ANALYSIS OF THE RETURN ON INVESTMENT AFTER THE IMPLEMENTATION OF THE RFID SYSTEM AT HOSPITAL ISRAELITA ALBERT EINSTEIN.

Moreno, Antonio C. de A.,
Undergraduate student in Clinical Engineering – Faculdade Israelita de Ciências da Saúde Albert Einstein, São Paulo, Brazil
e-mail: antonio.moreno@einstein.br

Abstract: Health care costs in Brazil continue to increase over the last decade and the inefficient management of medical technologies is one of the factors that has contributed to this high cost. On the other hand, there is a growing appreciation of technologies that help in the management of the technological park of hospitals. In this context, *radio frequency identification* (RFID) technology becomes essential for the management of hospital assets, allowing their real-time identification and the management of their information. Hospital Israelita Albert Einstein, in 2017, began studies for the implementation of the system, being implemented only in 2021, undergoing several feasibility and investment studies. The high investment in the RFID system is one of the factors that inhibit health institutions in Brazil from investing in this technology. Mobile assets benefiting the most from RFID technology were then selected within these variables. However, the return on investment (ROI) for RFID technology and its impact are based on the specifics of each healthcare organization and there is no standard methodology to assess this impact, but it is possible to project the gains and cost-benefit in a concrete way. The variables used in the ROI methodology were ***asset search time***, shrinkage ***rates,*** utilization rates***,*** and ***RFID implementation costs***. This study highlights important RFID asset management techniques and characteristics for hospitals to consider when determining their own financial viability with respect to RFID implementation. A full return on investment was achieved in only 10 months after the overall deployment of the system. **Keywords:** RFID, Asset Management, Return on Investment**.**

Introduction

Starting in 1990, the Ministry of Health proposed actions to manage hospital equipment, seeking greater efficiency. This management is crucial for the quality of healthcare services and to reduce costs, especially due to the increase in costs related to medical equipment and the difficulty in continuously tracking these devices, which are often mobile and can leave the hospital with patients. One suggestion to deal with this problem is the use of RFID for identification and control of this equipment. RFID (Radio Frequency Identification) is a radio frequency identification system that uses RFID tags to store and transmit information. The tags are made up of an antenna and a chip that contains the data to be transmitted. The operation of RFID is based on wireless communication between RFID tags and readers. When a reader emits a radio frequency signal, nearby tags pick up that signal, energize themselves, and respond by transmitting their stored information. This information may include equipment identification, patient data, maintenance status, equipment availability, installation location, and other information that may be added.

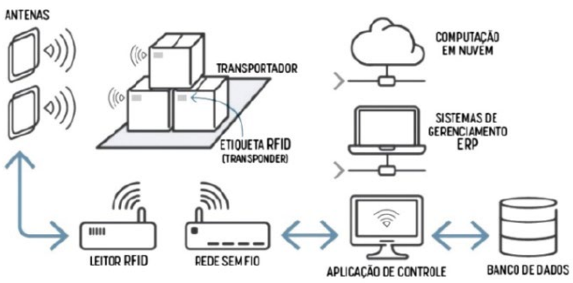

Figure 1. Simple Architecture of an RFID System

A well-known success story for the application of RFID to medical equipment took place at Addenbrooke's Hospital Institution, located in London. Active RFID tags were associated with approximately 10,000 pieces of medical equipment in order to track them. This technology was implemented due to the need for engineering members to locate equipment to perform maintenance, as the medical equipment management department is responsible for managing thousands of consumables and equipment in 45 departments across the hospital. This system made it possible to reduce long-term equipment loans to departments by 35%, reducing the time to search for equipment from 2 hours to 30 minutes, which allowed to increase the efficiency of maintenance and asset searches11.

