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Simulation Modeling of Hospital Discharge Process

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Abstract

In this paper, a discrete event simulation model of the hospital discharge process is introduced. Such a process starts from a discharge decision being made to the time the patient leaves the hospital (to home or an aftercare facility). Three primary parallel processes, which are initiated by the physician's discharge order, are included: works carried out by social worker/case manager, and by pharmacist, and transportation. In each process, multiple tasks need to be accomplished to ensure all medication, safety, insurance, aftercare, and transportation requirements are satisfied. In addition, patient education is needed before the final discharge. Such a model has been validated by the data collected through extensive observations in the medical units at University of Wisconsin Hospital and Clinics. Using this model, what-if analysis has been carried out to evaluate the impact of process and parameter changes. Potential improvement recommendations have been proposed to hospital leadership.

Keywords
Hospital discharge process, discrete event simulation, improvement.

1. Introduction

The hospital discharge process is a complex process with substantial variations and incredible challenges. It is estimated that there were 34.9 million discharges from nonfederal short-stay hospitals in the United States in 2006 ([1]). Due to the complexities involved in the process, delays in the discharge process are not uncommon. Therefore, improving the quality and efficiency of patient transitions across health care settings (such as the discharge process) has become a national priority ([2]).

A discharge process involves multidisciplinary efforts from multiple care providers in the hospital, such as physicians (MD), social workers (SW), case managers (CM), therapists, pharmacists (RPH), nurses (RN), etc., and requires a wide range of clinical and organizational skills to address the needs of patients, families, aftercare facilities, and support systems. An efficient discharge process is critical to improve hospital efficiency and patient outcome, increase surgical and emergency department capacity, improve hospital bed turnover rate, reduce waste and organizational cost. In addition, timely discharge of patients can improve patients' satisfaction and gain more time for interacting with patients and staff development.

Substantial amount of efforts have been devoted to improving the discharge process from various points of view. Most of the studies focus on different phases or aspects of the discharge process. For example, paper [2] indicates that the discharge plan often unfolds quickly in a fast-paced chaotic environment with many competing demands on staff. Paper [3] discusses discharge delay due to various disruptions, in particular, for senior patients. It is found in paper [4] that over 20% of the hospital stays are inappropriate, and almost half of them are due to internal hospital procedures. Factors, such as evaluation errors, hospital capacity limitation, shortage of local facilities, organizational assessment delays, external and psychosocial reasons, etc., all contribute to discharge delays (see, for instance, papers [5]-[8]). In addition, paper [9] studies the correlations in perception of patient's participation in the discharge planning process. Paper [10] develops a screening tool using hospital admission and clinical data for specialized discharge planning services.

In spite of these efforts, less attention has been paid to evaluate the process quantitatively or using an engineering approach from the whole system point of view. Although such approaches have been widely used in analyzing other health care units or delivery processes (see reviews [11]-[14] and representative papers [15]-[25]), no such studies have been found to investigate the discharge process. This paper presents a discrete event simulation study of the discharge process for the medical units at University of Wisconsin Hospital and Clinics (UWHC), developed through extensive observations, interviews, and discussions. The goal of this work is to evaluate the current state of the discharge process, identify areas of variations and bottlenecks that impede the process significantly, and discover strategies for potential improvement.

The remainder of the paper is structured as follows: Section 2 describes the discharge process at UWHC. The simulation model is introduced and validated in Section 3. Using this model, what-if analysis is carried out and the results are presented in Section 4. Finally, Section 5 formulates the conclusions.

2. Discharge Process

The discharge procedure is a complex process consisting of many factors and variations. In UWHC and many other hospitals, the procedures may vary between different units. Even in the same unit, the process could be different from each other due to various provider preferences, patient conditions, aftercare facilities, and ways of transportation, etc. To address such a complex process more effectively, we limit our study to the medical units at UWHC. Through extensive on-site observations, interviews and discussions, the most common discharge process is described below.

Typically, the discharge process starts just after the patient is admitted. The social workers and case managers deal with patient assessment, insurance information, referral and address issues, and discharge summary. Such a process is pretty much done before the patient is ready to be discharged. At UWHC, a morning-rounds meeting starts at 9:00 AM, including the physicians, pharmacists, nurses, social workers, case managers, and therapists. In the meeting, the physicians inform the attendees the condition of the patients and who is ready for discharge. The other staff will also report the progress of these patients. After the rounds meeting, a discharge signal or order is triggered and the discharge process starts. In this study, we focus on the discharge process after the morning-rounds meeting, when the discharge decision has been made.

