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Database Approach to Capital Medical Device Prioritization

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ABSTRACT

Each year in Canada, health organizations are tasked with prioritizing their capital medical devices (greater than $5k) for replacement due to the limited capital dollars available. Many methods, algorithms and criteria have been suggested to assist with the prioritization of medical devices due for replacement. Most of these methods rely on a subjective and manual assessment. Drawing on some of these methods and the historical service data available from an online asset database (TMS), a semi-automated capital medical device prioritization algorithm was developed. This algorithm uses the data available from the asset service database to compute multiple values that factor into an overall Prioritization Value for each medical device. The method is mostly automated and only requires the user to export the data from the database to a Capital Prioritization Calculation Spreadsheet. The Spreadsheet calculates a Prioritization Value using four factors for all assets and models.

INTRODUCTION

Most medical equipment capital prioritization systems use a weighted scoring chart usually consisting of four to six categories [1], [2], and [3]. The basis of these charts is sound, but given the simplicity of the scoring, many devices would likely have similar or the same scores [4].

Another less popular system is a logic gate system used mostly in poorer countries to prioritize what the medical authority needs and can afford [5]. This system on its own would not work well at Island Health Authority (IHA) as many of the devices proposed for capital replacement cannot be separated using a binary system. Combining the logic gate system with the weighted scoring chart system would be an option as the logic gate system could approve funding for urgent needs and the devices that fail the logic gate system could be scored on the weighted scoring chart.

Another successful system found was a weighted scoring chart developed by the Northwest Territories Heath Department. It includes three main sections: Technical, Device Safety, and Mission Critical that add up to a maximum of 50 points [4]. Each section is divided into subsections that depending on the sections are added or multiplied [4]. This system was developed by two biomedical engineers in the Northwest Territories with the intent of creating a province wide system for prioritizing medical equipment capital spending [4].

The above capital prioritization methods have all been successful to varying degrees, but to implement any one of them at IHA would require entering values manually for each device. Entering multiple subjective values for each device would require far too much time and a high level of knowledge of each device. With over 5000 devices reviewed each year, manually entering values for each device is not a practical way to prioritize capital device replacement.

After gaining access to TMS and reviewing the data available, it was determined that using the data in TMS to create a technical scoring system would be the best way to streamline the annual capital review process. More research was done looking at similar data based scoring systems and a method was found that scores medical devices based on three technical categories: number of repair work orders, amount spent repairing the medical device, and the age of the medical device [6]. This method would prove to be the foundation of the TMS based capital replacement method.

After reviewing multiple different medical device capital replacement models it was determined that the following five categories were the most commonly taken into consideration [1].

- Clinical - what are the technology capabilities required to meet the standard of care or clinical needs for the patient mix and procedures offered [1]?
- Operational - what are the effects on departmental and organizational workflow [1]?
- Life cycle - what is the performance, reliability, and parts availability of the technology [1]? Is the existing technology obsolete or will it become obsolete within the next several years [1]?
- Safety - Does the current complement of technology pose any predictable safety hazards for patients or staff [1]? Is the technology available to enhance or strengthen patient and staff safety [1]?
- Strategic - What is the planned direction of the clinical service [1]? What role will medical technology play in supporting that program [1]?

Incorporating the technical categories in [5] and the five categories above, the Capital Prioritization Algorithm began to take shape.

PROPOSED PRIORITIZATION ALGORITHM

Calculated Parameters

The data from TMS is used to calculate the following fields.

- Device Age (Years)

$$Device\ Age = {(Today's\ Date - Accepted\ Date)}/{365}$$

- End of Service Date (Date)

If End of Service Date is blank use Jan. 1st 1900

- Time Until End of Service

$$Time\ until\ End\ of\ Service_{\text{(Years)}} = IF\left(\frac{End\ of\ Service\ Date - Today's\ date}{365} < -100, 100, \frac{End\ of\ Service\ Date - Today'sdate}{365}\right)$$

- Work Order Frequency

$$Work\ Order\ Frequency = {Work\ Order\ Count}/{Device\ Age}$$

- Total Labour Cost

$$Total\ Labour\ Cost = Total\ Hours * 120$$

$120/hour Biomed Tech rate

- Total Repair Cost

$$Total\ Repair\ Cost = Total\ Labour\ Cost + Total\ Parts\ Cost$$

- Replacement Cost ($)

From TMS field

- Standardized Repair Cost

$$Standardized\ Repair\ Cost = {Total\ Repair\ Cost}/{Replacement\ Cost}$$

Prioritization Value Factors

- Work Order Frequency Factor

$$Work\ Order\ Frequency\ Factor = IF\left(\frac{3 * e^{Work\ Order\ Frequency/3.6}}{e} > 5, 5, \frac{3 * e^{Work\ Order\ Frequency/3.6}}{e}\right)$$

The Work Order Frequency Factor shown above uses an exponential growth rate that is equal to the Work Order Frequency divided by

3.6. This value is then multiplied by three and divided by *e*. Using this calculation the Work Order Frequency Factor will have a maximum value of 5 which will occur at a Work Order Frequency of 5.45 work orders per year or greater (a work order approximately every two months).

