units per one million inhabitants. As there is no data available on the appropriateness of current prescriptions and examinations compared to the clinical guidelines, it is not possible to demonstrate under- or over-use of this imaging technique, nor is it possible to determine the number of units needed at national level that can be scientifically justified. When jurisdictions want to install a national infrastructure planning, it is beyond their ability to fully base it on clinical evidence. What policy makers are able to do, however, is to determine an appropriate financing basis. Therefore detailed data on the investment as well as operational costs of MRI are needed. Against this background, a cost analysis was conducted to assess the total costs of purchasing and running an MRI unit. This article focuses on the evolution of the capital costs and the productivity of the units over the last decade, in order to estimate the evolution in average capital cost per examination over time. The results on the operational costs can be found in the report by Obyn et al. (1).

Materials and methods

The costing methodology applied in the current cost study is historical costing, as opposed to standard costing, in that it is based on historical and actual cost data of the hospitals instead of standards defined for qualitative, efficient and safe care.

Sources

A number of data sources were used, notably a hospital survey and face-to-face meetings with manufacturers. Table I in appendix gives an overview of the sources used per cost item. More details can be found in Obyn et al. (1).

Hospital survey

In search of reliable MRI cost data, separate questionnaires were sent to the general and financial management and the head of radiology departments of 56 Belgian hospitals with at least one accredited MRI scanner. Table I in appendix provides more detailed statistics on the response rates on the different cost items. The questionnaire sent to the heads of the radiology department contained a question relating to the operational hours, while the questions posed to the financial managers related to financial investment aspects of the services.

Manufacturers

The three manufacturers active on the Belgian MRI market were contacted: Philips, Siemens and General Electric. Questions posed related to the capital costs and the operational lifetime of the equipment as well as to the technical evolution in MRI over the last decade. Two of the mentioned manufacturers provided precise information that could be used for the analyses.

Capital costs

Capital costs cover the initial purchase (including installation) of the MRI unit, the upgrades, the building adaptations and the financing of

From: 1. Federaal Kenniscentrum voor de Gezondheidszorg (KCE), Brussel, 2. Federaal Kenniscentrum voor de Gezondheidszorg (KCE), Brussel, Belgium.
Address for correspondence: C. Obyn, KCE – Federaal Kenniscentrum voor de Gezondheidszorg - Centre fédéral d'expertise des soins de santé – Belgian Health Care Knowledge Centre Administratief Centrum Kruidtuin, Door Building (10e verdieping), Kruidtuinlaan 55, B-1000 Brussels, Belgium.
E-mail: caroline.obyn@kce.fgov.be
* This article is based on part of the KCE report "Magnetische Resonantie Beeldvorming: kostenstudie / Imagerie par résonance magnétique : analyse de coûts" (1) available on http://www.kce.fgov.be/index_nl.aspx?SGREF=5264&CREF=12925; http://www.kce.fgov.be/index_fr.aspx?SGREF=3465&CREF=12926)

these investments. In order to spread the capital costs over the lifetime of the equipment, an equivalent annual cost was calculated (2).

Initial purchase

Data on purchase and building adjustment costs were obtained through the hospital survey. For the initial purchase costs, a distinction was made between the purchase of a 1.5 versus a 3 Tesla unit.

Building adaptations

For building adaptation costs two scenarios were analysed: major versus minor building adjustment requirements. Building adjustment requirements were considered to be major when a new building place was needed, generally in case of a purchase of a first or extra unit or a switch to a higher field strength unit. They were considered to be minor when limited refurbishment of an existing building was sufficient, generally in case of replacement of an older unit without switching to a higher field strength. Based on data from the hospital survey and contacts with manufacturers, a probability distribution was defined for the initial purchase and building adaptation costs, serving as input for the investment cost simulations.

