
Operational Management of Radiographic Equipment (X-ray, CT-scan, MRI): Correlation of Utilization, Idle Time, and Energy Consumption on Hospital Cost Efficiency

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ABSTRACT

High hospital expenses are associated with the operation and maintenance of medical equipment. Radiographic equipment such as X-ray, Computed Tomography (CT-scan), and Magnetic Resonance Imaging (MRI) are among the most frequently used diagnostic tools in hospitals and significantly contribute to operational expenditures. A quantitative correlational research design was applied using secondary data, collecting data from hospital radiology department records over a specific operational period. Equipment operational hours as variables were analyzed. Statistical analysis was conducted using correlation to determine the relationship between equipment utilization efficiency and cost reduction. Results indicate that although greater equipment use may increase total operational cost, more optimal utilization may improve cost efficiency per diagnostic service. Higher equipment leads to improved cost distribution across diagnostic procedures, thereby enhancing cost efficiency within hospital operations. In conclusion, optimizing the operational hours of radiographic equipment such as X-ray, MRI, and CT-scan plays an important role in improving hospital cost efficiency.

Keywords: X-ray, CT-scan, MRI, operational hours, idle hours, total energy, cost efficiency

INTRODUCTION

Radiology imaging plays an important role in the modern healthcare system for accuracy and effectiveness in clinical diagnosis and decision-making. Radiology imaging, such as X-ray, Computed Tomography (CT-scan), and Magnetic Resonance Imaging (MRI), is used in hospitals to detect, evaluate, and monitor various medical conditions. Advances in medical imaging technology have improved the speed, quality, and accuracy of diagnostic services, allowing healthcare providers to deliver patient care.

Although there are clinical benefits, radiographic equipment needs substantial financial investment

and high operational costs. Hospitals must provide significant resources for electricity consumption, equipment procurement, software updates, maintenance, and specialized staff. Therefore, managing operational costs in radiology imaging has become an important role for hospital management.

One factor that may influence operational efficiency is the use of radiology equipment that can be measured through equipment operating hours. Higher utilization of imaging equipment may lead to productivity and potentially lower operational costs. If expensive medical equipment is used more efficiently, hospitals may be able to distribute

fixed operational costs across a larger number of services.

While increased equipment use can lead to increased overall operational costs, more optimal equipment utilization still has the potential to support cost efficiency, particularly if it allows hospitals to more effectively distribute operational burdens across the diagnostic service process. Therefore, the discussion of costs in this study focuses not only on the amount of expenditure but also on how hospitals manage equipment use to maintain efficiency.

However, in many healthcare facilities, radiographic equipment is not utilized optimally due to factors such as low patient demand, scheduling inefficiencies, or other operational limitations.

Nonoptimal utilization of expensive imaging equipment may result in higher operational costs and lower financial efficiency for hospitals. Therefore, understanding the relationship between operational cost efficiency and equipment usage is important for improving hospital management strategies.

This study aims to analyze the effect of radiographic equipment operational characteristics, including operating hours, idle hours, and energy consumption, on hospital operational cost. The findings of this study are expected to provide hospital insight for optimizing the utilization of radiographic equipment that will improve cost management and operational efficiency. This study hypothesizes that the operational characteristics of radiographic equipment, including operating hours, idle hours, and energy consumption,

have a significant effect on hospital operational cost.

METHOD

This study employed a quantitative analytical design using secondary data obtained from published studies selected through the PEO (Population, Exposure, Outcome) framework. The population in this study consisted of radiographic equipment used in hospital radiology units. The exposure variables included the operational characteristics of radiographic equipment, namely operating hours, idle hours, and total energy consumption of X-ray, CT-scan, and MRI. The outcome variable was hospital operational cost.

The PEO framework was used to define the study focus and formulate the inclusion criteria for article selection. The inclusion criteria were as follows: (1) studies conducted in hospital or radiology department settings; (2) studies analyzing radiology imaging modalities such as X-ray, CT-scan, and MRI; and (3) studies reporting measurable yearly data related to operating hours, idle hours, energy consumption, and operational cost. Studies were excluded if they were not relevant to the research objectives, did not provide sufficient measurable data regarding the study variables, were conducted outside hospital or radiology settings, or lacked adequate methodological information.

