

Healthcare Business Strategies: Analyzing Costs in a Medical Imaging Facility

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Abstract: The healthcare industry can benefit from costs research by using the outcomes as part of their decision making toolbelt. With this in mind, a detailed cost analysis was performed for a medical imaging facility in Puerto Rico to better understand where their costs were allocated and analyze them via different drivers. The study was conducted in a facility that offers more than 500 services divided into six different modalities: Sonography, Computed Tomography Scan (CT), Magnetic Resonance Imaging (MRI), Mammography, X-ray, and Densitometry. On a previous part of this project, it was established that to appropriately estimate the cost of each modality, costs were separated into three major classifications: direct material, direct labor, and overhead. One of the main objectives of this study was to analyze costs using different drivers, such as: Frequency, Time, & Human Capital Allocation. As we concluded our initial data analysis, we standardized how the information would be processed and created a tool using Microsoft Excel. This tool would receive costs, frequency, and the driver percentage inputs to calculate costs per modality in our client's company. This tool also created printable reports and a data analysis dashboard of the cost allocations. With these extrapolated results, company leaders can make informed cost driven decisions that positively impact their businesses.

Keywords: Cost Analysis, Medical Imaging, Cost Classifications, Cost Analysis Tool

1. Introduction

A key concept of business management is costs. Understanding costs can improve business decisions, expansions, and resource allocation. During this study we conducted a cost analysis in a Medical Imaging Facility located in the West side of the island of Puerto Rico. The study had two objectives, to validate a previous study with the imaging facility which focused on identifying the most appropriate and representative way to distribute or allocate all the incurred costs, and to develop a tool to ease data analysis and cost allocation. The purpose of our study was to help the management team make more data driven decisions and be strategic with their resources' allocation. This particular Medical Imaging Facility offers services in six different modalities: X-Rays, Sonography, MRI, CT Scan, Densitometry and Mammography.

The client shared with this research group very relevant information for our cost analysis; they shared actual data for complete fiscal years. These data include the following:

- Total number of employees per modality

- Direct costs per modality
 - Total material cost per year
 - Total labor cost per year
- Overhead costs
 - Essential indirect costs per year
 - Non-essential indirect costs per year
- Frequency of each modality per year

In the following sections of this article, the methodology used, the creation of the cost analysis tool, the results, and conclusions are presented.

2. Methodology

This research started validating the previous study done by a different research group with the same client in 2017 (Padilla-Martínez et. al., 2019). The same approach was used when calculating the different costs, and we did this with the known costs that our client had already calculated. Within Direct Costs, the client had information regarding: Direct Material costs and Direct Labor costs. Within Indirect Costs the client had data on Overhead costs associated with the services, and they were divided in two areas: Essential and Non-Essential Indirect Costs. We defined Frequency as a metadata variable, for it was a “data provided information about other data” (Merriam-Webster. (n.d.)), in this case, our modalities. With the frequency variable we calculated the percentage of time spent on that service by dividing the frequency per modality by the sum of all modalities, and divide our Indirect costs using said percentage.

The previously used cost data was available to calculate: Direct Labor per individual study, Direct Material per individual study, and Overhead per individual study (Padilla-Martínez et. al., 2019). In the following sub-sections of the methodology, the three cost categories are explained.

2.1 Direct Labor Cost

Within Direct Labor there are two types of employees: Radiologists and Radiological Technologists. To calculate the Direct Labor per Modality the following information was used:

- Radiologists (RA) Salary
- Radiological Technologists (RT) Salary
- Frequency per modality
- Number of Radiologists and Radiological Technologists per modality

With this information the Direct Labor Cost per Modality was calculated as followed (refer to equation (1)):

$$DLC \text{ per modality} = \frac{\text{Number of RT} \times \text{RT Salary}}{\text{Frequency}} + \frac{\% \text{ of time dedicated by RA} \times \text{RA Salary}}{\text{Frequency}} \quad (1)$$