As shown in Figure 1, there are two primary parallel discharge processes (referred as DC in the figure), conducted by the SW/CM and RPH at the same time. One more process shown in Figure 1 is the transportation work, which characterizes the period from discharge decision signal being triggered to the expected transportation time. The expected transportation time is set up by the social worker, with an agreement from the provider. Although no additional work is needed in it, the whole discharge process can be delayed due to late transportation. Thus, transportation can also become a bottleneck if the the SW/CM and RPH have both finished their work while the expected transportation time is not reached yet. Moreover, patient education is included in the process just before the end of pharmacist process. Below, detailed work flows in SW/CM and RPH discharge processes are described.

2.1 The SW/CM work flow

The main responsibility of SW/CM in the discharge process is to communicate with patients and their families, aftercare facilities, and insurance agencies, about the place to be discharged, insurance information, transportation arrangement, etc., and prepare the discharge packet. As mentioned before, such work can start long before the discharge decision is made, typically just after a patient is admitted as an in-patient. In most cases, the majority of the work has been finished before the "discharge day." Based on our observations and interviews, it is estimated that only about 2% of the discharge decisions are made unexpectedly. Otherwise, the main work of SW/CM on discharge day is to reaffirm that all the information is correct and all the procedures are followed. Typically, the SW/CM just goes through all the referral information, addresses any issues and prepares the summary report. The left part of Figure 1 illustrates the work flow of SW/CM. Specifically,

- The SW/CM will first review the medical record. If there are no unexpected changes, he/she will talk to the patient and reconfirm the issues, such as aftercare facility, insurance, transportation, etc. Finally, the SW/CM will prepare the discharge packet.
- If there is a change, the SW/CM needs to talk to the patient and his/her family, and also to communicate with the physician. If the patient will be discharged to home, after all the related issues are addressed, the discharge packet will be prepared by the SW/CM.