During deployment, security and privacy issues related to the use of RFID technology in medical equipment should be considered. Risks such as unauthorized access to data, signal interference, and leakage of patient information are highlighted. It is recommended to implement robust security protocols and encryption to address these challenges. Unauthorized access to data can be mitigated by authentication and encryption and other tools developed in conjunction with information security. Data integrity is critical, and the use of visibility verification and detection techniques is suggested. Risk mitigation strategies include authentication, authorization, encryption, and data anonymization. It is recommended to follow regulatory guidelines, such as the General Data Protection Law, (LGPD) in Brazil, equivalent to GPDR, and standards such as ISO/IEC 18000-63 to ensure best security practices. Capital investment in RFID includes the cost of investment in RFID implementation involving readers, tags, infrastructure, training, etc. RFID technology is relatively easy to integrate into healthcare settings (Angeles, 2005; Davis, 2004) and technology is becoming more widely available. Business value can be achieved through refinement of business processes and expansion of the business model (Tzeng et al., 2008). Several studies provide conservative estimates and state that the implementation of RFID technology would benefit healthcare systems by improving mobile asset search and asset reduction by 50% each and improving asset utilization rates by 10% (Con naughton and Wildeman, 2008; Sanchez et al., 2004). The various benefits come at a price, and RFID has greater capital investment for the readers and tags. A major challenge with the slow adoption of RFID is the lack of ability to quantify the returns from RFID use and compare them to the cost. Adoption can be increased by showing a reasonable payback period for RFID technology systems14.

Materials and Methods

RFID System Deployment

The Morumbi Unit is the Mother Unit of the Hospital Israelita Albert Einstein. This unit has 702 medical clinic beds, 134 adult ICU beds and 48 operating rooms, in addition to a large pediatrics structure, laboratories, specialized center for imaging, exams and offices. This entire unit has 12,500 pieces of equipment in the technology park, of which 9400 undergo some type of preventive maintenance, calibration or electrical safety test (in accordance with IEC 60601). The periodicity can be from one year for some equipment to 06 months for more critical equipment.

The RFID system was jointly implemented by the Clinical Engineering and Information Technology Department of Hospital Israelita Albert Einstein in mid-2018, but only in 2021, after several tests, it began to be used with an acceptable efficacy rate.

The tests considered several variables, such as location of the appropriate locations to place the antenna portals, number of reader-arrays, training of the Clinical and Care Engineering team, approval of RFID-capable equipment (standardized location with the best reading signal), effectiveness of readings, among other tests.

It is essential to emphasize that the contract with the supplier must contain in the scope: Maintenance and Installation of antennas; Training, system update and full-time advice. Antennas, hand readers and tags must be purchased on demand, with a cost of acquisition and implementation.

The cost of labor (Man per Hour – HxH) for the tagging of the equipment and insertion in the management system is from the clinical engineering itself and throughout the study for the analysis of the ROI it is discounted from the cost of labor in the search for equipment for Preventive Maintenance/Calibration activities.

For the tagging process of the equipment, a study was carried out of "taggable" and "non-taggable" equipment, that is, that it would be beneficial to place RFID tags and those that would not.

Benefits listed

- Quantity of Equipment;
- Preventive Maintenance/Calibration Activities;
- Satisfactory reading signal;
- Small/medium equipment, which can be stored;
- Equipment that can be moved;
- Low-metallic equipment that does not attenuate the radio frequency response signal

Of all the 18,000 pieces of equipment in the technology park, 9,000 taggable devices were identified.

ROI for RFID

A projection of return on investment should be made for small, medium and large projects that are long-lasting. Return on Investment (ROI) is a crucial metric for evaluating the financial performance of an investment. It is used to determine the effectiveness and profitability of a project, business strategy, or any initiative that involves capital expenditures. Calculating ROI is relatively simple, being expressed as a percentage that compares the net gain made from the investment to the cost of the initial investment. The basic ROI formula is:

$$ROI = \left(\frac{Ganho\ Líquido}{Custo\ do\ Investimento}\right) x\ 100\%.$$

Equation 1. Calculating ROI

Time x Man Application

To understand the financial feasibility of implementing RFID, we need to assign a value in reais to one man-hour (HxH) for the ROI analysis. The Glassdor platform was used for this analysis. The average remuneration of a Clinical Engineering Technician in Brazil is R$ 3,516.00, ranging from R$ 2,400.00 to R$ 4,098.00 (July/2023). The average monthly salary takes into account all the salaries, allowances, and benefits that a clinical engineering technician receives. The hours worked provided for by law by the CLT (Consolidation of Labor Laws in Brazil) is 220 hours per week. Thus, out of 08 hours of work per day, a clinical engineering technician spends 37.5% of his time in the day performing only this activity. At Hospital Israelita Albert Einstein, the average salary for a clinical engineering assistant is R$ 2,816.00, according to the same Glassdor platform.