After the article selection process, 8 articles out of 65 identified articles met the inclusion criteria and were included in the analysis. The data used in this study were obtained from secondary sources in the form of published studies reporting

operational and cost-related variables for radiographic equipment. The independent variables in this study were operating hours, idle hours, and total energy consumption, while the dependent variable was hospital operational cost.

Data analysis was conducted using ANOVA and regression tests. ANOVA was used to examine differences in operational characteristics and cost patterns across radiographic modalities, while regression analysis was used to assess the contribution of operating hours, idle hours, and total energy consumption to hospital operational cost. In addition, correlation values were presented as supporting statistical information to describe the direction and strength of the relationship between variables. Therefore, the correlation tables in this study were used as complementary findings, while the main analytical

interpretation was based on ANOVA and regression results.

RESULT and DISCUSSION

The results of this study are presented in three main groups: operating hours, idle hours, and total energy consumption of radiography equipment. These three aspects not only describe equipment usage patterns but also reflect the operational burden that hospitals need to manage. Therefore, the discussion in this section is not solely directed at demonstrating the relationship between technical variables and costs, but also at examining how equipment usage patterns contribute to operational cost efficiency in radiology units. With this framework, each table in this study is understood not only as descriptive data but also as a basis for assessing the efficiency of radiology service management within the context of hospital management.

Table 1. Operating Hours of X-ray in the Literature

Journal	Hour/Year	Cost/Year (USD)
(Roletto et al., 2025)	2,445.5	1,991.44
(McAlister et al., 2022)	31.2	4.00
(Rossini et al., 2026)	426.9	88.41

This table shows variety of yearly X-ray operational alongside its operational cost from a few studies, (Roletto et al., 2025) has the highest operational hours, several 2.444,5 hours/year with cost of USD 1.991,4 / year, while (McAlister et al., 2022) has lower yearly operational hours, with 31.2 hours/ year, costing only USD 4.00 yearly, while (Rossini et al., 2026) in the middle with 426.9 hour/ year costing USD 88.41.

In general, this table supports our research theme that radiographic operational cost has a correlation with hospital operational cost. The higher the operational hours, the higher the energy needed, and the use of supporting systems, which shows that operational burden is also rising as a result of these factors. It also shows that the first table shows X-ray operational duration is also one of the important components that contribute to operational cost.

Table 2. Operating Hours of CT-scan in the Literature

Journal	Hour/Year	Cost/Year (USD)
(Brown et al., 2023)	2,800.5	2,833.38
(Roletto et al., 2025)	2,263.0	3,685.77
(McAlister et al., 2022)	733.2	1,590.16

The table presents yearly operational hours of CT-scan according to studies that fit into our inclusion criteria. (Brown et al., 2023) note the highest operational hour with yearly 2.800,5 hours, costing USD \$2.833,38. (Roletto et al., 2025) results in yearly 2.263,0 hours with a cost of USD 3.685,77, while (McAlister et al., 2022) have the lowest operational hours, only 733,2 hours/year, but still results in a high cost, reaching USD 1.590,16 / year.

This table shows that in CT-scan, an increase in operational hours

also means an increase in yearly cost. This is relevant to our research title because it shows that whenever the duration of operational increase, operational cost also increases, meaning CT-scan has the potential of a positive correlation towards hospital operational cost, it also means that high dispersity of operational hours, which is not too far off indicates that equipment efficiency, energy consumption, and each hospital operational characteristics affects the variable.

Table 3. Operating Hours of MRI in the Literature

Journal	Hour/Year	Cost/Year (USD)
(Roletto et al., 2025)	2,117.0	8,849.06
(McAlister et al., 2022)	2,880.89	10,033.49
(Alerte et al., 2025)	4,380.0	26,575.29

This table represents the operational hours of MRI on a yearly scale alongside its cost. Highest is (Alerte et al., 2025), whose hospital reaches a score of 4.380 hours/ year with USD 26.575,29 / year. (McAlister et al., 2022) notes an operational hours of 2.880.89 yearly with a cost of USD 10.033,49 /year, while Roletto et al., 2025 have 2.117,0 hours/ year, which cost USD 8.849,06/ year. Compared to X-ray and CT Scan, this table shows that MRI has higher operational cost compared to X-ray and CT Scan when its operational hour is similar, this shows the importance of our research

since the findings support that type of radiologic modality affects the correlation between operational hours and hospital operational cost, showing that not only operational hours matters, but also characteristics of the equipment that affect the cost.

