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# DEVELOPMENT AND INITIAL IMPLEMENTATION OF PERFORMANCE ASSURANCE WORK ORDER PRIORITIZATION SYSTEM

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## ABSTRACT

The implementation of an effective performance assurance (PA) system requires appropriate risk-based prioritization and optimization processes. Although a number of prioritization models have been developed, there are no generally accepted risk-based guidelines for prioritization of PA inspections. This paper presents a data and risk-based system for prioritizing PA inspection work orders.

The developed system analyzes two parameters; the PA risk level of the device and the number of PA inspections missed, to determine the work order escalating factor and the priority level. To the best of our knowledge, incorporating the number of missed inspections in escalating inspections has not been extensively investigated. The system contributes to increasing inspection completion rates and optimizing resource utilization. The development and implementation of the system are presented, as well as opportunities for further development.

## INTRODUCTION

Performance assurance is an essential component of medical devices risk management – implemented to address risk at both clinical and enterprise levels [1]. The benefits of PA include quality of patient care and safety. For that reason, performance assurance is one of Accreditation Canada's Required Organizational Practices [2]. The safety and efficacy of medical devices is established through planned and/or scheduled inspections, which can include performance verification, preventative maintenance and safety testing [1]. PA inspections are usually prioritized to optimize utilization of limited resources while ensuring that devices that required regular inspections are inspected.

Prioritization of PA inspections, both within PA inspection work orders and between PA inspections and other work such as repair, is a complex process that takes into account a variety of factors [3]. A number of prioritization models have been developed [4-6] to assist with different decision making. Generally there is variability in the factors considered and the combination techniques applied by each model. Even though there continues to be research and development in the various aspects of evidence-informed performance assurance technology, there are no generally accepted risk-based guidelines for some of the PA processes, such as prioritization of inspections.

Clinical Engineering has identified the need for a systematic approach for determining inspection priorities. It was previously reported that surveyed BMETs in the region used qualitative methods, considering a variety of factors, to prioritize inspections [3]. This suggested the need to develop a quantitative prioritization model. The purpose of the study was to develop a data and risk-based system for prioritizing PA inspection work orders. This paper presents the results of the study as implemented in the Winnipeg Health Region.

## METHOD

To develop the inspection prioritization model, factors that influence the inspection of devices, including the ones identified in the

BMET survey [3], were analyzed. These factors include device risk levels, inspection deficiencies and resource allocation. The first step was to identify factors that either are already captured in the medical equipment management database or can easily be captured. Some of the data that already exists in the database is currently used to modify risk classification of devices in the PA system, as previously discussed [3]. The method for determining risk levels of all devices in the PA system was previously established through a regional study [7]. Devices are assigned risk scores based on a number of risk categories, such as failure consequence, equipment function, location of use, etc. Devices are then classified into risk levels low, medium and high.

One factor that exists on the database but is not used to modify the risk classification is the inspection deficiency; the number of PA inspections missed since the original work order issue date. The relationship between the risk levels and inspection deficiency was analyzed. A data and risk-based process to prioritize PA inspection work orders was developed, taking into account resource allocation. The system was developed and implemented by Clinical Engineering in the Winnipeg Health Region.

## RESULTS

The PA risk level and the number of PA inspections missed were combined to develop a feedback mechanism for determining the work order prioritization level. These parameters are combined to regulate the PA work order (WO) escalation level, which determines the inspection priority level.

Figure 1 provides an overview of the developed PA work order prioritization system, and how it is expected to interface with a future prioritization system to include other work orders to make up a single WO prioritization system.