$$\frac{R\$\ 2816{,}00}{220\ h} = R\$\ 12{,}80/hora$$

Equation 2. Hourly x Man Calculation (Clinical Engineering Technician)

RFID System Implementation and Demand

Currently, the service volume of the Clinical Engineering Biomedical Instrumentation team averages 700 preventive maintenance orders per month. An average of 81 infusion pumps per month alone is available, as the unit has 1675 infusion pumps. Also, among the 10 types of equipment with the highest number are: 588 multi-parameter monitors, 537 sphygmomanometers (pedestal/parade), 508 bipaps and cpap ventilators, 484 diet pumps, 453 scales (adult/pediatric), 356 light and video surgery systems, 187 cardioverters, 174 vital sign meters and 97 anesthesia machines. This amount of equipment represents around 56% of all preventive maintenance activities in the year. Currently, all models of the equipment listed above have an RFID tag since 2022.

A questionnaire was made available on the office forms platform for the Biomedical Instrumentation team of Clinical Engineering to understand how long it took to carry out the equipment search time survey. The result is shown in the tables below (Table 1 and Table 2), with 14 respondents. For the calculation of the ROI, the difference between the search time with RFID and without RFID, which corresponds to 39 min, will be considered.

Table 1. Time to search for equipment with RFID

Time	Respondents
up to 15min	8
up to 30min	4
No Response	2

Average of 21 minutes

Table 2. Time to search for RFID-free equipment

Time	Respondents
up to 30min	3

until 01:00h	8
until 01:30h	3

Average of 01 hour

Shrinkage Rate

The shrinkage rate consists of the amount of equipment deactivated because it has not been located in the Hospital, which may be due to loss or misplacement, by the total number of equipment. It is possible to determine the financial impact and costs associated with this analysis of medical equipment reduction rates.

As previously stated, the analysis with different different types of equipment that have a high utilization rate, are mobile, need periodic preventive maintenance and are in greater quantity in the technological park, are the equipment that has the highest shrinkage rate. It is estimated that the shrinkage rate in a large hospital is 5% to 15% per year. We can then consider that at least 5% of this reduction comes from the most used equipment.

Result

After each asset management variable had been defined, collected, and analyzed, specific mobile assets were chosen to be included in the ROI calculation. The selection of mobile assets was based on their high usage, mobility, contribution to patient safety, reduction rates, and constant need for scheduled maintenance/calibrations, resulting in a maximum potential benefit from RFID technology. In addition, by focusing on specific assets, it is possible to extract the full potential of RFID technology and bring data that can be used for a negotiation of products and services.

The equipment search time rate has an estimate of how long a clinical engineering assistant would take throughout the day looking for a series of 21 pieces of equipment per day to perform Preventive Maintenance (PM) activities. The average search time is 01:00 hours per day without RFID and up to 21 minutes with RFID, according to two studies carried out for this same purpose, the average time can reach up to 03:00 hours for equipment without RFID. This estimate was used with a model of 10 types of equipment most sought after for the Hospital Israelita Albert Einstein.

It was also considered that these PM activities take place throughout the year in a periodic preventive maintenance or calibration plan. For this, the annual TMP (Average Search Time) is calculated, calculated by the total amount of equipment in the maintenance plan, by the periodicity and resulting in the man value per hour per year of this single activity and evaluating the difference between the demand with RFID and without RFID, the difference is 39 minutes.

Table 3. Cost Estimation of Equipment Demand

The data on the reduction rate of assets were formed by cross-listing "Assets not located by year and deactivated" and "amount of equipment in the technology park".