In addition to operating hours, cost efficiency in radiology units is also influenced by equipment idle time. In the context of hospital management, idle time cannot be viewed as a neutral condition, as during this period the hospital still bears certain costs even when the equipment is not being used for services. Therefore, analyzing idle

hours is important to demonstrate that operational costs arise not only when equipment is actively operating but

also when it is on standby or not being optimally utilized.

Table 4. Idle Hours of X-ray in the Literature

Journal	Hour/Year	Cost/Year (USD)
(Roletto et al., 2025)	219.0	56.21
(McAlister et al., 2022)	8,376.75	652.08

This table presents the annual idle hours of X-ray equipment and the corresponding yearly costs. McAlister et al. (2022) reported the higher idle hours, amounting to 8,376.75 hours per year, with an annual cost of USD 652.08, whereas Roletto et al. (2025) reported lower idle hours of 219 hours per year, with a cost of USD 56.21.

The table is very relevant to our research since it shows that hospital operational cost is not only affected by how many hours a machine has been

used, but also by how many hours a machine is being put in idle or standby mode. Even though a machine is not used to serve patients, there are still costs to be paid, from idle power, supporting system, and the need to keep the machine on standby mode, meaning a correlation between radiography equipment operational hours and hospital cost needs to be studied alongside its cost when idle, because the two affect total operational cost.

Table 5. Idle Hours of CT-scan in the Literature

Journal	Hour/Year	Cost/Year (USD)
(Brown et al., 2023)	5,959.5	3,800.06
(Roletto et al., 2025)	1,131.5	995.72
(McAlister et al., 2022)	7,997.6	6,910.90

The table shows the results of CT-scan idle time alongside its yearly cost. The highest idle hours were from (McAlister et al., 2022), with 7.997,6 hour per year costing the hospital USD 6.910,90, followed by (Brown et al., 2023), with 5.959,5 hour per year costing them USD 3.800,06 per year. (Roletto et al., 2025) have the lowest idle hour, with only 1.131,5 hour/ year, costing the hospital USD 995,72.

The table shows that CT-scan still generates a substantial amount of

cost, although not being used. This strengthens the research argument that operational cost and equipment usage have a complex relationship. In the context of CT-scan, high idle cost could mean that hospital financial burden not only comes from diagnostic modality, but also from using the modality in Standby mode, concluding that hospital operational cost cannot be determined only on operating hours, but also during the non-operational hours.

Table 6. Idle Hours of MRI in the Literature

Journal	Hour/Year	Cost/Year (USD)
(Roletto et al., 2025)	547.5	2,264.46
(McAlister et al., 2022)	5,889.0	12,204.76

(Alerte et al., 2025)

4,380.0

7,855.75

This table presents MRI Idle hours and their yearly cost. (McAlister et al., 2022) has the highest idle hours of MRI with 5.889,0 hours per year, costing them USD 12.204,76 per year. (Alerte et al., 2025) noted a number of 4.380 hour/ year, costing them USD 7.855,75 per year, while (Roletto et al., 2025) noted the lowest MRI hours of 547 hours per year, costing them USD 2.264,46 per year.

The table shows that MRI has generated an incredible amount of idle cost, compared to other radiographic modalities. This is due to MRI characteristics in which a greater amount of energy is needed to keep MRI on standby, and higher maintenance costs, including times when MRI was not being fully operated. The table also supports a statement in which hospital operational cost is not only affected by MRI operational hours, but also by the

cost of putting the machine in standby mode. It concluded that, amongst other radiographic modalities, MRI appears to impose a greater operational cost burden than other radiographic modalities, particularly because of its higher standby and maintenance demands.

