

## Improving Hospital Operations Using Bar-Code Capture Data and System Dynamics Modeling Techniques

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### Introduction

The need for information technology (IT) implementation in hospital environments has been well documented, yet the challenges to successful implementation as demonstrated by numerous high-profile failed attempts, have similarly been recorded. To date, the majority of proposed solutions to Healthcare Information Systems (HIS) have focused on solving technology, integration, and operational issues. While important, these approaches fail to take advantage of the new opportunities provided by data collections systems. For example, the emerging HIS environment at a number of Japanese hospitals includes operational bar-code systems, providing increased patient safety with regard to injections. In the process of providing increased safety, the system collects information on every interaction between order, drug, nurse, and patient. Improved data collection systems give us the means to quantify system-wide behavior and can point us in new directions for improving hospital operations.

### Case Diagnosis and Methods

This case concerns a major Japanese hospital's examination of the results from their implementation of a comprehensive health information system, named POAS (Point of Act System). As described by Akiyama (2001 and

2006)<sup>1</sup>, the underlying concept of POAS is to enable records of “‘who did what to whom, where, when, using what, and for what reason.’” In short, real-time input becomes possible at the point of action.” Under the system, logs of medical actions and inventories are created throughout the course of operations, recorded using bar-code scanning technology and nurses equipped with PDAS (personal digital assistants). The system operates continuously at the hospital, handling 100 transactions per second, or more than 360,000 transactions per hour, and has been in continuous operation for four years.

Soon after implementation, POAS facilitated vast improvement in multiple areas of hospital operations, with estimated savings reaching millions of dollars. In addition to POAS-enabled cost savings, the system also led to impressive improvement in patient safety. Prior to the implementation of POAS, there existed nearly a 40 percent chance that there would be a misadministration of an injection prescription; after implementation, errors were cut dramatically.

Despite continued benefits in patient-safety benefits, concern was raised about the sustainability of the system's financial performance. Recent data indicated that the growth in POAS-enabled savings had slowed to a peak, and may actually be on the decline. System managers were concerned about how to obtain further improvements in the hospital's financial performance based on the current implementation of POAS.

<sup>1</sup> Akiyama, Masanori. Risk Management and Measuring Productivity with POAS – Point of Act System. Center for Digital Business, Massachusetts Institute of Technology Sloan School of Management.

### Sustaining the Benefits of POAS: The Structure of Drug Injection Interactions

To appreciate the dynamics of process improvement and provide a platform for ongoing improvement, our investigation focuses on the injection process—the sequence of operations that starts with a request by a doctor for treatment and culminates in an injection performed by a nurse.

Figure 1 begins with the basic “physics” underlying the injection process. The first series of constructs in our model relate to the flow of orders and material. The flows, denoted by straight arrows with values, are the rate at which orders for injections are successfully moved (referred to as Rps, a bundled collection of injection materials) between stations in the hospital. Figure 1 also shows three of the system stocks, denoted by a rectangle, which are computed as the integration of the stock’s inflows less its outflows. The stocks are the accumulation of orders waiting to be processed at three stages, the pharmacy; the nurse station, and the patient’s bedside.

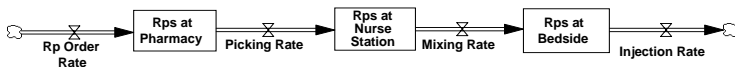


Figure 1: Flow of Drugs for Injection Process

In Figure 2, a second series of outflows correspond to Rp orders that are canceled or amended subsequent to the initial order but prior to the injection. If the order change is processed prior to the mixing phase, the Rp components can be returned to stock by a nurse and are generally reusable for future patient orders. However, if the Rp has been mixed, the cancellation results in the disposal of the Rp.

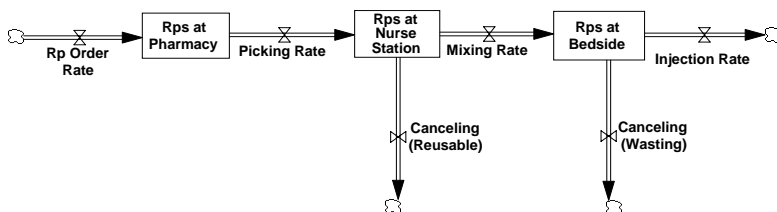


Figure 2: The Two Effects of Order Cancellation

Figure 3 depicts the basic factors that result in wasted Rps. As the number of Rps waiting at the bedside rises, so does the average injection delay, given a steady rate of injections. That is, if the stock of Rps increases while the injection rate does not similarly increase, an Rp will spend a longer time, on average, at the bedside. One consequence of the longer average delay at the bedside is that a longer window is open during which the injection is mixed and subject to being wasted due to cancellation. The loop structure forms a balancing feedback loop (B1).