Upgrading costs and lifetime of equipment

As the MRI technology continues to advance, machines that are up-to-date at the time of installation may be considered obsolete within a number of years. Regular upgrades of soft- and hardware are therefore desired. By upgrading an MRI unit, scanning speed and consequently operating efficiency can be increased, imaging quality can be enhanced and clinical capabilities may be expanded. Upgrading costs were obtained from the hospital survey. As most of the units of the responding hospitals were still operational, no average lifetime, nor average upgrade costs, could be determined. Therefore, 4 scenarios were examined: 14 years lifetime of the equipment with a 50% or a 70% upgrade cost after 7 years, 10 years lifetime with a 50% upgrade cost after 5 years and a 7 years lifetime without upgrade investments. Each of these scenarios was analysed for both a 1.5 and a 3 Tesla unit and for both minor and major building adjustment costs.

Financing costs

An interest rate of 4.61% was used to estimate financing costs. This rate corresponds with the average 10 year-OLO rate over the period 1998-2007 (4.46%), increased with 15 basis points as risk premium.

Scanning speed

The historical evolution of the scanning speed was estimated by combining data from the NIHDI on the number of examinations in Belgium with data on the number of operational MRI units and the average number of operating hours as derived from the hospital survey.

Scenarios and uncertainty

As described above, multiple scenarios were analysed, in terms of operating hours (55-65-75 hours per week), lifetime of the equipment (7-10-14 years), upgrade investments (0%-50%-70%) and building adaptations (minor-major).

Uncertainty and variability of cost inputs (within each of the scenarios) was taken into account by fitting probability distribution functions to the data and incorporating the distributions instead of mean or median point estimates in the simulations. By running 1000 Monte Carlo simulations, during which input values are drawn at random from the distributions, a probability distribution was obtained for the output, the total capital costs. For this probabilistic analysis, the software package @risk 5.0 (Palisade, London, UK) was used. Appendix Table II shows the distribution functions applied for capital cost inputs.

Results

Productivity of the units

Through the hospital survey, data was obtained on the current and historical weekly operating hours of a Belgian MRI service. The data show that the average operating hours did not change considerably over the last eight years (from 64.7 hrs on average in 1999/2000 to 65.7 hrs in 2007/2008). Summary statistics of the survey results are show in Table I. The number of examinations per unit grew by on average 6% per year (Table II). Correspondingly, the inferred examination time decreased from on average 45 minutes in 1999/2000 to 31 minutes in 2007/2008. This examination time includes imaging, patient positioning, computer set-up, patient discharge and idle time in between two patients. Examination time is not only influenced by the type of the MRI unit (mainly magnetic field strength), but also by case complexity (type of examination and patient), and by the personal preferences of the radiologist with regard to the trade-off between sharpness of images, signal-noise ratio and scanning time. Belgian figures show that the average case-mix in terms of body parts examined and examination setting (hospitalized versus ambulatory) did not change much over the considered period (Table III). These data hence do not support the hypothesis that the increased speed is linked to lower case complexity. The available data rather suggest that the increase in speed is driven by technology advancements (and the accompanying switch to higher magnetic field units) and likely also by improvements in general workflow efficiency.

Capital costs

Figure 1 shows the cost of purchase over time for 50 MRI units at 28 Belgian hospitals. The figure shows that the responding hospitals most frequently installed a 1.5 Tesla unit, which has currently a lower investment cost than the 3 Tesla units installed by some hospitals more recently. None of the responding hospitals acquired a 1 Tesla unit after 2004. Based on this dataset, the average initial investment costs for a 1.5 Tesla MRI unit slightly decreased from 1999-2000 to 2006-2008 from around €1 300 000 to €1 200 000, second hand units omitted. The small sample size of purchased units (n = 16 respectively n = 5) however precludes firm conclusions.

Price information was also obtained from 2 manufacturers for a 1.5 and 3 Tesla MRI unit in 2008. The average sales price for a basic or standard configuration of an MRI unit, which can be used for routine MR imaging in the whole body (neuro, orthopedics, abdomen and angio) and including software and coils for it, was €1 027 000[1] for a 1.5 Tesla and € 1 581 000 for a 3 Tesla. With extra options for hardware (mainly specialized coils for specific body parts) and software (such as software for advanced neuro imaging, spectroscopy, soft tissue motion correction etcetera), the upper price would be about €1 378 000 for a

[1] All prices include VAT of 21%.