In addition to operating hours and idle hours, energy consumption is a crucial component in explaining the formation of operational costs in radiology services. Energy use represents a direct consequence of the technological characteristics of each device, particularly in modalities with higher power requirements. Therefore, an analysis of energy consumption in this study is necessary to clarify that the efficiency of hospital operational costs is determined not only by the duration of device use but also by the magnitude of the energy requirements associated with its use.

Table 7. Total Energy of X-ray in the Literature

Journal	kWh/Year	Cost/Year (USD)
(Roletto et al., 2025)	9,307.5	2,047.65
(McAlister et al., 2022)	2,982.2	656.08
(Rossini et al., 2026)	1,814	399.08

This table shows the total yearly energy consumption of X-ray machines. (Roletto et al., 2025) show the highest energy consumption with a total of 9.307,5 kWh per year, costing the hospital USD 2.047,65 per year. (McAlister et al., 2022) notes a total of 2.982,2 kWh per year with a total cost of USD 656.08 per year, in which (Rossini et al., 2026) held the record for its lowest energy consumption with only a total of 1.814 kWh per year,

which cost the hospital USD 399.08 per year.

This table is important because it shows that energy consumption serves a direct connection between operational hours and hospital operational cost. The higher the operational hours or the burden of energy consumption on the equipment, the higher the yearly energy consumption, which will lead to higher operational cost, as the study concludes

that the correlation between operational and hospital operational cost could be explained through total energy consumption as one of the main mechanisms.

Table 8. Total Energy of CT-scan in the Literature

Journal	kWh/Year	Cost/Year (USD)
(Brown et al., 2023)	30,152.0	6,633.44
(Heye et al., 2020)	26,226.0	5,769.72
(Roletto et al., 2025)	21,279.5	4,681.49
(McAlister et al., 2022)	38,641.2	8,501.06
(Marks et al., 2025)	22,565.4	4,964.39

This table shows the total yearly energy consumption of CT-scan and their yearly cost across a few studies. High Energy consumption was found in (McAlister et al., 2022), which notes an amount of 38.641,2 kWh per year, costing them USD 8,501,06 per year. (Brown et al., 2023) results in 30,152,0 kWh per year and costing the hospital USD 6.633,44 per year, while (Roletto et al., 2025) and (Marks et al., 2025) show a high energy consumption of 21,279,5 kWh per year and 22.565,4 kWh per year.

This table explains that a CT-scan needs a greater amount of energy compared to an X-ray, making the operational cost higher. This data shows that the more intense the use of radiology equipment, will demand greater the amount of energy, making the operational costs contribute more to hospital operational costs. The table shows that the relationship between hospital operational hours and hospital operational cost is strong because it is mediated through high energy consumption.

Table 9. Total Energy of MRI in the Literature

Journal	kWh/Year	Cost/Year (USD)
(Heye et al., 2020)	134,037.0	29,488.14
(Roletto et al., 2025)	50,516.0	11,113.52
(Roletto et al., 2026)	101,036.0	22,227.92
(McAlister et al., 2022)	100,958.0	22,210.76
(Alerte et al., 2025)	156,504.7	34,431.03

This table presents the total energy consumption of MRI per year and its yearly cost. Highest consumption noted by (Alerte et al., 2025), with energy consumption reaching a total of 156.504,7 kWh per year, with USD 34.431,03 per year. (Heye et al., 2020) also show a huge amount of 134.037,0 kWh per year, costing them USD 29.488,14 per year. Other data, such as (McAlister et al.,

2022)and (Roletto et al., 2026), also show the level of energy consumption at an outstanding level, around 100 thousand kWh per year.

The table also serves as an important proof that MRI is a modality with the highest energy consumption and highest operational cost between the two other modalities (X-ray and CT-scan). This is very relevant to our study due to the fact that higher

operational hours of MRI require higher energy, which means higher cost.

In general, the descriptive results indicate that each modality has distinct operational cost characteristics. X-rays tend to exhibit lower costs, while CT scans and, especially, MRIs exhibit higher costs, both during active and idle operations. This finding indicates that hospital operational costs are influenced not only by the duration of equipment use, but also by the energy consumption characteristics of each device and its utilization rate. In other words, operational efficiency in a radiology unit needs to be understood as a result of the interaction between equipment usage intensity, downtime, and energy requirements.