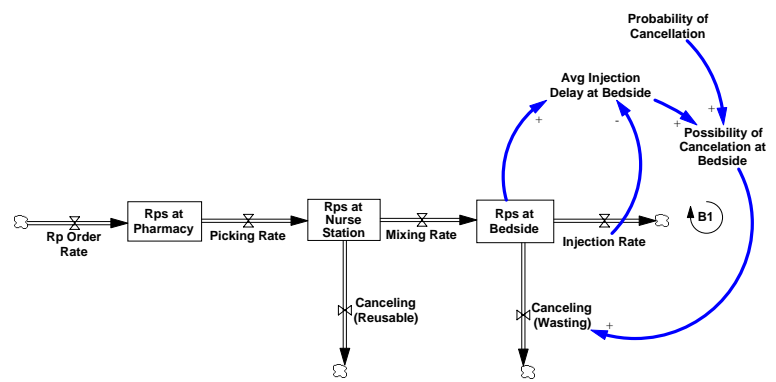


Figure 3: Modeling Causes of Drug Waste

During our investigation, we focused on dynamics that would likely increase the backlog of Rps at the bedside, in turn increasing the force, or gain, of loop B1. Through focused interviews, we uncovered a dynamic referred to as “batch mixing,” depicted in Figure 4.

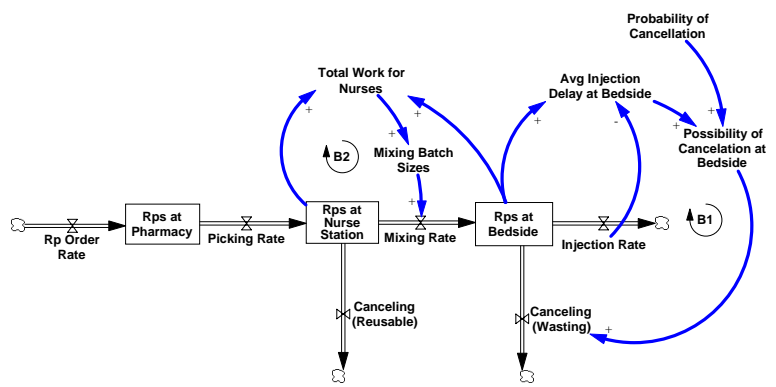


Figure 4: Batch Mixing of Drugs

As intended under POAS, each Rp is scheduled in advance to be mixed at a specific time, which corresponds to the staggered schedule of each injection. Instead of following the schedule, however, system managers became concerned during our investigation that nurses were mixing Rps in large batches throughout the day, which clusters the nurse’s workload and increases the blocks of available downtime. While this might benefit the nurses, it also, in effect, increases the mixing rate, and accelerates the rate at which Rps are moved from the nurse station to the bedside (i.e., in the mixed form). As shown above in loop B1, this increases the rate at which Rps are wasted.

Increasing the cancellation rate also has a second-order effect that diminishes hospital efficiency. Because canceled orders often involve “rework” to correct and remix the new replacement order, they increase the total workload for the nurses, as show in loop R1 of Figure 5.

