



IMPROVED REPLACEMENT PLAN STRATEGY: AN APPLICATION OF EQUIPMENT REPLACEMENT PRIORITIZATION SCORES (ERPS) ON PATIENT MONITOR REPLACEMENT

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INTRODUCTION

The healthcare environment is increasingly in demand of a high-quality level of service and to meet those demands, equipment needs to be properly maintained and taken care of. All equipment possesses a life span which may be shortened by various factors that make keeping a device in use in the healthcare environment, very unfavorable [2]. These other factors that could render the continuous use of a device unfavorable, range from reliability and safety concerns to lack of manufacturer support. Thus, replacements need to be considered for existing equipment as they become a greater risk to patients and the hospital finances. To remove subjective and anecdotal reasons for replacement and drive a cost-effective and safe healthcare environment, technology replacement plans are necessary [3]. Furthermore, there is the added challenge of limited finances for capital purchases by healthcare organizations [1]. To deal with these problems, a systematic replacement plan should exist using accurate and unbiased data, incorporating technical and clinical factors, and integrate the strategic initiatives of the healthcare organisation [3]. The development of such a replacement plan can be a long, laborious process.

This paper will address how an existing equipment replacement prioritization scoring (ERPS) system was leveraged for creating replacement plans with less effort than previous plans thus avoiding a single large expenditure on monitoring equipment.

Across the Winnipeg region, many bedside patient monitors will no longer be supported by their original manufacturers, be out-of-support from their manufacturers in the next few years

or are approaching their useful life. In 2009, the Clinical Engineering (CE) department collaborated with the Clinical Programs of the Winnipeg Regional Health Authority (WRHA) to produce a multi-year replacement plan for the physiologic monitoring systems in the region. This plan involved extensive research of various technical (e.g. age, support status) and clinical (e.g. strategic plans) contributing factors that typically influence replacement decisions in the region. This second iteration would systematically replace patient monitoring systems over the next seven years in a prioritized fashion across the region.

METHODOLOGY

The CE Computerised Maintenance Management System (CMMS) was employed to generate accurate information about the inventory of bedside monitors of each department at all WRHA sites. The CE team already use an Equipment Replacement Prioritization Scoring (ERPS) system which includes some technical factors such as age and repair cost with most equipment. The inventory reports were analyzed to determine additional technical factors for replacement. The next step involved obtaining information about clinical factors for replacement. The technical and clinical factors were then incorporated into a weighted matrix to derive a replacement score for the devices in each department. Replacement priority for each department was established based on their respective mean replacement scores and a budgetary estimate of the replacement costs was given.

The ERPS is calculated using device-specific information of Age, Repair Cost, Reliability, Equipment Function, and Failure Consequence.

Age is defined as the absolute age of the device in years and calculated as:

$$Age = \frac{(Present\ date - Install\ date)}{365.25} \quad (1)$$

The repair cost is the average annual labor cost over the last 3 years as a percentage of purchase cost. The reliability as used in this plan, is defined as the count of repairs over the last 3 years. Equipment function measures clinical necessity (the main purpose for device use) and addresses the consequences of a device being unavailable for patient care [4]. Failure consequence measures the physical consequence to patient or operator because of equipment failure during use [4]. Each of the criteria are assigned a score based on a scale assigned to them.

The ERPS are then calculated as follows:

$$Prelim.ERPS \quad (2)$$

$$= 0.2 * \left(\frac{RCS}{5}\right) + 0.1 * \left(\frac{AS}{6}\right) + 0.5 * \left(\frac{RLS}{5}\right) + 0.1 * \left(\frac{EFS}{8}\right) + 0.1 * \left(\frac{FCS}{5}\right)$$

where,

ERPS = Equipment Replacement Priority Score

RCS = Repair Cost Score

AS = Age Score

RLS = Reliability Score

EFS = Equipment Function Score

FCS = Failure Consequence Score

The preliminary ERPS is then normalized to 100 using the following equation:

$$ERPS = \frac{[Prelim.ERPS - min.]}{[max. - min.]} \times 100 \quad (3)$$

where,

min = the minimum possible score obtainable from preliminary ERPS.

max = the maximum possible score obtainable from preliminary ERPS.

The other technical factors considered include: Accessory Status (AcS), Support status (SS), Upgradability (U), and Unresolved Safety Issues (USI).

To establish the typical clinical needs of each department, their functional requirements for bedside patient monitoring, and how monitoring fits into the department's strategic plans, such as Electronic Health Record (EHR) integration, a

high-level clinical needs assessment form was developed. The clinical factors were derived from the responses to the high-level needs assessment. These were: Clinical needs met (CN), Standard of care met (SoC), and Strategic Plans met (SP).