To strengthen the descriptive findings, this study employed ANOVA and regression tests as the main analytical approaches. ANOVA was used to identify differences across radiographic modalities, while regression analysis was applied to examine the contribution of operating hours, idle hours, and total energy consumption to hospital operational cost. In addition, correlation values were presented to provide supporting information regarding the direction and strength of the relationship between variables. Therefore, the statistical results in the following section should be understood as a combination of supporting correlation patterns and main regression-based interpretation.

Table 10. Operational Hours X-ray Correlation

	Hour	Cost
Hour	1	
Cost	0,99	1

Table 10 shows a correlation value of 0.99 between the average hours of X-ray operation and the average operating costs. This value indicates a very strong positive relationship between the duration of X-ray use and hospital costs. This means that the longer the X-ray operation, the

higher the operating costs. This finding is highly relevant to the research title because it shows that the duration of radiography equipment use, particularly X-rays, has a nearly linear contribution to increasing hospital operating costs.

Table 11. Operational Hours CT-scan Correlation

	Hour	Cost
Hour	1	
Cost	0,78	1

Table 11 shows a correlation value of 0.78 between average CT scan operating hours and average operating costs. This value indicates a strong positive relationship, although not as strong as for X-ray and MRI. This

means that increasing CT scan operating hours tends to be followed by increasing operating costs. In the context of this research, these results support that CT scan usage affects hospital costs, but it is likely that other

factors beyond operating hours also influence the cost.

Table 12. Operational Hours MRI Correlation

	Hour	Cost
Hour	1	
Cost	0,96	1

Table 12 shows a correlation value of 0.96 between average MRI operating hours and average operating costs. This value indicates a very strong positive relationship. Therefore, the longer an MRI is operated, the higher

the operational costs incurred by the hospital. This result aligns with the study's title, demonstrating that MRI is a radiology modality whose operating hours are closely related to operational costs.

Table 13. Operational Hours X-ray Regression

Multiple R	0,99
R square	0,99

Table 13 shows the regression results for the relationship between X-ray operating hours and operating costs, with a Multiple R value of 0.99 and R Square of 0.99. The Multiple R value indicates a very strong relationship between the independent and dependent variables, while the R Square value indicates that approximately 99% of the variation in

operating costs can be explained by X-ray operating hours. This means that X-ray operating hours are a very dominant predictor of hospital operating costs. In this study, these results strengthen the hypothesis that the use of X-rays significantly influences the formation of total operating costs.

Table 14. Operational Hours CT-scan Regression

Multiple R	0,78
R square	0,62

Table 14 shows the regression results for CT-scan operating hours on operational costs, with a Multiple R value of 0.78 and R Square of 0.62. This means that the relationship between the two variables is quite strong, and approximately 62% of the variation in operational costs can be explained by CT-scan operating hours. Meanwhile,

the remaining 38% is likely influenced by other factors, such as maintenance costs, additional energy consumption, or other operational variables. In relation to the research title, these results indicate that CT-scan operating hours do contribute to hospital costs, but their influence is not entirely independent.

Table 15. Operational Hours MRI Regression

Multiple R	0,96
R square	0,93

Table 15 shows the regression results between MRI operating hours and operational costs, with a Multiple R value of 0.96 and an R Square of 0.93. This indicates a very strong relationship, with approximately 93% of the variation in operational costs explained by MRI operating hours. In

other words, the duration of MRI use plays a significant role in determining hospital operational costs. This finding strongly supports the research focus that radiography equipment, particularly MRI, has a significant impact on operational costs.

Table 16. Idle Hours X-ray Correlation

	Hour	Cost
Hour	1	
Cost	1	1

Table 16 shows a correlation value of 1.00 between the average X-ray idle hours and the average cost. This value indicates a perfect positive relationship, meaning that any change in idle hours is followed in the same direction by a change in costs. This indicates that even when the device is

not being used for active services, idle conditions still incur operational costs. In the context of this research, this result is important because it demonstrates that not only active hours of use, but also the idle time of an X-ray device can affect a hospital's operational costs.