2.2 Direct Materials Cost

For the Direct Materials Cost (DMC) analysis, a simple approach suggested by the management team was used based on their particular needs. The Material Cost was calculated multiplying the Total Direct Materials costs times the percentage of frequency per modality, as shown in equation (2).

$$DMC \text{ per modality} = \text{Total Direct Material Costs} \times \% \text{ of frequency} \quad (2)$$

2.3 Overhead Costs

For a clearer understanding of overhead allocation, the management team divided overhead costs in two areas: Essential and Non-Essential Overhead costs. Examples of Essential Overhead costs would be: Electricity, Rent, Indirect Labor, etc. Examples of Non-Essential Indirect Costs would be: Out of office activities, uniforms, charity, etc. For the calculation of Overhead per modality the total Overhead costs were multiplied by the percentage of frequency of each modality.

$$\text{Overhead per modality} = (\text{Essential Overhead Costs} + \text{Non – Essential Overhead Costs}) \times \% \text{ of frequency} \quad (3)$$

2.4 Total cost per Modality

The total cost of any service or product can be calculated by adding the unit costs of Direct Labor Costs, Direct Material Costs, and Overhead Costs (Hansen and Mowen, 2009) shown in Equation 4 .

$$\text{Total Cost} = \text{Direct Labor Cost} + \text{Direct Material Cost} + \text{Overhead Costs} \quad (4)$$

Since the cost categories had already been calculated, the total cost per study are used to have a better understanding of the behavior of the cost per unit, in this case of each medical imaging modality.

2.5 Validation of previous research

In 2017 a different research group did a similar cost analysis with the same client (Padilla-Martínez et. al., 2019). Their study gave the company a clear cost breakdown for their different cost groups and laid the foundation for this study during year 2020. The cost breakdown and formulas previously developed were used for this study, and their analysis was reviewed as well as validated. This was a very important step to be able to create a tool that represents the reality of the operations of the medical imaging facility. The only change on the way the calculations were made, was in one percentage driver to reflect the facility's current way to operate.

3. Cost Analysis Tool

Once the validation of the past research was concluded, this research group was able to continue with their main objective: to create an easy to use tool that would facilitate cost analysis and cost allocation for the medical imaging facility personnel. Because the initial calculations were done using Microsoft Excel (Microsoft Corporation, 2018) and this is a program commonly used by private industries, the template was prepared by standardizing it with input and output areas, which would perform all the calculations for the client and present the information in an intuitive way. The tool was named as the Decision Support Tool (DST), a user-friendly and powerful Microsoft Excel tool, that empowered the client to conduct their cost research independently.

3.1 Input areas

The tool needed three different input areas, which were the costs categorized for the client: Direct Costs, Indirect Costs, and Metadata. Three sheets were created in Microsoft Excel for these input areas and color coded where the client needed to input the data. These input data would be used to calculate the cost groups mentioned in section 2 with their respective formulas.

3.1.1 Driver

A powerful feature of the tool was the input area, Metadata. Within this feature the client could decide what driver percentage to use to analyze their cost depending on different methods. The main study was done using Frequency as the driver, but the client has the option to use Time, Human Capital Allocation, and even Space requirements per modality. This versatility of the tool represents a major contribution to literature and gives the client different perspectives when analyzing their costs.

3.2 Output areas

The tool can provide outputs of all the calculations related to Direct Materials per study, Direct Labor per study, Overhead per study, and Average Cost per study in different sheets inside of the DST Microsoft Excel document with clear breakdowns of where the costs were allocated.

3.3 Extra Features

There are some extra features included in the DST to make it more interactive. These features are:

- *Home page* – A primary page where the client could access all the information through buttons.
- *Dashboard* – A powerful visual representation reporting on business metrics and analytics using the input data.