Table I. — Number of operational hours per week.

	1999/2000	2007/2008
Response rate (n° of hospitals)	11	20
Average n° of operational hrs / wk	64.7	65.7
Min n° of operational hrs / wk	54.0	52.5
Max n° of operational hrs / wk	86.0	86.0

Source: hospital survey.

Table II. — Evolution of time required per MRI examination.

	1999/2000	2007/2008
N° of examinations per operational MRI unit	4 307	6 332
N° of operating hours per year	3 235*	3 285**
N° of examinations per hour	1.33	1.93
Time required per MRI examination	45 min.	31 min.

* 64.7 hours/week * 50 weeks/year
** 65.7 hours/week * 50 weeks/year.

Table III. — Case mix evolution in terms of body parts: 2000 versus 2007.

	2000	2007
Spine	31.7%	30.3%
Head	31.7%	26.4%
Limbs	22.3%	24.7%
Trunk	9.8%	11.0%
MRA body	2.8%	4.4%
Mammo	1.4%	2.7%
Cardiac	0.2%	0.5%
Functional	0.1%	0.1%
% ambulatory	84%	86%

Source: based on national statistics from NIHDI.

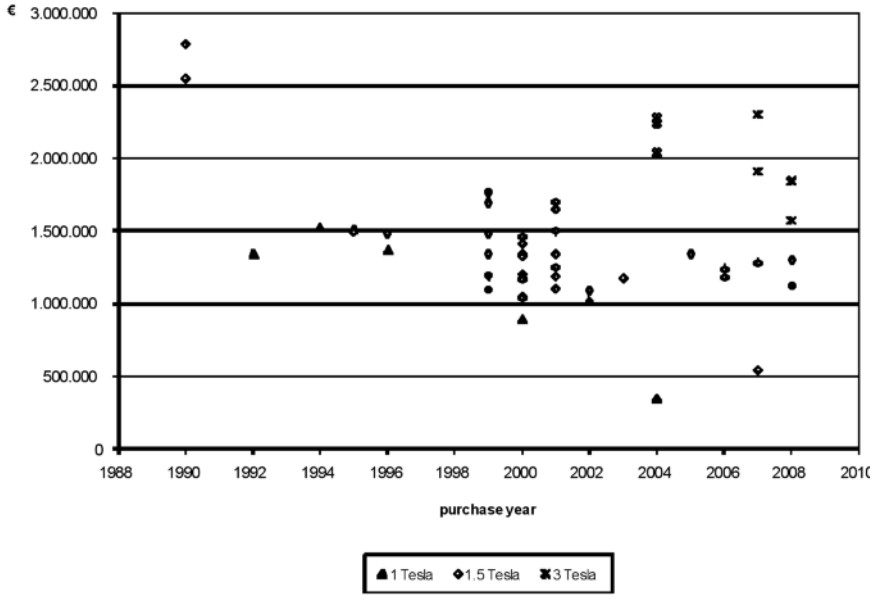

Fig. 1. — Purchase cost of MRI units.
Source: hospital survey.

1.5 Tesla unit and about €1 945 000 for a 3 Tesla unit. These prices include first year maintenance and training of nurses and physicians. This data is in line with the data derived from the hospital survey.

Table IV shows the results for the building adjustment costs. Within the two categories considered, major versus minor building adjustments, large differences in costs were observed between hospitals. These may be explained by, amongst others, the size and suitability of the location, the used materials, the variations in cages of Faraday and the number of walls needing extra shielding.