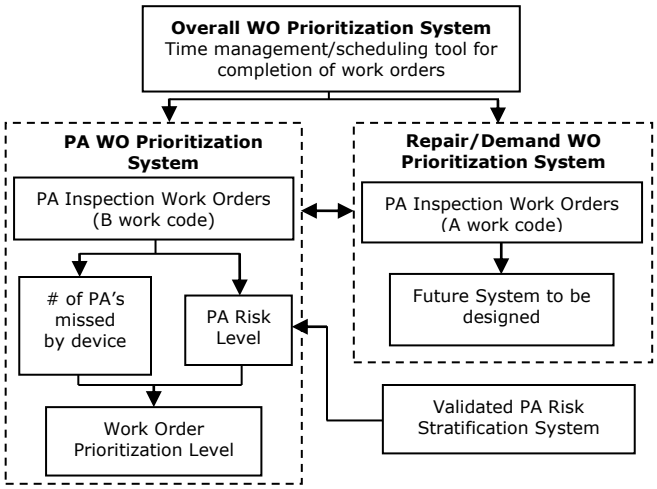


Figure 1: Simplified flow diagram describing the designed PA WO Prioritization System

Five distinct PA work order prioritization levels have been established; low, medium, high, immediate and urgent priority. Guidelines for escalating the work orders through these levels have been established based on the number of PA inspections missed.

In general all work orders follow the same escalation rules. However, the starting point at which the work order is classified for the prioritization depends on the device risk level. To assign the PA inspection WO priority level, the number of missed PAs is first calculated using the following equations:

$$\#\ \text{of PA's missed} = \frac{\#\ \text{of days since asset last passed PA}}{\text{PA Period for scheduled PA in days}} \quad (1)$$

$$\#\ \text{of PA's missed} = \frac{\text{WO due to start} - \text{Last date PA passed}}{\text{PA Period for scheduled PA in days}} \quad (2)$$

The # of PAs missed is to be truncated to only include the integer when entered into the report.

The system also incorporates a buffer as part of the inspection period. Therefore, the next step is to determine the grace period/ window period for the inspection before it is escalated to the next priority level. In general the window period is 20% of the PA period ($W_{20\%}$ = 20% of PA period). Hence, the 20% window period can be calculated using the equation (3),

$$W_{20\%} = 0.20(\text{PA Period for scheduled PA}) \quad (3)$$

While the 20% window period is the general rule for escalation paths, there is an exception when the work order priority level escalates from the immediate to the urgent action priority. In this case, the window period becomes the work order window, which takes the period of time between the work order due to start and finish dates. The work order window period is pre-determined in the database. The window period is not generic; it is set according to multiple factors such as the site of the devices requiring inspection, number of devices requiring inspections, and the staff resource level available at the site. The work order window period is the number of days the work order is left open after the work order issue date. It can be calculated using the equation (4),

$$W_{WO} = \text{WO due to finish date} - \text{WO due to start date} \quad (4)$$

Escalation to the next work order prioritization level is dependent on the number of inspections the device has missed. The following rule applies:

IF $\{T_{PA} < T < (\lambda T_{PA} + W)\}$ THEN {# PAs missed = $(\lambda-1)$ PA periods}.

Here T=time from the last completed PA test chart, $T_{PA}$= PA period, $\lambda$=number of PA periods and W=window period. Work order prioritization levels escalate according to the guidelines shown in Table 1.

The work order prioritization level is visible through reports from the database. Two separate reports are generated; one for the BMETs and another for the site manager. The report for the BMETs indicates the work order that have been classified as low, medium, high or immediate priority for completion. The report for the manager captures work orders that have escalated into the immediate and urgent priority. The urgent priority WO is an absolute action level – 'take urgent action'. At this level, additional resources may be committed to complete the task.

