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Economic Evaluation of Multislice Computed Tomography Scanners Through a Life Cycle Cost Analysis

KEYWORDS: Life Cycle Cost Analysis, Uncertainty, Computed Tomography scanners

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ABSTRACT *A macro-economic modeling tool named Life Cycle Cost Analysis (LCCA) was performed in order to compare the total cost of ownership of two MSCT scanners, 128-slice and 64-slice, and identify the positive Net Savings of them. Additionally, among the scopes of the paper was to assess the uncertainty of the LCCA and identify which input values would make a difference to the total cost of ownership. A period of 5 years was established with a discount rate of 3%. All costs were discounted into its present value. Economic data were reviewed from the accountant's office of two private hospitals in Greece which owned different MSCT scanner. LCCA suggested that the NS were 647,199 €, in favor of 128-slice CT scanner. Additionally, Operation Maintenance, Repair and Initial costs had a great impact on total LCC of both scanners, so decision makers should take them into account when aiming for cost containment.*

1. Introduction

1.1 Background

The accelerating pace of medical technology development has tended to improve medical outcomes and increase cost. [Okunade & Murthy, 2002] Computed Tomography (CT) technology and its clinical applications have shown enormous resilience against alternative diagnostic methods providing high power x-ray tubes, multi channel detectors, faster rotation times, multiple image capturing resulting in moving CT to dynamic applications in cardiology and 3-dimensional imaging of vascular and musculoskeletal anatomy. (International Committee on Radiological Protection [ICRP], 2000) CT systems will continue to be the fastest growing technology in the medical imaging arena around the world in the upcoming decade and has been dominated by the presence of four major players, namely GE, Siemens, Toshiba, and Philips. (Global Data, 2009) Europe, United States and Japan collectively account for more than 85% share of the worldwide installed base of computed tomography scanners for 2008 and is expected a modest growth rate with the installed base for computed tomography scanners exceeding eighty eight thousand units by 2015. (Global Industry Analysts, 2008)

Multi-Slice Computed Tomography (MSCT) scanners are one of the most expensive health technologies where decision makers can be under pressure to minimize total cost. Unfortunately, many health professionals do not understand the concept of total cost resulting in seeking to minimize the acquisition cost rather than the total cost. (Stephen & Alphonse, 1995)

In view of this information, the economic evaluation of this technology is imperative aiming for cost containment. As worldwide healthcare systems struggle to control medical expenditures methods like Life Cycle Cost Analysis (LCCA) can be attractive.

LCCA is an economic method of project evaluation in which all costs arising from owing, operating, maintaining and ultimately disposing of a project are considered to be potentially important to the decision makers. (Fuller & Petersen, 1996)

1.1 Objective

The objective of this study was, to compute and compare the total cost of ownership of two MSCT scanners, 128-slice and 64-slice, through a LCCA and identify the positive Net Savings of them. Additionally, among the scopes of the paper was to assess the uncertainty of the LCCA and identify which input values, if different, would make a crucial difference to the total cost of ownership of the MSCT scanners.

2. Methods

2.1 Model structure and parameters

Economic data were reviewed in the present study from the accountant's office of two private hospitals in Greece which owned different MSCT scanner. A 128-slice scanner was purchased in 2009 and the service contract, including x-ray tube, was for five years. A 64-slice scanner was purchased also in 2009 and the service contract was for one year including x-ray tube.

The study protocol was approved by the ethics committee of Athens University, Faculty of Nursing.

LCCA allows the estimations of the costs of acquiring, owning, operating, maintaining and totally disposing of a computed-tomography scanner. The LCC formula was stated with the following equation: (Fuller & Petersen, 1996)

LCC = I + Repl – Res + E + OM & R

Where:

LCC	=	Total LCC in present-value euros
I	=	Present-value investment costs
Repl	=	Present-value capital replacement costs

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Res = Present-value residual value
E = Present-value energy costs
OM&R = Present-value operating, maintenance and repair costs

For conducting a LCCA we divided LCC equation into three variables: the pertinent costs of ownership, the study period and the discount rate that is applied to future costs to equate them with present day costs. So we established a common study period of five years and a common base date (year 2009) with a discount rate of 3% as commonly used in Greece.

