Health Care Digital Data Collection System: An Opportunity to Improve Operations

S.Reza Sajjadi, Jing Shi, Kambiz Farahmand
Department of Industrial and Manufacturing Engineering, North Dakota State University
Fargo, ND 58108, USA

ABSTRACT

The improvement of health care delivery has become an urgent issue in the recent years. Many improvement tools have been applied to optimize the operations in health care systems. Discrete event simulation technique, originally developed for analyzing manufacturing and production systems, is now widely utilized for health care delivery. To construct a simulation model and conduct analysis, one critical task is to observe system operations and collect data. The collected data needs to be analyzed to provide input for the simulation model. Therefore the data must be correct and accurate to reflect the actual system behavior. On the other hand, making observation is a common data collection technique, and very often the inaccuracy of data becomes a major problem when too much manual sampling is involved. Without proper input data, the simulation model will not generate any useful output. As such, reducing human error becomes an urgent issue. The data collection methodology which can be used in health care improvement studies are reviewed in this paper, and a systematic approach to data collection is presented and discussed.

Keywords: Digital Data Collection, Health Care, Operations, Improvement

1. INTRODUCTION

Health care improvement has been received great attention in the recent years. Heavy cost of health care systems demands for solutions to improve the system efficiency. Many projects and studies are now being conducted across the United States to optimize the health care operations. In general, health care systems are complex and consequently difficult to analyze and improve. As a well known fact, operation management tools such as linear and non-linear programming, multi-criteria decision making, dynamic and stochastic programming, queuing and simulation models, and statistics as well as Lean and information technology tools have been applied to improve health care operations. However, the complexity of the health care systems limits the flexibility of these improvement tools in real situation. Simulation model, a powerful tool which can capture a complex system by what-if analysis, seems to be an ideal technique. This approach has been widely applied in health care improvement projects. One of the challenges for constructing a simulation model is data collection. Jun et al. [1] indicate that data availability and model credibility are the key factors in the successful implementation of simulation in health care systems. Future managerial decisions regarding health care systems will depend on the accuracy of data and the validity of the simulation model to tackle the optimization problems. This paper presents a data collection toolbox and application of digital data collection system for health care improvement projects.

2. BRIEF LITERATURE REVIEW

Jun et al. [1] review the application of simulation models in health care system. They classify the literature in two major categories: patient flow and allocation of resources. While the former is composed of patient scheduling and admissions, patient routing and flow schemes, as well as
scheduling and availability of resources, the latter covers bed sizing and planning, room sizing and planning as well as staff sizing and planning. One of the primary uses of digital patient flow tracking system is the work of Rotondi et al. [2] where a digital tracking system which follows the flow of the patient in the hospital is presented. Using the digitalized system, the authors indicate how the system can be dramatically improved in terms of patient flow and resource utilization. Other improvement techniques such as time flow study and motion study are proposed by Racin & Davidso [3] and Meyer et al. [4]. Racin & Davidso [3] describe a time-flow study at a pediatric clinic to redesign the patient flow. They report reasonable improvement in the patient waiting time, process time, and resource utilization usage. Meyer et al. [4] study a multi step ambulatory preoperative system. An automatic tracking system tracks the tagged patient in the clinic. The process time at each station of the clinic is automatically collected, and this helps to analyze the system and to determine the improvement opportunities. Pope et al. [5] propose that the qualitative research which is a common practice in health care studies is difficult to analyze, labor intensive, time consuming, and analyzer skill-dependant. To remove these drawbacks, authors propose to use quantitative methods which enable the users to systematically collect the data. Lusignan & Weel [6] present the application of digital data collection in a primary care facility. The study shows that a large volume of data can be shortly collected and analyzed while at the same time the quality of the data collected is promising. There are also some negative points in using digital data collection. The private data may be released and the fast pace of change in medicine and technology may result in incompatibility. Seebregts et al. [7] apply handheld computers for survey and trial data collection. By developing the questionnaire in the handheld computers (also known as Personal Digital Assistant – PDA), the implementers conduct interview with 90,000 respondents. The study shows that both interviewers and respondents prefer to use the PDA over the paper questionnaire. It is argued that although such hardware increases the setup cost, total cost of the data collection should decrease.

3. DATA COLLECTION IN HEALTH CARE SYSTEMS

There are a number of different tools that can be used in a health care facility to collect the data. While some of the tools are designed to record the time, others can be used to collect a wide spectrum of information about the process in the system. Such tools can be categorized as follows.