Table 1: Summarization of escalation path for work order prioritization level along with corresponding report generation

| **DEVICE RISK LEVEL OBTAINED FROM VALIDATED RISK STRATIFICATION SYSTEM** | | | |
|---|---|---|---|
| **# OF PA'S MISSED** | **LOW RISK DEVICE** | **MEDIUM RISK DEVICE** | **HIGH RISK DEVICE** |
| 0 missed PA's | *Low Priority* **+TR** | *Medium Priority* **+TR** | *High Priority* **+TR** |
| 1 PA missed + *window | *Medium Priority* **+TR** | *High Priority* **+TR** | *Immediate Priority* **+TR** & **MR** |
| 2 PA missed + *window | *High Priority* **+TR** | *Immediate Priority* **+TR** & **MR** | *Urgent Priority* **+MR** |
| 3 PA missed + *window | *Immediate Priority* **+TR** & **MR** | *Urgent Priority* **+MR** | - |
| 4 PA missed + *window | *Urgent Priority* **+MR** | - | - |

*The window is equal to $W_{20\%}$ until the work order has become an immediate priority. For the transition of a work order priority from the immediate to urgent priority the window is equal to $W_{WO}$. +TR = Technologist report generated, MR = Manager report generated.

## DISCUSSION AND CONCLUSIONS

The PA WO Prioritization System has been developed and implemented based on a feedback mechanism that analyzes two parameters; the device PA risk level and the PA inspection deficiency. The PA risk level in some cases is static although risk-based systems are increasingly implementing dynamic risk levels driven by data and/or risk classification factors. The number of missed PA inspections is always a dynamic parameter. Thus, this system relies on accurate data. Initiatives such as development of appropriate work codes [8] are important aspects of dynamic systems. This is also currently being undertaken simultaneously to enhance the accuracy of the system. The outlined system provides a data and risk-based mechanism for prioritizing inspection work orders. The system could serve as a guideline and may be adopted and/or adapted by other clinical engineering programs.

Currently, the PA developed system is in the process of being implemented within the regional database. Testing and validation of the PA WO Prioritization System is required to ensure efficient operation. The PA completion rate is anticipated to increase and converge toward the target PA completion rate. The overall completion rate is currently set at a minimum of 75% due to a variety of factors, which include resources. This system, combined with PA completion targets that are based of device risk levels, provides a tool for prioritizing work and allocating resources to the highest risk devices.

The system has been designed to allow for future modification. Further research and development is required for the system to incorporate parameters from other work orders, such as repair, to allow for prioritization of all types of work orders.

## ACKNOWLEDGMENTS

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## REFERENCES

[1] *A Guide for Developing and Implementing a Medical Device Performance Assurance Program: Essential process information for Clinical Engineering*. 1st ed. 2015, Winnipeg: WRHA Regional Clinical Engineering Program.

[2] Accreditation Canada. *Required Organizational Practices*. Handbook 2016 [cited 2016 Feb 26]; Available from: http://www.accreditation.ca/sites/default/files/rop-handbook-2016-en.pdf.

[3] Gaamangwe, T., Babbar, V., Krivoy, A., Moore, M., Kresta, P., *Medical Device Risk Management for Performance Assurance Optimization and Prioritization.* Biomed Instrum Technol, 2015. **49**(6): p. 446-451.

[4] Hamdi, N., et al., *An intelligent healthcare management system: a new approach in work-order prioritization for medical equipment maintenance requests.* J Med Syst, 2012. **36**(2): p. 557-567.

[5] Saleh, N., Sharawi, A., Elwahed, M. A., Petti, A., Puppato, D., Balestra, G. *A new approach for preventive maintenance prioritization of medical equipment*. in *IFMBE Proceedings of XIII Mediterranean Conference on Medical and Biological Engineering and Computing*. 2013. Seville, Spain: Springer International Publishing Switzerland.

[6] Taghipour, S., Banjevic, D., Jardine, A., *Prioritization of medical equipment for maintenance decisions.* Journal of the Operational Research Society, 2010: p. 1-22.

[7] Babbar, V., *Risk Stratification of Medical Equipment for Performance Assurance Purposes at WRHA*. 2014, Winnipeg Regional Health Authority: (Unpublished).

[8] Wang, B., et al., *Evidence-Based Maintenance: Part I: Measuring Maintenance Effectiveness With Failure Codes.* J Clin Eng, 2010. **35**(3): p. 132-144.