Before calculating the total LCC we defined two major cost categories: Initial expenses and Future expenses. Initial expenses were all costs that incurred prior to occupation of the CT Scanners namely the Investment costs (I) including also contrast material injectors and printers and Future expenses were Operation, Maintenance and Repair costs (OM&R), Replacement costs (Repl) and Residual Value (Res) namely costs that incurred after occupation of CT Scanners. Investment costs were defined as the initial investment costs that will be incurred prior to the occupation of CT Scanners. Operation costs were annual costs involved in the operation of CT scanners namely radiology films, set of injector's syringes, contrast media and oxygen bottle. Maintenance costs were scheduled costs associated with the upkeep of CT scanners namely maintenance of scanner, of contrast media injector and of printer and repair costs were expenditures unexpected that were required to prolong the life of CT scanners without replacing them. Residual value was defined as the net worth of the CT scanner at the end of the study period. We assumed that CT scanners have a useful life of 15 years and the study period was 5 years, so the residual value was approximately 1/3 of its initial cost [=(15-10)/15]. Our assumption was based on the rules published by the European Coordination Committee of the Radiological and Electromedical Industries for the evaluation of medical equipment. According to these guidelines, technologies older than 10 years are considered to be no longer "state-of-the-art" (Keller, 2005). Finally, all future expenses were discounted to their present value prior to addition to the LCCA total.

As far as electricity cost (E) is concerned, we found that both scanners were supplied by a 3-phase electricity system. We measured E assuming that we make 20 tomographies per day on contrast media for twelve hours per day and for three hundred days per year. Our assumption was based on the average ct exams/ct scanner of OECD Health Data 2010 (5,692.1 ct exams/ct scanner). (OECD, 2010). According to manufacturers, 64-slice CT scanner's consumption was 8 kwh and 128-slice scanner's consumption was 6 kwh. Cost of energy's consumption was computed according to national electric system charges namely 0,096€/kwh.

Before we computed the total LCC of CT scanners, Res and Repl were discounted to their Present Value (PV). PV calculation uses a discount rate, d, and the time, t, a future cash amount (Ft) was or will be incurred to establish the PV of the future cash amount in the base year of the study period and was represented as:

$$PV = F_t \times \frac{1}{(1+d)^t}$$

Where:

PV = present value
F = cash amount
d = discount rate
t = years

E was discounted into its PV by Modified Uniform Present Value$_5$ (UPV$_5$) factor at a constant escalation rate 2% and was represented as:

$$PV = A_0 \times \sum_{t=1}^{n} \left(\frac{1+e}{1+d}\right)^t = A_0 \times \frac{(1+e)}{(d-e)}\left[1-\left(\frac{1+e}{1+d}\right)^n\right]$$

Where:

PV = present value
A_0 = cash amount
d = discount rate

n = years
e = escalation rate

OM&R were discounted into its PV by Uniform Present Value$_5$ (UPV$_5$) factor and was represented as:

$$PV = A_0 \times \sum_{t=1}^{n} \frac{1}{(1+d)^t} = A_0 \times \frac{(1+d)^n - 1}{d(1+d)^n}$$

Where:

PV = present value
A_0 = cash amount
d = discount rate
n = years

The Net Savings (NS) measure is a variation of the Net Benefits measure of economic performance of a project (Fuller & Petersen, 1996). The NS method calculates the net amount that a project alternative is expected to save over the study period and was represented by subtracting the total LCC of the two MSCT scanners as:

$NS = LCC_A - LCC_B$

2.2 Deterministic sensitivity analysis

If there is substantial uncertainty concerning cost, an LCCA may have little value for decision makers. It therefore makes sense to assess the degree of uncertainty associated with the LCC results and to take additional information into account when making decisions. Uncertainty assessment was approached by deterministic sensitivity analysis, that is, a technique for determining which input values, if different, would affect the outcome of the analysis. To identify which input values were crucial to the outcome we increased all values by 15% for both scanners and recalculated the LCC. (Fuller & Petersen, 1996)

To fulfill the LCCA we followed nine basic steps which are described in details in the literature (Mearig, Coffee and Morgan, 1999):

1. State objective
2. Identify alternatives
3. Establish common assumptions and parameters
4. Estimate costs and time of occurrence for each alternative
5. Discount future costs to present value
6. Compute and compare LCC for each alternative
7. Compute supplementary measures
8. Assess uncertainty of input data
9. Advice on the decision maker

3. Results

Table 1 illustrates the values for the 128-slice scanner that were calculated and were discounted into its PV. According to our results, the total LCC was 2.2 times higher than the initial cost during the study period.