All the factors not scored using ERPS was scored using their assigned risk weights and calculated using equations 4 and 5.

$$Prelim.NonERPS_{Score} \quad (4)$$

$$= ((1 * AcS) + (5 * USI) + (1 * U) + (5 * CN) + (3 * SoC) + (1 * SP))$$

$$NonERPS_{Score} \quad (5)$$

$$= \frac{[Prelim.NonERPS_{Score} - 0]}{[26 - 0]} \times 100$$

The final replacement score becomes an amalgamation of the ERPS and total scores of other factors in a 60:40 ratio. The replacement scores thus determine the priority of replacement. Each department was assigned a replacement priority depending on the mean of the total replacement scores for each piece of monitoring equipment in that department. This was done to foster standardization and compatibility of patient monitoring equipment within departments (and departments occasionally receiving patients from each other).

Based on individual priority scores, every department was allotted a replacement priority and given a budgetary replacement cost estimate. The search criteria included the relevant departments from each site as well as the primary components of a physiologic monitoring system; the central station, bedside monitors, and ambulatory telemetry systems. The inventory data was exported to Microsoft Excel and organized into a weighted matrix for each site. The weighted matrix for each site contained the following information: department, type of equipment, manufacturer, model number, end-of-support (EOS) date, purchase date, number of units, the technical and clinical factors, and the total score. For the purposes of this plan, only the primary component of a modular bedside monitor (the central processing unit) was listed in the weighted matrices and served as a placeholder to represent the entire modular monitor.

RESULTS

The technical criteria that were measured leveraging ERPS include: Age, Repair Cost, Reliability, Support Status, Equipment Function, and Failure Consequence. The other technical factors of Upgradability, Unresolved Safety Issues and Accessory Status were allotted risk weights depending on their effect on the useful life of the patient monitors and/or patient safety.

The resulting clinical factors were scored by assigning risk weights to them depending on individual department's responses and contributed to the overall replacement score.

The order of priority was determined as shown in Table 1 below after all scores were examined.

Table 1 - Replacement priority scale

Priority	Mean Total Score	Replacement Period
High	Higher than 21	1 st wave
Medium	16 - 21	2 nd wave
Low	11 - 15	3 rd wave
None	Less than 11	Not within planning period

The total value of all physiologic monitoring systems in the region was estimated at 26.8 million dollars. Only 12.3 million dollars of equipment was considered in this replacement

plan. This represents approximately 46% of the total value of all equipment within the scope of the replacement plan.

DISCUSSION AND CONCLUSION

After determining the budget, the next step was to distribute the replacement costs of 12.3 million dollars over the planning period, from 2018 to 2025. Part of the capital funds provided by the government for medical equipment replacement may be reasonably allocated towards replacement of bedside monitoring equipment (See sample of departmental budgetary allocation in Table 2). Therefore, an even distribution of the replacement cost would result in a commitment of 1.8 million dollars of capital per year. The goal of the plan was the allocation of capital between 1.0 and 2.5 million dollars per year towards bedside monitor replacement. This goal led to several replacement scenarios being considered (See Figure 1). They were designed to distribute the replacement cost while replacing bedside monitors by priority to maintain patient care and safety. Scenario A attempted to distribute the replacement costs evenly by replacing most equipment as close to its end-of-support date as possible. Scenario B replaced more equipment in the middle of the planning period to accommodate unforeseen replacement needs

Table 2 - Sample of departmental budgetary allocation after implementing scores.

Department	Priority (Mean Priority Score)	Reason	Current Number Planned for Replacement / Total Number in Department					Budgetary Replacement Cost
			High Acuity (HM)	Flexible Acuity (FM)	Transportable (TM)	Central Station (CS)	Telemetry (TT, TR, TS)	
CH - Emergency	None (8.95)		0 / 2	0 / 0	0 / 10	0 / 2	0 / 0	\$0
GGH - Emergency	Low (13.62)	Reliability	0 / 0	10 / 10	0 / 1	1 / 1	0 / 2	\$310,000
HSC - Adult Emergency	High (27.92)	Support, Age, Upgradability	0 / 0	0 / 26	0 / 0	4 / 4	0 / 0	\$160,000
	Low (13.77)	Age	0 / 0	26 / 26	0 / 0	4 / 4	0 / 0	\$702,000
SBGH - Emergency	Medium (17.06)	Reliability, Repair Cost, Support, Accessory Status	4 / 4	0 / 22	2 / 2	4 / 4	0 / 0	\$370,000
SOGH - Emergency	None (5.67)		0 / 3	0 / 0	0 / 12	0 / 1	0 / 0	\$0
VGH - Emergency	Low (11.84)	Reliability, Repair Cost	0 / 0	1 / 15	2 / 2	1 / 1	0 / 0	\$117,000