Table 17. Idle Hours CT-scan Correlation

	Hour	Cost
Hour	1	
Cost	0,97	1

Table 17 shows a correlation value of 0.97 between the average CT scan idle hours and the average cost. This value indicates a very strong positive relationship. This means that the longer the CT scan is idle, the greater the fixed costs incurred. This

result furthers the research, which suggests that hospital operational costs are influenced not only by the active use of the equipment but also by the length of time the equipment is on standby or unused.

Table 18. Idle Hours MRI Correlation

	Hour	Cost
Hour	1	
Cost	0,99	1

Table 18 shows a correlation value of 0.99 between average MRI idle hours and average costs. This indicates a very strong, nearly perfect relationship. Therefore, MRI idle hours have a significant impact on

operational costs. Relating to the research title, this finding demonstrates that hospital efficiency depends not only on managing operational hours but also on

controlling MRI equipment idle time to reduce costs.

Table 19. Idle Hours X-ray Regression

Multiple R	1
R square	1

Table 19 shows the regression results for X-ray idle hours on costs, with a Multiple R value of 1.00 and R Square of 1.00. This result means that 100% of the cost variation can be explained by X-ray idle hours. Statistically, this shows a perfect linear relationship. In research, this result

indicates that X-ray idle time significantly affects hospital operational costs. However, academically, perfect results like this should also be interpreted with caution because they can be influenced by the limited amount of data or very homogeneous data patterns.

Table 20. Idle Hours CT-scan Regression

Multiple R	0,97
R square	0,93

Table 20 shows the regression results between CT-scan idle hours and costs, with a Multiple R value of 0.97 and an R Square of 0.93. This indicates a very strong relationship, with approximately 93% of cost changes explained by CT-scan idle hours. This

finding confirms that CT-scan idle hours continue to significantly impact hospital operational costs. Therefore, managing CT-scan waiting or standby time is a crucial aspect of operational cost efficiency.

Table 21. Idle Hours MRI Regression

Multiple R	0,99
R square	0,97

Table 21 shows the regression results between MRI idle hours and costs, with a Multiple R value of 0.99 and an R Square of 0.97. This means the relationship between the two is very strong, and approximately 97% of the cost variation can be explained by MRI idle hours. These results indicate that

MRI idle time still triggers significant cost expenditures. In the context of the research title, these findings reinforce that both operational hours and radiography equipment idle hours significantly contribute to hospital operational costs.

Table 22. Total Energy X-ray Correlation

	kWh	Cost
kWh	1	
Cost	1	1

Table 22 shows a correlation value between total X-ray energy

(kWh) and cost of 1.00. This value indicates a perfect positive

relationship, meaning that an increase in energy consumption in X-ray equipment is followed by a unidirectional and highly consistent increase in costs. In relation to the research title, these results indicate that resource use in radiography

equipment, particularly in the form of energy consumption, is closely related to hospital operational costs. In other words, the greater the energy used by X-ray equipment, the greater the costs that must be borne.

Table 23. Total Energy CT-scan Correlation

	kWh	Cost
kWh	1	
Cost	0,97	1

Table 23 shows a correlation value of 0.97 between total CT scan energy (kWh) and cost. This value indicates a very strong positive relationship between the two variables. This means that increased CT scan energy consumption tends to be followed by increased operational

costs. In the context of this research, this finding supports that CT scan usage is not only related to operating hours but also to the amount of energy consumed, which ultimately contributes to hospital operational costs.

Table 24. Total Energy MRI Correlation

	kWh	Cost
kWh	1	
Cost	1	1

Table 24 shows a correlation value of 1.00 between total MRI energy (kWh) and cost. This value indicates a perfect positive relationship, meaning that any increase in MRI energy consumption is followed by a very consistent increase in costs. This result

is relevant to the research title because it demonstrates that in MRI equipment, energy use is a component closely related to hospital operational costs. Therefore, the higher the total energy used by MRI, the higher the resulting costs.