Equipment	Inventory	MP/CAL	Media TMP (min)	What is the cost of the H (R$)
Infusion pump	1675	Annual	39	R$ 836.160,00
Multi-parameter monitors	588	Biannual	39	R$ 146.764,80
Sphygmomanometer	537	Annual	39	R$ 268.070,40
Bipap/CPAP Ventilator	508	Annual	39	R$ 253.593,60
Diet Bomb	484	Annual	39	R$ 241.612,80
Scale (Adult/Ped)	453	Annual	39	R$ 226.137,60
Video Surgery System	306	Annual	39	R$ 152.755,20
Cardioinverter	187	Annual	39	R$ 93,350.40
Vital Signs Meter	174	Annual	39	R$ 86,860.80.
Anesthesia Machine	97	Annual	39	R$ 48,422.40
Total	**5009**		**390**	**R$ 2.353.728,00**

The value of the equipment was extracted from the Clinical Engineering database, considering the average value of new equipment, i.e., without considering the depreciation of the equipment 'lost' or 'misplaced' due to its replacement.

Considering the maintenance orders of clinical engineering, in 2021 there were 312 total of the park deactivated by Not Located, which represented 3.10% shrinkage in the year, AND, 2022 there were 219 representing 2.15% of shrinkage and in 2023 135, representing 1.47% as shown in Figure 2. The "not located" process for the deactivation of the asset includes three active searches. If the equipment is not found in these searches, clinical engineering follows the flow to deactivate the equipment in the system.

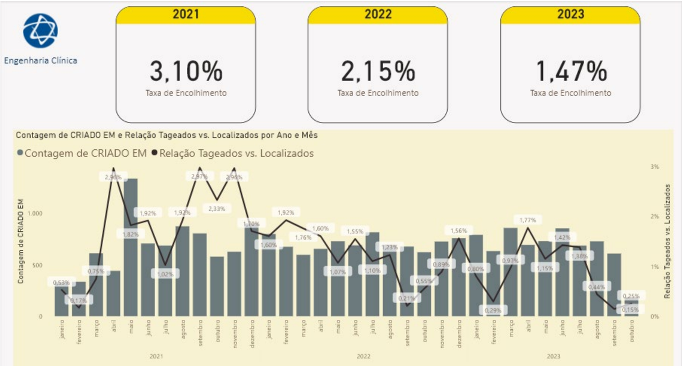

Figure 2. Shrinkage Rate 2021, 2022 and 2023

The cost of Annual Shrinkage, reflected in loss of productivity (equipment availability) and replacement accumulated in 2021, 2022 and 2023, has decreased over the years. However, the accumulated amount is estimated at R$ 6,287,635.20, as shown in Table 4.

In addition, the costs related to the total productivity of the equipment were surveyed. The non-performance of preventive maintenance and technical intervention or corrective activities that generate higher costs, the calculation of Downtime is very important to justify the investment in RFID. The cost of downtime (Table 5), unavailability of the equipment, is on average 3% of the value of the technology park and this unavailability can be due to several reasons, such as corrective maintenance and failure to carry out preventive activities due to not locating the equipment. With an average unavailability of 5% for various reasons, there is a projection of an increase of at least 1% in availability, which suggests lower expenses with downtime, considering the unit value of the equipment * availability 1% * amount of equipment, even with a high associated investment. This can be seen in the graph "profit versus availability" (Murty & Naikan, 1995) (Figure 3). In other words, the greater the availability of the equipment, the lower the expense with its unavailability, maintenance and replacement, but the investments for this to occur need to increase according to demand, reducing profit

Table 4. Cumulative Shrinkage Cost 2021, 2022 and 2023*

Equipment	Total	Not Located*	Value/unit	Annual Shrinkage Cost
Infusion pump	1675	6,72%	R$ 8,730.00	R$ 982.648,80
Multi-parameter monitors	588	6,72%	R$ 65,000.00	R$ 2.568.384,00
Sphygmomanometer	537	6,72%	R$ 1.100,00	R$ 39,695.04
Bipap/CPAP Ventilator	508	6,72%	R$ 17,000.00	R$ 580.339,20
Diet Bomb	484	6,72%	R$ 6,000.00	R$ 195.148,80
Scale (Adult/Ped)	453	6,72%	R$ 1.350,00	R$ 41,096.16.
Video Surgery System	306	6,72%	R$ 50.000,00	R$ 1.028.160,00
Cardioinverter	187	6,72%	R$ 35,000.00	R$ 439.824,00
Vital Signs Meter	174	6,72%	R$ 23.000,00	R$ 268.934,40
Anesthesia Machine	97	6,72%	R$ 22,000.00	R$ 143.404,80
Total				R$ 6.287.635,20