3.1 Stop watch and programmed data sheet

Stop watch is an instrument which can be used to collect the time related data. It is inexpensive and easy to use. Stop watch has been used in a number of applications. There are various methods which can be utilized to measure a process such as Methods-Time Measurement (MTM) and Maynard Operation Sequence Technique (MOST) (Kanawaty [8] and Zandin [9]). Using the stopwatch for time measurement includes a wide range of devices from simple wrist watches to more complex watches designed for high-precision time measurement. In health care application, the observer uses it to record the arrival and/or departure time for the processes defined in the system. For example, the observer can record the starting and finishing time of a nurse visit. However, it will be sometimes confusing if the observed system is complex. In practice, an observer records time for one or more tasks simultaneously enabling him/her to handle the situation appropriately. The number of tasks an observer can handle at the same time depends on the rate of task occurrence and the watch technology. For a high rate task, it will be more controllable to record only that task during observation time. However, for low rate tasks, it is possible to record more than one task at a time. While stop watch is easy to use, some kind of time sheet is needed to record the time since the time recorded by stop watch will be overwritten. To remove this drawback, the programmed data sheet can be used. Such a sheet should be programmed first and then each event can be recorded by hitting a key. The sheet can be programmed in a laptop or other digital devices such as personal digital assistant (PDA). This makes both stop watch and time sheet recorder
unnecessary. However, it is more costly than the stop watch approach and requires some initial programming skills.

3.2 Staff interview

This tool can be used in the form of face to face or telephone. Using this instrument one can ask about the important issues and collect data about the system. A list of questions can be prepared before the interview will allow the observer to collect data needed in an efficient way. The observer takes note and records the interview for further analysis. It is noted that many practitioners are not interested in such a method since they have a busy schedule.

3.3 Detailing the process using forms and/or VSM

Define the process using standard chart tools is another instrument which can provide a brief and yet comprehensive view of the system. The tool shows the processes which occur for a typical patient from his/her entry to departure. The chart may or may not consider the process time at each station. It is also useful to capture the layout to indicate the relations between any two departments. Visual Stream Mapping (VSM) is a Lean tool which is widely used to capture the current and future system conditions for improvement purposes.

3.4 Patient interview and/or satisfaction questionnaire

Patients are one of the best sources for collecting insightful information about the performance of a health care system. This is because they observe and experience the system from inside and know exactly the problems that affect their satisfaction. A simple concise volunteered interview or questionnaire will provide the overall idea about the system.

3.5 Reviewing clinic records

The review of clinic records can identify additional information about the system. These records are not necessarily limited to the patient data such as age, sex, and so on. They should also cover information about the space dimensions, purchasing, inventory, equipments, staff availability etc. Such information may be gathered directly or indirectly from hard or soft records.

3.6 Conducting onsite observations

The study team (third party) directly gathers the data by observing the operations of the target health care system. This approach is independent, and thus it helps the data accuracy. However, it is important to set appropriate times for the data collection. Otherwise, it may interrupt the regular activities of the staff.

3.7 Video recording

If there is no restriction to make the video recording it is suitable for certain events/functions to be recorded. The video recording will allow the analysts to observe the operation in great detail in the target environment. Repeated viewing provide for a great capability for the analysis of certain functions.

3.8 Checklist/questionnaire

This field observation instrument consists of questionnaire related to subjects such as operational research, task load, work load scheduling, space and human factor. The questionnaire developed includes the issues which have been discovered from the literature review. The results should be shared with the management, providers, nurses, other staffs and patients in the medical facility for verification.

3.9 Barcode scanner

The reason to use the barcode device is that it minimizes the human errors and allows the collection of accurate data. This task can be done with close cooperation between the implementers and the clinic staff. The suitable barcode device is a portable, easy to use device that can be assigned to each station (room). Once a patient enters the station, the care giver (clerk, nurse, or provider) scans a bar-coded badge or alternatively a wrist band worn by the patient. This scan records the starting time of the service. Similarly, once the service is finished, the scanner again reads the barcode on the badge to record the finishing time.

The barcode device may support Bluetooth, and Wi-Fi technology, so data can be either real-time transmitted to a central depository or they can be downloaded later using wired connection. However, many of the medical facilities follow policies and regulations that limit the use of wireless technologies in the facilities. In such cases, it is
suggested to select a mobile device that does not support these technologies yet provides flexibility and ease of use. Other issues with the barcode devices are the availability of keyboard and screen as well as their programmability. Knowing that the final users of the barcode device are the clinic staff not the bar coding professionals, it is important to make the data collection as easy as possible. The basic programming capability allows developing menu on the barcode device screen. Using the menu feature, the user can determine in which room the patient is being treated. Besides, it is also possible to identify the user barcode. Although the application of barcode in health care data collection task could vary in format, it follows the common procedure in the clinic application. Every patient should follow a predefined route no matter the category they belong to. The patient routing process could be coded and programmed in the barcode device. For example, suppose that there are three types of patients checking in the clinic every day, namely, returned (A), walk-in (B), and new (C). Patients need to check in first and then wait for the nurse, and then provider. Such a route could be coded in advance as shown Table 1.