Table 2 also illustrates the values for the 64-slice scanner that were calculated and were discounted into its PV. According to our results, the total LCC was 3.6 times higher than the initial cost during the study period.

The NS were 647,199€, in favor of 128-slice CT scanner and

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this means that the LCC decision criterion is that the scanner with the lower LCC and the highest NS can be the preferred one for purchase.

Table 3 illustrates the sensitivity analysis for the 128-slice scanner. OM&R and I costs were the values with the greater impact on total LCC of the 64-slice scanner.

Table 4 illustrates the sensitivity analysis for the 64-slice scanner. OM&R and I costs were the values with the greater impact on total LCC of the 64-slice scanner.

Table 5 illustrates the costs that were calculated for both MSCT scanners.

4. Discussion

According to our results, we found that the 128-slice scanner was cheaper than the 64-slice scanner making economic savings of 647,199 € for the study period. Moreover, we found that OM&R and I costs were of great impact on the total LCC of both scanners so decision makers can take them into account thus optimizing decision making by searching for alternatives. Furthermore, our study showed that long term service contracts like 128-slice scanner's can minimize maintenance cost and consequently the total cost and make potential economic savings. The diffusion of MSCT scanner with newer options than 64-slices does not mean higher cost. It depends on the cash-flow capability of the stakeholder and the deal that will make with the supplier.

Rising health care costs and limited resources imply the implementation of the principles of LCCA in decision making. An economic evaluation identifies, measures, values and compares the costs and outcomes of a technology. (Canadian Agency for Drugs and Technologies in Health, 2006) The rapid technological development of MSCT scanners enforces economic analyses like LCCA because CT scanners entail ongoing maintenance and operational cost and the initial cost does not accurately reflect the total cost of ownership.

LCCA provides a significantly better assessment of the long-term cost effectiveness of medical devices than alternative economic methods that focus only on initial costs or on operational-related costs in the short term. Economic modeling evaluation of medical devices can help decision makers to get reliable and trustworthy evidence in order to make the most cost benefit purchase.

The total cost of ownership of MSCT scanners of our study can be compared with other similar investigations which have been performed from other research institutes. For example, the ECRI Institute published in 2002 (4-slice, slip ring, CT system) (Emergency Care Research Institute [ECRI], 2003) as well as in 2008 (64-slice CT system) a PV/LCCA for the assuming period of 5 years. The study for the 4-slice CT showed a total LCC of $3,643,022 meaning 3.03 times higher cost than the initial cost of $1,200,000 and the 64 slice CT showed a total LCC of $5,216,320 meaning 4.3 times higher cost than initial cost of $1,200,000. (ECRI, 2008) Therefore, with the increase of the CT clinical applications, the total LCC also increases. In our study, total LCC of MSCT scanners found to be 3.6 times higher than the initial cost for the 64-slice scanner and 2.2 times higher for the 128-slice scanner proving that there can be potential economic savings through HTA processes even if CT clinical applications are increased.

In addition, in 1999, a PV/LCCA has been published in evaluating an ultrasound scanner in order to provide the decision makers with information about the total LCC of the device. (ECRI, 1999) Thus, in 2008, a cost-effectiveness analysis through an LCCA has been published, computing the total cost visibility of an MRI scan in both "In-house" and "outsourcing of facility" configuration. The study concluded that every decision for acquiring high-end technology must be subjected to LCCA. (Chakravarty & Naware, 2008) So, the method of LCCA can be a strategic tool for assessing the cost benefit of these medical devices.