Figure 2 plots the probabilistic outcomes for the resulting total yearly equivalent capital costs for 1.5 and 3 Tesla units. These costs vary from on average €160 000 (in the scenario 14 yrs – 50% upgrade – minor building adaptations) to €240 000 (7 yrs – 0% upgrade or 10 yrs – 50% upgrade – minor building adaptations) for 1.5 Tesla units. For 3 Tesla units, these average costs vary from €230 000 to €330 000 respectively. These capital costs are one-time, fixed costs. The associated cost per examination therefore depends on the utilization of the unit. Combining the annual capital costs with the different scenarios for operational hours, whilst taking into account an average examination speed of 31 minutes, an average capital cost per examination was obtained ranging from €23 to €45 for 1.5 Tesla units and from €32 to €62 for 3 Tesla units in 2008 (Table V). In 1999/2000, when the average examination speed was still 45 minutes, the average capital cost per examination is estimated to range from €40 to €71 for 1.5 Tesla units[2].

Discussion and conclusion

As the demand for MRI examinations increased over the last years and as the number of MRI units was restricted by the government, Belgian hospitals have been spurred to make the most efficient utilization of the limited resources. The hospital survey highlights that operating hours ranged from 53 to 86 hours per week with an average of 66 hours, resulting in on average 6 300 examinations per year per unit. In a previous Belgian study (3), this productivity appeared the

[2] Cost in nominal terms.

Table IV. — Building adjustment costs.

	Minor building adjustments	Major building adjustments
Response rate (n° of units)	12	21
Average cost (€)	119 458	369 819
Median cost (€)	58 876	413 768
Min cost (€)	0	42 926
Max cost (€)	363 652	700 631

Source: hospital survey.

Table V. — Capital cost per examination (2007/2008).

	1.5 Tesla	Average capital cost per examination (€)							
Operational scenario:	55 hrs	45	40	45	41	34	31	37	34
	65 hrs	38	34	38	34	29	26	31	29
	75 hrs	33	29	33	30	25	23	27	25
	3 Tesla								
	55 hrs	61	55	62	57	47	43	51	48
	65 hrs	52	47	52	49	40	37	44	41
	75 hrs	45	41	45	42	34	32	38	35
		Investment scenario:							
	Life (yrs)	7	7	10	10	14	14	14	14
	Upgrade %	0%	0%	50%	50%	50%	50%	70%	70%
	Building adaptations	major	minor	major	minor	major	minor	major	minor

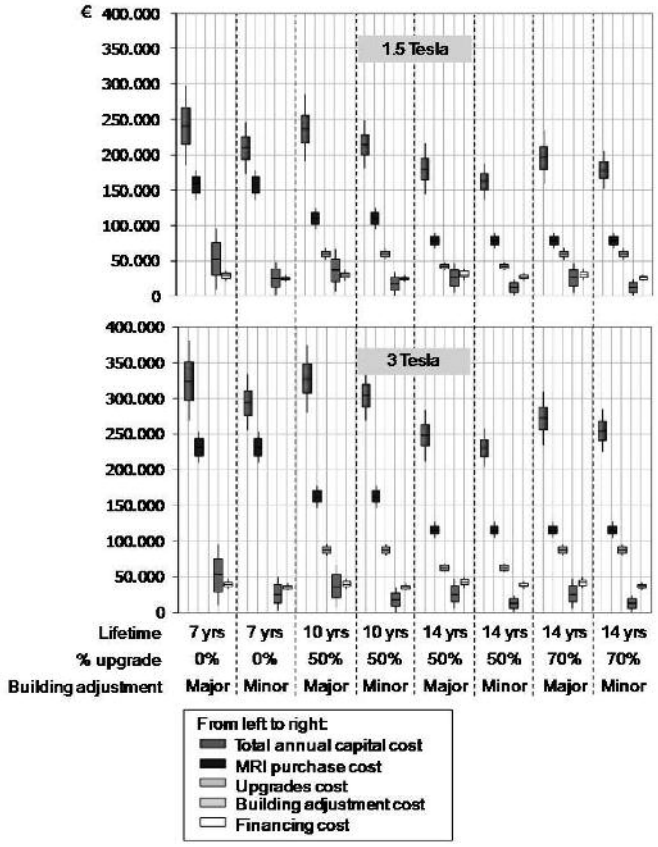

Fig. 2. — Equivalent annual capital cost for an MRI unit.
Note: Box plot values: center line: mean; box: 25%-75% percentiles; whiskers: 5%-95% percentiles.

highest in a sample of 8 countries. As a considerable part of the costs are fixed (such as investment costs and maintenance contracts), the longer the operational hours, the lower the cost per examination.