Table 5. Downtime Cost

Equipment	Inventory	% Downtime	Value/unit	Cost of Downtime
Infusion pump	1675	1%	R$ 8.730,00	R$ 146.227,50
Multi-parameter monitors	588	1%	R$ 65,000.00	R$ 382.200,00
Sphygmomanometer	537	1%	R$ 1,100.00	R$ 5,907.00
Bipap/CPAP Ventilator	508	1%	R$ 17,000.00	R$ 86,360.00
Diet Bomb	484	1%	R$ 6,000.00	R$ 29,040.00
Scale (Adult/Ped)	453	1%	R$ 1.350,00	R$ 6,115.50
Video Surgery System	306	1%	R$ 50.000,00	R$ 153.000,00

Cardioinverter	187	1%	R$ 35,000.00	R$ 65.450,00
Vital Signs Meter	174	1%	R$ 23.000,00	R$ 40,020.00
Anesthesia Machine	97	1%	R$ 22,000.00	R$ 21,340.00
Total	**5009**			**R$ 935.660,00**

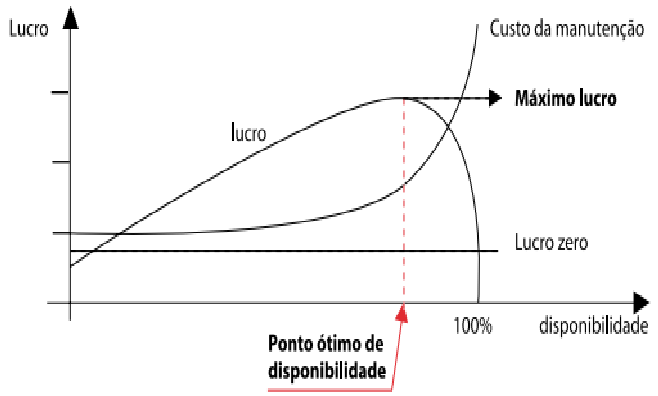

Figure 3. Luco vs. Availability (Murty & Naikan, 1995)

The calculations for ROI in this study (Annex 1.) found that RFID implementation is not only feasible, but can produce a profit in the first year of implementing the system.

The calculations used consider exclusive and conservative hospital data, where only 5009 out of a total of 9000 tageable were analyzed from a technology park of just over 18 thousand assets.

Some of the previous research and case studies on productivity and ROI improvement measures with RFID simulate real-life situations in the day-to-day medical technology management sector in a small and medium-sized hospital. That said, additional analysis and more accurate budget estimates are needed to verify the feasibility of RFID. Although the ROI does not guarantee real results, it demonstrates the potential savings that RFID technology can have in a large hospital that understands that asset management is a viable business for the sustainable health economy, as analyzed in this study.

Conclusion

In the calculations presented, it was evidenced that even with several measures and a long time between the project, the installation of the system and the use, the feasibility study needs to consider several factors and the Manager must know his technological park and the team with whom he works. HIAE's Clinical Engineering benefits daily from the various functionalities found in the RFID system, however, for this to happen, a long road has been taken. From the point of view of health economics, ROI can be achieved within the first year after starting its use, making the solution viable. Payback was given in this analysis in just 14 months. It is important that the management body is close to the technical team to understand the difficulties of locating the equipment within the hospital unit so that, in addition to the implementation of RFID, continuous improvement activities can be carried out in the processes involving medical technologies.

In addition, the entire system requires a well-trained team so that the technology is used to its fullest, thus generating, in addition to cost reduction, improvement in the performance indicators of the medical technology management group.

In order to move forward with RFID implementation, awareness and support across the organization are needed. Not only knowing the capabilities of RFID, but also knowing how different departments will need to work together, it is important for all hospital employees to understand its inherent benefits and challenges of the technology.

References

1. CALIL, S. J. Clinical Engineering and Public Health in Brazil. Brazilian Journal of Biomedical Engineering, v. 17, n. 2, p. 57-68, 2001.

2. Galvan, R. J. Development of a medical equipment management program. Journal of Clinical Engineering, 29(6), 343-348, 2004.