- Replacement Cost Factor

The Replacement Cost Factor is the second of the four factors used to calculate the Prioritization Value. The Replacement Cost Factor represents the percentage of the Replacement Cost that has been spent on parts and labour. The Replacement Cost Factor can be determined as follows:

$$Replacement\ Cost\ Factor = IF\left(\frac{3 * e^{Standardized\ Repair\ Cost*1.667}}{e} > 5,5,\frac{3 * e^{Standardized\ Repair\ Cost*1.667}}{e}\right)$$

Like the Work Order Frequency Factor the Replacement Cost Factor uses an exponential growth rate. The Replacement Cost Factor's growth rate is equal to the Standardized Repair Cost multiplied by 1.667. This value is then multiplied by three and divided by *e*. Using this calculation the Replacement Cost Factor will have a value of 3 when 60% of the replacement cost has been spent on parts and labour. The Replacement Cost Factor has a maximum of 5 which is reached when more than 90% of the Replacement Cost has been spent on parts and labour.

- Age Factor

The Age Factor is the third of the four factors used to calculate the Prioritization Value. The Age Factor increases as the age of the device increases and can be determined as follows:

$$Age\ Factor = IF\left(\left(\frac{e^{\frac{Device\ Age}{10}}}{e}\right)^{3.2} > 5,5,\left(\frac{e^{\frac{Device\ Age}{10}}}{e}\right)^{3.2}\right)$$

Like the previous two factors the Age Factor uses an exponential growth rate. The Age Factor's exponential growth rate is equal to the Device Age divided by ten. The value is then divided by *e* and raised to the power of 3.2. The Age Factor has a value of 1 when a device is ten years old and reaches a maximum of five when a device is about 15 years old.

- Discontinuation Factor

The Discontinuation Factor is the final factor considered in the Prioritization Value. The Discontinuation Factor increases as the device approaches its end of service date and can be determined as follows:

$$Discontinuation\ Factor = IF\left(\frac{5}{e^{(Time\ until\ End\ of\ Service)^{\frac{1}{2}}}} > 5,5,\frac{5}{e^{(Time\ until\ End\ of\ Service)^{\frac{1}{2}}}}\right)$$

The Discontinuation Factor uses an exponential decay rate because, unlike the Age Factor, a shorter time until End of Service will score higher. The Discontinuation Factor's exponential decay rate is equal to 5 divided by *e* to the power of the time until End of Service to the power of 1/2. This evaluation produces a maximum of five when Time until End of Service is zero or the End of Service Date has already passed. When a device is three years from the End of Service Date the Discontinuation Factor is approximately one. For a device where the End of Service Date has not been entered into TMS or the company has not released an End of Service Date the Discontinuation Factor is approximately zero.

Usage Multiplier

The Usage Multiplier takes into account the amount a device is getting used based on where the device is located. Devices at bigger, busier sites have a higher Usage Multiplier while devices at smaller, rural sites have a lower Usage Multiplier. The Usage Multiplier is scaled from 1.0 to 1.5 so it does not affect the final prioritization value as much as the four main factors. To give a value to each site, background research was done on where the site is, how many people live in the area of the site, and what medical departments are available at the site.

Prioritization Value

The Prioritization Value is the final grading value for each asset; it takes into consideration the four factors: the Work Order Frequency Factor, the Replacement Cost Factor, the Age Factor, and the Discontinuation Factor as well as the Usage Multiplier. The Prioritization Value can be determined as follows:

$$\begin{aligned}&Prioritization\ Value\\&= (Work\ Order\ Frequency\ Factor\\&+ Replacement\ Cost\ Factor)\\&* (Age\ Factor + Discontinuation\ Factor)\\&* Usage\ Multiplier\end{aligned}$$

The Prioritization Value adds the Work Order Frequency Factor and the Replacement Cost Factor, multiplies that value by the sum of the Age Factor and the Discontinuation Factor, and multiplies the value by the Usage Multiplier.

By adding the related factors (Work Order Frequency Factor related to Replacement Cost Factor and Age Factor related to Discontinuation Factor) then multiplying the sums, the Prioritization Value is greater for devices that scored higher across all the four factors, not just scoring highly in one or two. The maximum Prioritization Value is 150 and the highest value calculated in the current iteration of the Capital Prioritization Spreadsheet is about 69.5.