Table 1: Example of Coding Clinic Visit Process

<table>
<thead>
<tr>
<th>Staff</th>
<th>Code</th>
<th>Location</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clerk 1</td>
<td>10</td>
<td>Check-in area</td>
<td>1000</td>
</tr>
<tr>
<td>Nurse 1</td>
<td>20</td>
<td>Nurse room 1</td>
<td>2000</td>
</tr>
<tr>
<td>Nurse 2</td>
<td>30</td>
<td>Nurse room 2</td>
<td>10000</td>
</tr>
<tr>
<td>Provider 1</td>
<td>40</td>
<td>Exam room 1</td>
<td>20000</td>
</tr>
<tr>
<td>Provider 2</td>
<td>50</td>
<td>Exam room 2</td>
<td>30000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event</th>
<th>Code</th>
<th>Type of Patient</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start service</td>
<td>1</td>
<td>Returned</td>
<td>R</td>
</tr>
<tr>
<td>Finish Service</td>
<td>2</td>
<td>Walk-in</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New</td>
<td>N</td>
</tr>
</tbody>
</table>

3.10 RFID, PDA, and other methods

Radio Frequency Identification (RFID) is a well adopted tool which has many applications in health care facilities. It uses radio-frequency signal technology to communicate with an object (Smith & Konsynski [10]). Personal Digital Assistant (PDA) is a mobile tool which enables the user to collect the data electronically. One application of PDA in health care is to make the data collection paperless (Seebregs [7] and Kuziemsky [11]). Also, there are a number of other instruments which can be used to gather the data. Since they are less used in the real situation and are self explanatory they will not be discussed here. A list of such tools is as follows:

- Prototype
- Joint Application Design and Joint Requirements Analysis
- Focus Groups
- Mail Surveys
- Facilitated Sessions

4. HEALTH CARE DATA COLLECTION IMPLEMENTATION: A SYSTEMATIC APPROACH

In this section a systematic data collection approach is presented. This approach is primarily designed for primary care clinics. However, it can be modified for other applications as well. To this end, the steps are as follows.

4.1 Identify the techniques to collect the data

In the real situation, it is common to follow more than one method to collect the data. A complete view of the system may not be achievable if only one technique is applied. There are some time-related data that can be collected manually or by using a digital instrument; however, other data such as layout of the facility, patient demand, patient satisfaction rate, performance measures, will require different collection techniques. Note these techniques are described in the previous section.

4.2 Develop questions which need to be answered by the selected techniques

Once it is determined which techniques are to be applied, it is the time to develop a comprehensive list of questions that need to be answered by the staff, nurses, and providers. A number of questions that are related to the clinic can be classified into process, staffing, patient, IT, and inventory-related groups. For instance, regarding process, “what is the process bottleneck” is one of the commonly asked questions; regarding staffing, the number of staff, nurses, and providers, as well as their schedules is often asked; regarding patient, the number of patient visits, no-show rate, and over-booking are among the commonly asked questions.

4.3 Determine the instruments that will be used to collect data
The instruments are determined based on the data collection method. If it is determined that a digital method for data collection is needed, the barcode device could then be used. The stopwatch and camera for interview recording are the examples of such instruments as well.

4.4 Do preparation for the determined instruments

Designing the questionnaire, developing interview template, designing the manual menu template for barcode device, and deciding on the patient identification method such as wrist band or badge are some of preparation needed.

4.5 Conduct economic analysis and purchase equipment

Obviously, there are many options available on the market. However, an economic analysis will indicate which alternatives fit the requirement. Budgets are always limited and the price of the equipment is generally a function of the size of the purchase. The size of the purchase in turn depends on the time availability and demand. Combining all information together, one could decide on the best alternative.

4.6 Run tests

All equipment should pass the tests. For example, in case of using barcode devices, each station has a barcode device to collect the data. Each device follows its own clock. It is important to synchronize all barcodes clocks. Otherwise, the time data collected will not be accurate. To do that, it is necessary to set the same time for all devices first and check the clock time variability over time. If the variability is less than the acceptance level, the devices pass the test.

4.7 Determine the implementer team

In general, a part of the team members are selected to incorporate in data collection phase. This team supports the real implementers who are the staff of the clinic. The team and the clinic staff need to work closely to handle data collection phase successfully. Before starting the data collection, clinic staff need to learn how to work with equipment. In case of barcode device, they need to have a clear idea about the process and what they should do. If the project time allows, it is useful to implement a pilot project to observe the difficulties and make the required modifications. However, in many case time is limited and this step may not happen.

4.8 Data collection and analysis

At this step, everything is in place according to plan and the actual data gathering process could begin. The data collected should be transferred to a host computer. Once the data collection is complete, data is available in different files and could be distinguished based on the collection type. To analyze the data, it is needed to combine all data collected in a single file, probably a spread sheet. As a result of such analysis, an accurate and correct data will be used as the input to the simulation software.

5. CONCLUSION

The cost of health care systems in the United States and many other countries has been growing at an unsustainable rate. Reducing the cost by applying operation management techniques is currently attracting interests from academia and health care industry nationwide. Discrete-event simulation is one example, which can capture the complex system operations, and has been widely adopted for health care settings. Considering that the data collection is a key factor in successful simulation analysis, this paper reviews the data collection methods which can be applied in health care system and examines how the digital data collection is applicable in health care improvement studies. A systematic data collection approach is presented.

REFERENCES