Generally, cost data vary from country to country reflecting differences in resource use patterns and relative unit cost levels. Our economic modeling presented, suggests that it is feasible for other hospitals or radiology centers to succeed in the cost containment by performing LCCA resulting in remaining competitive by delivering high-quality care and financially viable. In addition, hospitals are now commonly operating under limited budgets and so decision makers may be tempted to use our results as benchmarks in order to make the best cost benefit purchase for a MSCT scanner.

The technology of MSCT scanners has been a major cost driver for Greece the last years due to the fact that between 2005 and 2009 there was a high Compound Annual Growth Rate that reached 8%. (OECD, 2010) LCCA can be a macro-economic modeling tool for decision makers so as to understand and predict future economic outcomes. The absence of economic evaluations like LCCA has led to investments without enhancing efficiency in health care or minimizing costs. It is probable that the implementation of the principles of an LCCA for medical devices can result in huge economic savings and in increased efficient use of resources. In view of the current economic crisis, the Greek government should establish a Health Technology Assessment sector in order to make value for money judgments and to identify less effective or even inadequate practices and technologies.

5. Conclusion

Under worldwide economic crisis, we suggest that economic analyses like LCCA can be considered as a part of decision making in national health technology policies for the selection of alternative medical devices when aiming for cost containment and thus long-term service contracts for medical devices that detail maintenance cost can minimize healthcare costs in the long run. In conclusion, we summarize the key points of our research that can be helpful for any similar research.

Table 1. Data Summary of 128-slice Scanner

Cost items (1)	Base Date (2)	Year of Occurrence (3)	Discount Factor (4)	Present Value (5)=(2)x(4)
Initial costs (I)	891,000 €	2009	1	891,000 €
Capital replacement costs (Repl)	0 €	2013	0.863	0 €
Residual value (Res)	297,000 €	2013	0.863	-256,311 €
Energy costs (E)	2,074 €	2013	4.8562	10,072 €
Operation, Maintenance, Repair (OM & R)	294,600 €	2013	4.58	1,349,268 €
Total Life Cycle Cost (LCC)				1,994,029 €

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Table 2. Data Summary of 64-slice Scanner

Cost items (1)	Base Date (2)	Year of Occurrence (3)	Discount Factor (4)	Present Value (5)=(2)x(4)
Initial costs (I)	726,000 €	2009	1	726,000 €
Capital replacement costs (Repl)	0 €	2013	0.863	0 €
Residual value (Res)	242,000 €	2013	0.863	-208,846 €
Energy costs (E)	2,765 €	2013	4.8562	13,427 €
Operation, Maintenance, Repair (OM & R)	460,840 €	2013	4.58	2,110,647 €
Total Life Cycle Cost (LCC)				2,641,228 €

Table 3. Sensitivity analysis on 128-slice Scanner

Cost	Input value increased by 15%	Change in LCC in PV in %	
Initial costs (I)	891,000 €	133,650 €	+6.702
Capital replacement costs (Repl)	0 €	0 €	0
Residual value (Res)	-256,311 €	38,447 €	<-1.93
Energy costs (E)	10,072 €	1,511 €	+0.075
Operation, Maintenance, Repair (OM & R)	1,349,268 €	202,390 €	+10.149

Table 4. Sensitivity analysis on 64-slice Scanner

Cost	Input value increased by 15%	Change in LCC in PV in %	
Initial costs (I)	726,000 €	108,900 €	+4.123
Capital replacement costs (Repl)	0 €	0 €	0
Residual value (Res)	-208,846 €	31,327 €	<-1.185
Energy costs (E)	13,427 €	2,014 €	+0.076
Operation, Maintenance, Repair (OM & R)	2,110,647 €	316,597 €	+11.986

Table 5. Cost analysis of MSCT Scanners

Costs	64-slice scanner	128-slice scanner
Initial		
CT scanner	700,000€	855,000€
Printer	6,000€	6,000€
Contrast media injector	20,000€	30,000€
Operation		
Radiology films 3films/exam	6€	4.56€
CT syringes 200ml/exam	19.1€	17€
Contrast media 100ml/exam	36.5€	27€
Oxygen bottle/year	240€	240€
Maintenance		
CT scanner/year	90,000€	0€
Printer/year	1,000€	1,000€
Contrast media injector/year	0€	2,000€

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