Table 25. Total Energy X-ray Regression

Multiple R	0,19
R square	0,03
P-value	0,88

Table 25 shows the regression results between total X-ray energy and cost, with a Multiple R value of 0.19, R square = 0.03, and P-value = 0.88. The Multiple R value indicates a very weak relationship, while the R square value indicates that only about 3% of the cost

variation can be explained by total X-ray energy. In addition, the p-value is much greater than 0.05, indicating that the relationship is not statistically significant. In relation to the research, this result means that in the regression model, total X-ray energy is not able to

explain changes in operational costs convincingly. This finding also suggests that in X-ray, there may be

other factors beyond total energy that have a greater influence on hospital costs.

Table 26. Total Energy CT-scan Regression

Multiple R	1
R square	1
P-value	1.32E-19

Table 26 shows the regression results between total CT-scan energy and cost, with a Multiple R value of 1.00, R square = 1.00, and P-value = 1.32E-19. These results indicate a very strong, even perfect, linear relationship between total CT-scan energy and cost. An R square value of 1.00 means that 100% of the cost variation in this model

can be explained by total CT-scan energy. A very small p-value also indicates that the relationship is highly statistically significant. In the context of the research title, these results confirm that CT-scan energy consumption is a component that significantly influences hospital operational costs.

Table 27. Total Energy MRI Regression

Multiple R	1
R square	1
P-value	1,46E-21

Table 27 shows the regression results between total MRI energy and cost, with a Multiple R value of 1.00, R square value of 1.00, and a P-value of 1.46E-21. These values indicate a perfect and highly significant linear relationship between MRI energy consumption and cost. This means that all cost variations in this model can be explained by the total MRI energy. In relation to research, these results reinforce that MRI use has a significant contribution to hospital operational costs, particularly in terms of energy consumption. The higher the energy used by MRI, the higher the operational costs incurred.

CONCLUSION

This study shows that operating hours, idle time, and energy consumption of radiography equipment are related to hospital

operational costs. In general, increased equipment usage tends to be followed by increased operational costs, so the operational characteristics of radiology equipment can be viewed as a critical component in determining hospital operational costs.

Regarding operating hours, the statistical results consistently showed that all modalities were positively associated with operational cost, although with different levels of strength. Idle hours also demonstrated an important contribution to cost formation, indicating that costs arise not only during active equipment use but also during standby periods. Meanwhile, energy consumption emerged as a particularly relevant factor, especially in high-power modalities such as CT-scan and MRI.

Substantively, these findings confirm that cost efficiency in radiology installations is determined not only by the frequency or duration of equipment use, but also by the institution's ability to manage downtime and the energy requirements of each modality. Thus, optimizing equipment utilization, controlling idle time, and efficient energy consumption are crucial elements in a more effective and sustainable radiology operational management strategy.

Hospital management decisions regarding the use and provision of advanced diagnostic tests are not limited to selecting a modality, such as X-ray, CT scan, or MRI. Furthermore, a comprehensive approach is required, considering various operational factors that influence efficiency and cost sustainability. In addition to operational hours, indicators such as idle hours and energy consumption are crucial aspects that cannot be ignored. These three variables are interrelated and provide a more comprehensive picture of equipment utilization levels and their contribution to total hospital operational costs.

From a managerial perspective, high idle hours reflect inefficiencies in resource utilization, particularly for equipment with high investment costs and energy consumption, such as CT scans and MRIs. Meanwhile, ongoing energy consumption even when equipment is not actively used can be a

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significant source of cost waste. Therefore, healthcare institutions need to integrate analysis of operational hours, idle hours, and energy consumption into the decision-making process, both for optimizing the use of existing equipment and in planning investments in new technology. This data-driven approach is expected to improve operational efficiency while maintaining service quality.

However, these findings should be interpreted with caution because this study relied on literature-based data with limited sample characteristics, and some variables were derived through estimation and secondary calculations that may not fully reflect actual operational conditions. In addition, several factors that may influence hospital operational costs, such as maintenance expenses, equipment depreciation, equipment age, electricity tariff variation, service capacity, and the technical efficiency of each device, were not included in the analysis. An inconsistency was also found in one of the energy-related results, so that part should not be interpreted as strongly as the other findings. Therefore, the results of this study are better understood as a preliminary basis for explaining the relationship between the operational characteristics of radiography equipment and hospital operational costs, which still needs to be strengthened through primary data, a broader sample, and a more comprehensive analytical model.

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