The exponential growth rates used for all four of the factors in the Prioritization Value were based on the subjective scoring weightings in the capital prioritization methods reviewed in references [1], [2], [3], and [4]. These methods all assigned higher weight to values as they approached the maximum values for a given factor. For example, the capital prioritization method released by the government of Nova Scotia, [2], has a "Status and Useful Life" factor that assigns a value to a device based on where it is in its life cycle from 0 to 10 [2]. A device that is "Nearing end of life" receives a 2 and a device that is "Past end of life, no longer able to repair, no parts available" receives a 10 [2]. This category corresponds to the Discontinuation Factor. The "Nearing end of life" score correlates to three years from the End of Service Date, which receives a 1, and the "Past end of life, no longer able to repair, no parts available" correlates to the End of Service Date, which receives a 5.

DISCUSSION

The Capital Prioritization Algorithm was used to evaluate all capital medical devices in TMS and the results were consistent with recommendations the head engineer made for capital replacements for the 2015-2016 fiscal year. Some devices that had recently been replaced, but had not yet been removed from TMS, ranked within the top 20 when sorted by Prioritization Value. Other devices that are top priorities for replacement also ranked within the top 20 when sorted by Prioritization Value. The only devices that were not consistent with the head engineer's recommendations were devices with incomplete information in TMS and devices with service contracts.

Devices with incomplete data can have incorrect values for up to all four of the factors contributing to the Prioritization Value. At this point in time there are a few devices that do not have an Accepted Date. A device without an Accepted Date will have incorrect values for the Age Factor, Work Order Frequency Factor, and Replacement Factor. Currently, only 398 devices have an End of Service Date. A device that does not have an End of Service Date will score approximately zero on the Discontinuation Factor because it is assumed that the end of service has not been announced by the manufacturer.

For most devices with a service contract there is no service data available in TMS. Most companies responsible for service contracts do not release parts and labour costs to their clients. These blank fields result in zero values for Total Labour Hours and Parts Costs; therefore, the Total Repair costs are also zero. Work is underway to incorporate the contract costs to ensure devices that are supported via contracts also produce a reasonable Prioritization Value.

CONCLUSIONS

The Capital Prioritization Algorithm prioritizes capital medical devices for replacement based on the service information available in TMS. Some effort is required to extract the service information from TMS, but once loaded into a spreadsheet, the Prioritization values are easily calculated. Initial iterations of the algorithm using service information from TMS correlate well with a manual prioritization process followed by the head engineer. The prioritized list of medical technology for replacement assists the decision making process, but does not take into consideration strategic capital planning or clinical needs. The Capital Prioritization Algorithm using the service database was designed to save time and provide a more data driven approach to the capital prioritization process.

RECOMMENDATIONS

In order to improve the accuracy of the results, it is recommended to improve the service data in TMS. Specifically, effort should be made to ensure all Accepted Date information is populated and that all labour hours and parts cost information is entered correctly.

The algorithm can be improved by also incorporating the service contract cost information, which is now available in the TMS service history.

Finally, the algorithm could be incorporated into the TMS database so that a current Prioritization Value could be displayed at all times.

REFERENCES

[1] R. P. Maliff, " Managing Medical Equipment Replacements when Capital Funding Returns" *[Online]*, 2012. Available: http://www.hfmmagazine.com/display/HFM-news-article.dhtml?dcrPath=/templatedata/HF_Common/NewsArticle/data/HFM/Magazine/2012/Jun/0612HFM_FEA_Technology

[2] Auditor General, "Health and Wellness: Hospital System Capital Planning," *Government of Nova Scotia,* November, 2012.

[3] P. Prowse et al, "Development of a Scoring System to Support Medical Equipment Replacement Prioritization Using the Analytical Hierarchy Process (AHP)," *Clinical Engineering, Winnipeg Regional Health Authority,* Winnipeg, MB, 2015.

[4] K. Taylor and S. Jackson, "A Medical Equipment Replacement Score System," *Journal of Clinical Engineering*, vol. 30, No. 1, pp. 37-41, Jan/March, 2005.

[5] Dr. M. Cheng, "Medical Device Regulations: Global Overview and Guiding Principles," *World Health Organization,* Geneva, Switzerland, January, 2003.

[6] R. M. Dondelinger, "A Complex Method of Equipment Replacement Planning: An Advanced Plan for the Replacement of Medical Equipment," *Biomedical Instrumentation and Technology,* vol. 38, No. 1, pp. 26-31, Jan/Feb, 2004.