- *Printable report* – A sheet that would organize the tables and graphs into a printable pdf document.
- *Restart button* – A button that would erase every input area to start the data analysis again.
- *Password protected document and sheets* – The Microsoft Excel document, as well as every sheet, was password protected. Only the input areas were unprotected to let the client have a smooth experience.
- *Instruction manual* – An instruction manual was created with step by step instructions explaining the tool and how to use it.

3.4 Screenshots of the Decision Support Tool

On this section, screenshots of the Decision Support Tool are presented. Figure 1 shows the Home Page window, which is comprised by different buttons that redirect the client to the desired window. Figure 2 shows the cost breakdown summary, the fundamental aspect of our tool. These are the final cost calculation results after the client has inputted their initial cost data. Lastly, figure 3 shows the Dashboard that we created that gives a visual snapshot of the data. It is comprised of four graphs visualizing different data sets. The numbers portrayed in these images are example data.

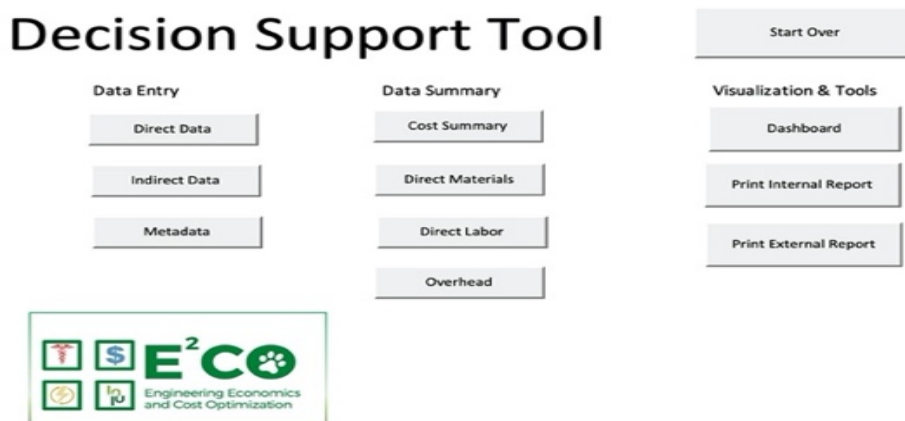


Figure 1. DST - Home page view

Modality	Direct Labor			Direct Materials	Overhead			Cost/Study	Total Cost
	Rad.Tech.	Radiologists	Total		Essentials	Non-Essentials	Total		
MRI	\$ 16.25	\$ 39.50	\$ 55.75	\$ 3.50	\$ 91.48	\$ 13.27	\$ 104.75	\$ 164.00	\$ 655,996.53
CT	\$ 4.33	\$ 19.00	\$ 23.33	\$ 3.67	\$ 77.64	\$ 14.47	\$ 92.12	\$ 119.12	\$ 357,352.07
Rayos X	\$ 2.30	\$ 10.80	\$ 13.10	\$ 3.80	\$ 69.75	\$ 14.96	\$ 84.70	\$ 101.60	\$ 1,016,020.13
Mamografía	\$ 6.33	\$ 19.00	\$ 25.33	\$ 3.33	\$ 58.68	\$ 12.87	\$ 71.55	\$ 100.21	\$ 601,283.88
Densitometría	\$ 10.50	\$ 3.50	\$ 14.00	\$ 4.00	\$ 65.63	\$ 14.47	\$ 80.11	\$ 98.11	\$ 196,215.38
Sonografía	\$ 12.89	\$ 21.11	\$ 34.00	\$ 3.67	\$ 68.46	\$ 14.47	\$ 82.93	\$ 120.60	\$ 1,085,380.21

Figure 2. DST - Cost overview table



Figure 3. DST - Dashboard

4. Results

The results obtained with the tool are summarized in three cost categories: Direct Labor, Direct Material, and Overhead. The cost per study for each of these categories is summarized and presented below in tables. The following tables are populated with example data. Table 1 shows a summary of Direct Labor Costs and shows the Direct labor per study for each modality. Table 2 shows the Direct Materials Costs and the material costs per study for each modality. Table 3 shows the total overhead costs and the overhead costs per study for each modality. Lastly, Table 4 shows the total costs per study per modality which was calculated by adding the direct materials, direct labor, and overhead cost per study for each modality.