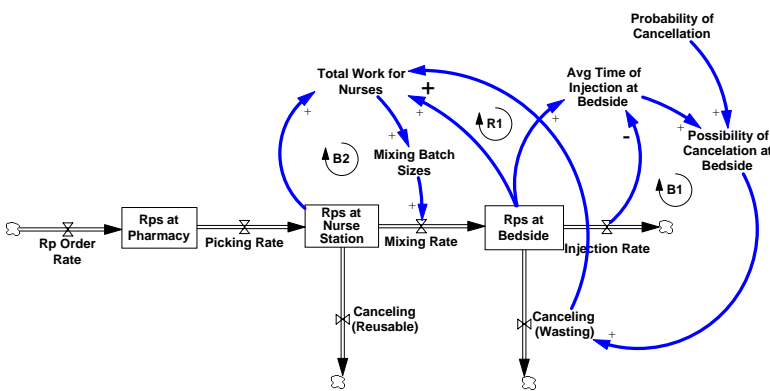


Figure 5: Rework Created By Cancellation after Mixing

When taken together, loops B1, B2, and R1 depict the dynamics leading to increased costs, both in wasted Rps and in staff time. This loss of material and staff time accounts for the decreased financial performance experienced during the later stages of POAS implementation. It is important to note that none of the loops directly affect patient safety. Because POAS was billed as a patient-safety system to the staff, nurses believed the system was operating as intended.

### Analysis and Recommendations

As a first step to address the dynamics inhibiting the ongoing financial success, we simulated the effects on removing specific costly medicines from the batch mixing dynamic. We were aided by the use of POAS-enable data, which allowed us to find high-leverage candidates by analyzing the stream of operational output. We chose five medicines—Novact M, Funguard, Kenketsu Venoglobulin-IH, Rituximab, and Gran Injection—that we determined accounted for nearly 25 percent of the overall waste.

We used the coded data as an input to the system dynamics simulation model. Simulating the effects of subjecting these five medicines to different mixing procedures, which would ensure a desirably scheduled mixing, leads us to estimate potential savings of approximately 70 million yen, or 600 thousand US dollars, on an annual basis (Figure 7). In addition, with the new approach to batching we saw an improvement of nursing utilization. The total time spent on injection operations decreased by approximately 7 percent (Figure 8).

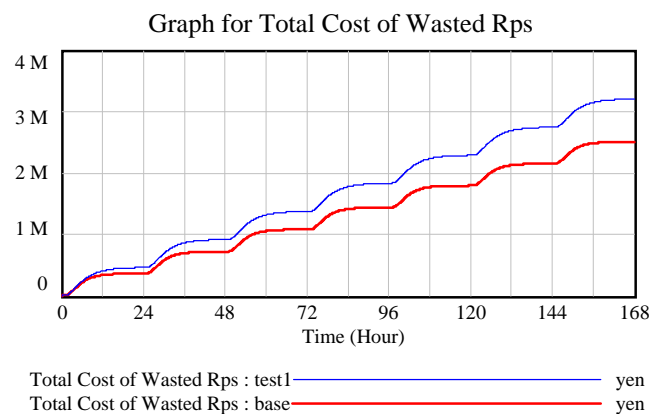


Figure 7: Cost Savings Due to Delayed Mixing of Five Drugs

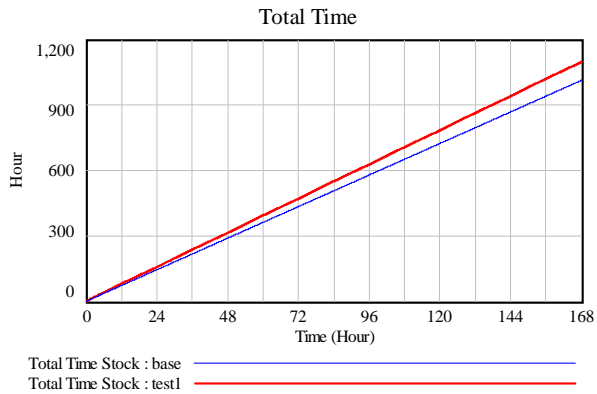


Figure 8: Weekly Savings in Nurse Time Due to Delayed Mixing

Our analysis used system dynamics modeling techniques combined with hospital system data to identify a considerable savings in both materials and staff utilization.

### Conclusion

We envision a system that merges newly available operational data sources (i.e., real-time POAS data), electronic medical records, and operational data into feedback models that create dynamic ward management tools. We propose a system that would provide information to hospital about efficiency metrics, and would provide managers a means to change policies, such as which drugs to exempt from mixing, at any point during on-going hospital operations. This platform would be open for improvements, promoting the development of additional tools that improve operations and manage patient risk. With the reported initial results and continued research, we predict that this work will have a significant impact on reducing hospital costs, improving patient safety, and accommodating improvements in hospital staff operations.

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