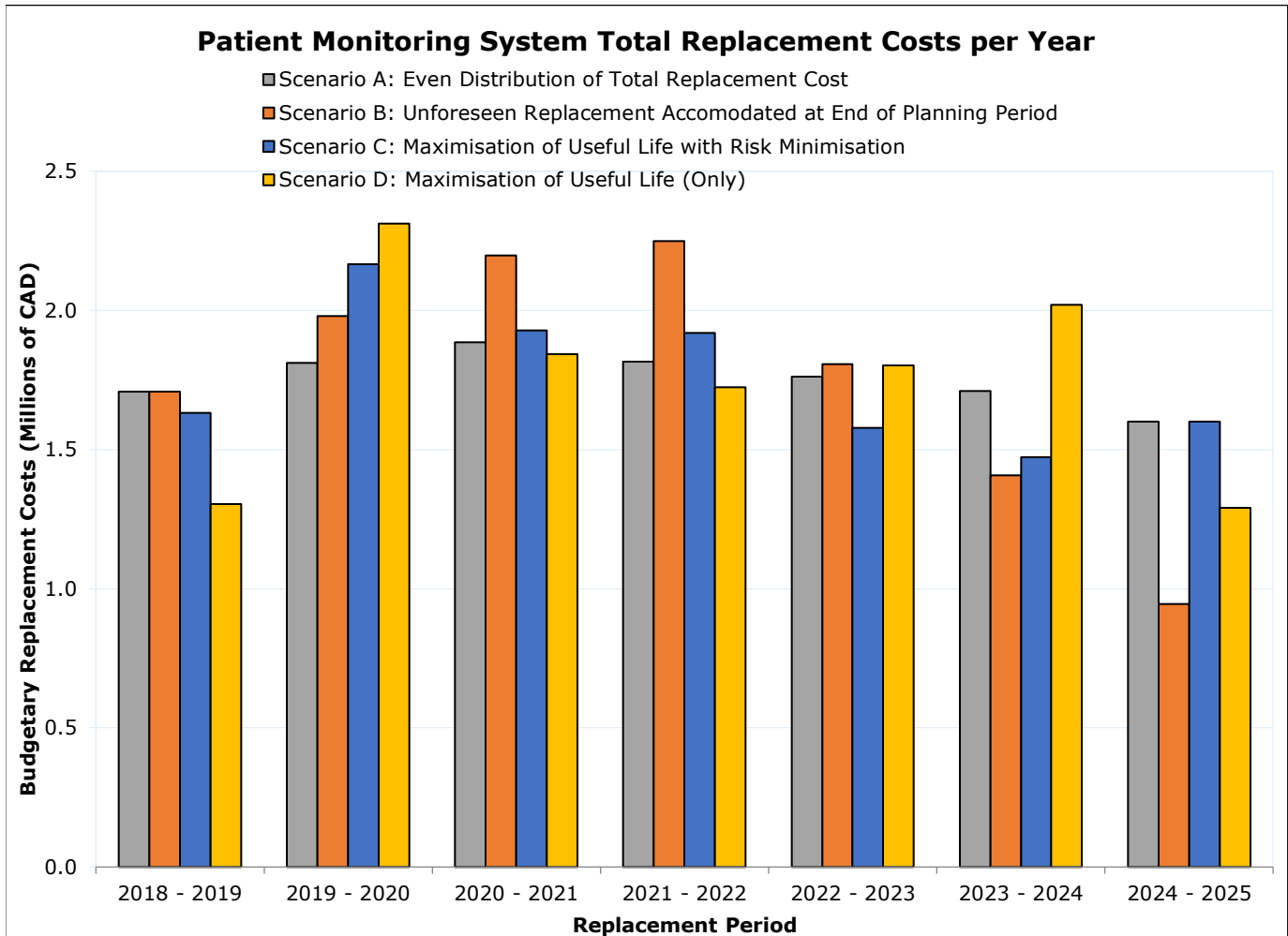


Figure 1 - Patient Monitoring System Total Replacement Costs per Year

that may occur at the end of the planning period. Scenarios C and D attempted to maximize the useful life of monitoring equipment. All scenarios used replaced equipment to extend the useful life of similar equipment awaiting replacement in another department.

Conclusively, the ERPS based plan allowed for a very tailored replacement plan with several scenarios that ensured not spending several millions at once, with less effort than previous plans. The use of ERPS ensured that the replacement plan considered strong contributing factors in a strong objective way. Also, since the system was already in place, scores were easier to obtain.

REFERENCES

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