Table 1. Direct Labor Costs

Modality	Radiological Tech. Salary – Yearly	Radiological Tech. Salary per service	Radiologists Salary – Yearly	Radiologists Labor Cost per study	Direct Labor per study
MRI	\$ 65,000.00	\$ 16.25	\$ 166,000.00	\$ 39.50	\$ 55.75
CT Scans	\$ 13,000.00	\$ 4.33	\$ 42,000.00	\$ 19.00	\$ 23.33
X-Rays	\$ 23,000.00	\$ 2.30	\$ 125,000.00	\$ 10.80	\$ 13.10
Mammography	\$ 38,000.00	\$ 6.33	\$ 101,000.00	\$ 19.00	\$ 25.33
Densitometry	\$ 21,000.00	\$ 10.50	\$ 6,000.00	\$ 3.50	\$ 14.00
Sonography	\$ 116,000.00	\$ 12.89	\$ 155,000.00	\$ 21.11	\$ 34.00

Table 2. Direct Materials Costs

Modality	Total Material Costs per Modality	Direct Materials Cost per study
MRI	\$ 14,000.00	\$ 3.50
CT Scans	\$ 11,000.00	\$ 3.67
X-Rays	\$ 38,000.00	\$ 3.80
Mammography	\$ 20,000.00	\$ 3.33
Densitometry	\$ 8,000.00	\$ 4.00
Sonography	\$ 33,000.00	\$ 3.67

Table 3. Overhead Costs

<i>Modality</i>	<i>Total Overhead per modality</i>	<i>Overhead per study</i>
MRI	\$ 418,996.53	\$ 104.75
CT Scans	\$ 276,352.07	\$ 92.12
X-Rays	\$ 847,020.13	\$ 84.70
Mammography	\$ 429,283.88	\$ 71.55
Densitometry	\$ 160,215.38	\$ 80.11
Sonography	\$ 746,380.21	\$ 82.93

Table 4. Total Costs per Study per modality

<i>Modality</i>	<i>Direct Labor per study</i>	<i>Direct Materials per study</i>	<i>Overhead per study</i>	<i>Total Costs per service</i>
MRI	\$ 55.75	\$ 3.50	\$ 104.75	\$ 164.00
CT Scans	\$ 23.33	\$ 3.67	\$ 92.12	\$ 119.12
X-Rays	\$ 13.10	\$ 3.80	\$ 84.70	\$ 101.60
Mammography	\$ 25.33	\$ 3.33	\$ 71.55	\$ 100.21
Densitometry	\$ 14.00	\$ 4.00	\$ 80.11	\$ 98.11
Sonography	\$ 34.00	\$ 3.67	\$ 82.93	\$ 120.60

5. Conclusion

After a lot of data analysis and tinkering with Microsoft Excel to make the most user-friendly tool possible we were able to complete this project. We went through some intense challenges during our research because of the COVID-19 pandemic, shifting our lives to a complete lockdown setting and adapting to a virtual academic experience. The client went through extreme challenges as well by being several weeks without being able to serve customers and generate revenue. By the end of the semester they were operating at a 50% capacity and were able to assist us with any new information.

By validating the previous research, we had a clear foundation for our Decision Support Tool. This tool saves the client hours of work and can give them different cost perspectives to drive more strategic business decisions. It is a user-friendly interface meaning that anyone in the management team will be able to understand it, and if there are any doubts, we created the Instruction Manual for them. Something that adds value to this tool is that it could be expanded in the future to accommodate different areas within the healthcare environment. An interesting implementation could be the use of the model in private medical practices where the different services would substitute modalities.

6. References

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