3. Gentles, D. The role of clinical engineering in health care. Biomedical Instrumentation & Technology, 38(5), 364-368, 2004.

4. Sumalgy, P. "The Role of Technology in Healthcare Equipment Management: A Review of Recent Developments." Health Technology Letters, vol. 1, 2014.

5. FINKENZELLER, K. RFID Handbook: Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication. Wiley, 2010.

6. FANBERG, Hank. The RFID Revolution. American Marketing Association Marketing Health Services, p. 43, 2004.

7. Casey, Michael, “New Technology Focuses on Equipment Management”, The MC Report, 8 June, 2004.

8. Floerkemeier, C.; Sarma, S. "An Overview of RFID System Interfaces and Reader Protocols." In: 2008 IEEE International Conference on RFID. Las Vegas, NV, USA, 2008. p. 232-240. DOI: 10.1109/RFID.2008.4519372.

9. Hagl, A.; Aslanidis, K. "RFID: Fundamentals and Applications." In: Kitsos, P.; Zhang, Y. (eds.) RFID Security. Springer, Boston, MA, 2008. Available at: https://doi.org/10.1007/978-0-387-76481-8_1.

10. Ajami, S. Radio frequency identification (RFID) and patient safety. Journal of Medical Sciences Research: The Official Journal of Isfahan University of Medical Sciences, 18(9), 809–813, 2013.

11. Rousek, J. B., Asset management in healthcare: Evaluation of RFID, IIE Transactions on Healthcare Systems Engineering, 4:3, 144-155, 2014. DOI: 10.1080/19488300.2014.938207

12. Anand, A., Business Value of RFID-Enabled Devices: Healthcare Transformation Projects. Business Process Management Journal, 19(1), 111–145, 2013.

13. Kaplan, R. S., The Balanced Scorecard: Translating Strategy into Action, Brasil, Editora Elsevier. 1996.

14. The Value of RFID: Benefits Vs. Costs. Países Baixos: Springer London, 2013. Part IIJustifying RFID investiments in Different Application Areas. RFID Adoption in Health Care and ROI Analysis, 7, 81-95.

15. Sánchez, J. A., Nixon, R. A., Cháves, S. Medical equipment management through the use of radio frequency identification (RFID). MBA Professional Report, California. Naval Postgraduate School, 2004.

Annex 1. Return on Investment for the RFID System at HIAE

	Year	Investment	RFID Costs				Benefits		Cash Flow	Desc Factor	Cash Flow	Balance a
			Contract	Tags	HxH Tageing	Shrinkage	HxH	Availability	Nominal	9,00%	Discounted	Retrieve
2020	0	**242.000,00**							**-242.000,00**	**1**	**-242.000,00**	**-242.000,00**
2021	1		228.000,00	2.055,00	163.852,80	R$ 2.900.546,00	R$ 2.353.728,00	R$ 935.660,00	**-247.065,80**	**1,09**	**-226.665,87**	-468.665,87
2022	2		228.000,00	2.055,00	163.852,80	R$ 2.011.669,00	R$ 2.353.728,00	R$ 935.660,00	**883.811,20**	**1,1881**	**743.886,20**	275.220,33
2023	3		228.000,00	2.055,00	163.852,80	R$ 1.375.420,20	R$ 2.353.728,00	R$ 935.660,00	**1.520.060,00**	**1,295**	**1.173.791,51**	1.449.011,84
2024	4		228.000,00	2.055,00	163.852,80	R$ 991.799,60	R$ 2.353.728,00	R$ 935.660,00	**1.903.680,60**	**1,4116**	**1.348.597,76**	2.797.609,60
2025	5		228.000,00	2.055,00	163.852,80	R$ 860.807,20	R$ 2.353.728,00	R$ 935.660,00	**2.034.673,00**	**1,5386**	**1.322.418,43**	4.120.028,03
									5.853.159,00		**4.120.028,03**	**Viable Financial Return**

Discounted Pay Back

226.665,87 — 12 months

275.220,33 — x

= 3.302.644,00

x = 3.302.644,00 / 226.665,87

x = 14,57

x = 14 months

Investment **242.000,00**

Financ Return **4.362.028,03**

TIR = 140,37% a.a.