Besides operational hours, the time to do an examination obviously is another important parameter to which the cost per examination is very sensitive. In this study, an overall evolution of 45 to 31 minutes was calculated over the last 8 years in Belgium. This evolution inevitably led to a considerable decrease in cost per examination.

Looking at the investment data derived from the hospital survey, no major price erosion could be observed for 1.5 Tesla units in the last decade. The major trend seems that more performing MRI technology was bought at roughly the same price level, at least for 1.5 Tesla units. The investment cost of 3 Tesla units is considerably higher, but this higher investment cost is still counterbalanced by the increased productivity over the years. For both 1.5 and 3 Tesla units, the average capital cost per examination (of respectively €23-€45 and €32-€62) now is lower than for a 1.5 unit 8 years ago (€40-€71).

Inevitably, this cost analysis is subject to a number of limitations. It relies on actual cost and operational data as reported by hospitals in a small sample size. Furthermore, no detailed analysis was made of how examination speed depends on case complexity (types of examinations and patients) and on type of MRI units (magnetic field strength). In light of these limitations the presented findings should be interpreted adequately.

This study provides information on the costs of investing in an MRI unit in Belgium. The information can serve as input for decision making at both governmental and hospital level. At governmental level, it can be useful for policy makers who have to design financing mechanisms for these services. At hospital level, it can support discussions on operational and financial management issues. This cost analysis can also be seen as a first step in a broader cost-effectiveness evaluation of the use of MRI. In order to evaluate whether the higher costs of MRI are worth the clinical advantages compared to CT, both costs and advantages of both techniques need to be compared.

References

1. Obyn C., Cleemput I., Léonard C., Closon J.-P.: Magnetische Resonantie Beeldvorming: kostenstudie. Brussel: Federaal Kenniscentrum voor de Gezondheidszorg (KCE), 2009.
2. Drummond M., Sculpher M., Torrance G., O'Brien B., Stoddart G.: Methods for the economic evaluation of health care programmes: Oxford University Press, 2005.
3. Demaerel P., Hermans R., Verstraete K., et al.: Magnetische Resonantie Beeldvorming. Brussel: Federaal Kenniscentrum voor de gezondheidszorg (KCE), 2006.

Appendix table I. — Detailed overview of sources used for cost analysis.

Data	Sources used
Initial investment and upgrading costs	Hospital questionnaire – N° of units bought in 2006-2008: 9 – N° of units bought in 1999-2000: 16 Manufacturers – N° of manufacturers = 2
Building adjustment costs	Hospital questionnaire – N° of hospitals = 22 – N° of units = 33
Operational hours per week	Hospital questionnaire – N° of hospitals = 11 for 1999/2000 – N° of hospitals = 20 for 2007/2008

Appendix table II. — Distribution functions for capital cost input variables.

Variable	Lower Bound	Upper Bound	Base Case value (= average)	Distribution	Source
MR unit investment – 1.5 T[3]	€1 027 000	€1 378 000	€1 202 500	Uniform	Manufacturers (lower and upper bound input)
MR unit investment – 3 T	€1 581 000	€1 945 000	€1 763 000	Uniform	
Major building adaptation	€43 000	€701 000	€372 000	Uniform	Hospital questionnaire
Minor building adaptation	€0	€364 000	€162 000	Uniform	

[3] Note that generally first year maintenance is included in this purchase price. This has been taken into account in the equivalent annual investment cost calculation.