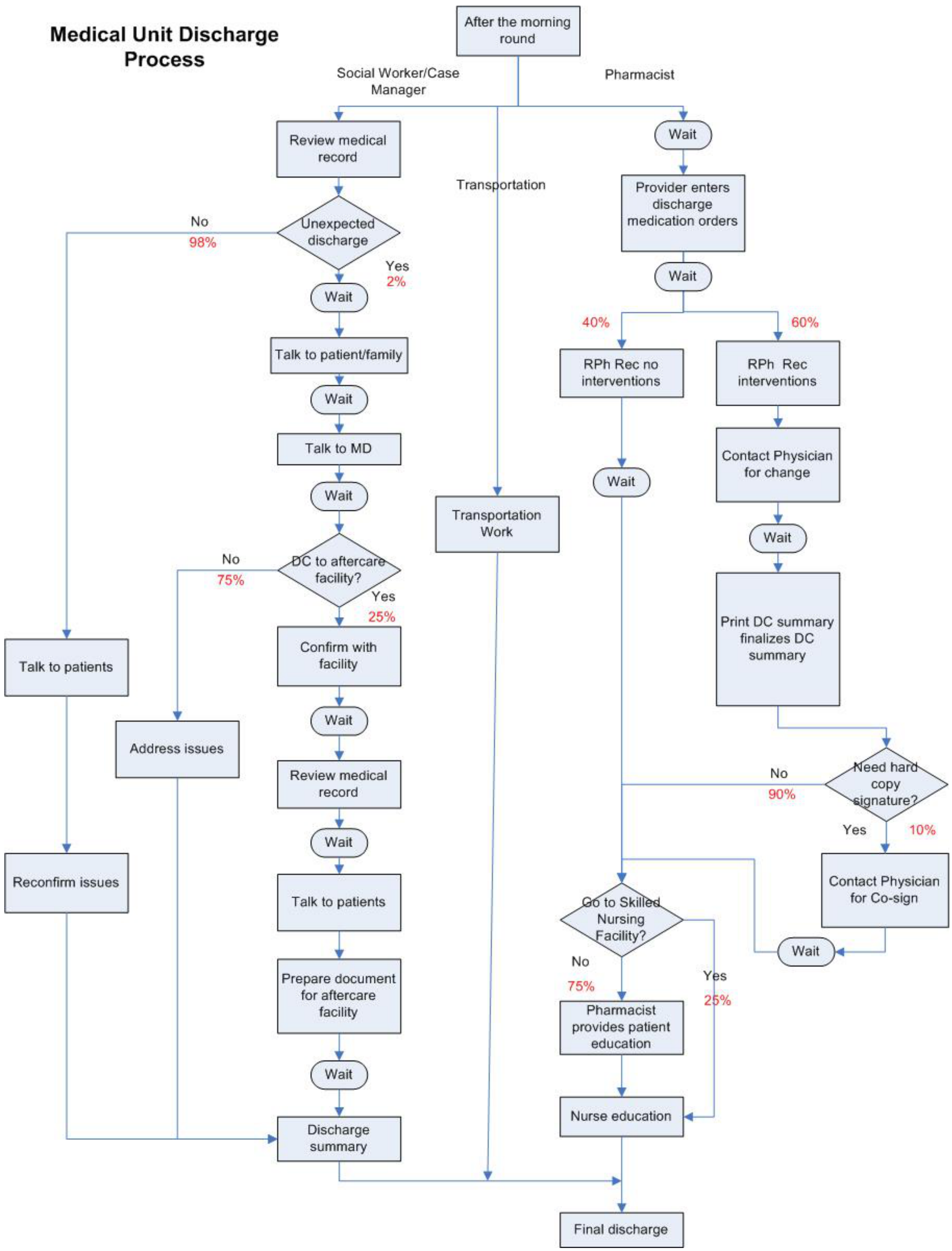

Figure 1: Hospital discharge process

- If the patient will be discharged to an aftercare facility, the SW/CM needs to confirm with the facility, review the medical record again, talk to the patient, and prepare the discharge packet and necessary documents for aftercare facility.

2.2 The RPH work flow

The RPH plays an important role in the discharge process. The main responsibility is to review the medical record prescribed by the physician, make sure there is no error in the prescriptions, and communicate with patients about the prescriptions. Specifically, the following procedures are needed:

- Once the medical order is prescribed (which occurs after the morning-rounds meeting), the RPH will go through the medical order to check if there is any error or question/issue in the order. If no error or question is found or raised, the RPH does not need to contact the physician for permission.
- There is about 60% of chance that the RPH intervention is needed. In this case, the RPH will correct it and contact with the physician to change the order and get permission for new prescriptions. The prescriptions need to be printed out. If there is a specific medicine prescribed in the medical order, the RPH needs to ask the physician to co-sign it. Then the discharge summary is finalized.
- After all the paperwork described above has been finished, if the patient is discharged to home, the RPH would print the order and bring it to the patient to talk to him/her.
- If the patient is discharged to an aftercare facility, the RPH will only need to submit the order to the discharge summary.
- In addition, if the patient is discharged to home, RPH will provide patient education, and the nurse will also give education to the patient.

The work flow of RPH is shown in the right part of Figure 1.

3. Simulation Model

Computer or discrete event simulation has become an effective tool for assisting decision making to improve system performance. It has been widely used in manufacturing and health care systems to improve operation efficiency. In this study, we develop a simulation model using *SIMUL8* to emulate the discharge process. The model is conducted based on the work flow of one patient. Three parallel processes are included in the model: works done by SW/CM and RPH, and transportation. All parallel processes have to be completed before the patient can be discharged. The data and parameters used in the model are based on observations and time stamps collected from "UW healthlink" database (UWHC electronic medical records). More than 50 observations have been conducted to record the time spent on each procedure. Random processing times are assumed in the model based on these data. The total discharge time is 336 minutes with standard deviation of 147 minutes. The "UW healthlink" database provides the "discharge time stamps" which can be used to calculate the routing probabilities (such as RPH intervention percentage, probability to discharge to home or aftercare facility, etc.). A total of 2934 stamps have been extracted from the database. An illustration of the simulation model is shown in Figure 2.

Using the simulation model developed, it is estimated that the discharge time with 95% confidence interval is 353 ± 2.3 minutes. Comparing with the discharge time of 336 minutes summarized from observations, the difference is about 5%, which validates the model. Such a model is then used for subsequent what-if analysis.

Note that the discharge process is completed only when all the processes of SW/CM, RPH, and transportation are finished. Therefore, the expected time will be much longer than the expected time of an individual process (SW/CM, RPH, or transportation) due to the fact that it considers the maximum of the variabilities in each process. For instance, the average time for SW/CM itself is only 59 minutes. RPH and transportation will take, on average, 225 and 245 minutes, respectively. However, the overall discharge time is 353 minutes. Thus, only studying one process (even if it is the critical path) is not sufficient. Developing a complete model to integrate all the processes is necessary.

4. Analysis and Results

Using this model, what-if analysis has been carried out to study the impacts of parameter change and possible improvements. The results are introduced below.

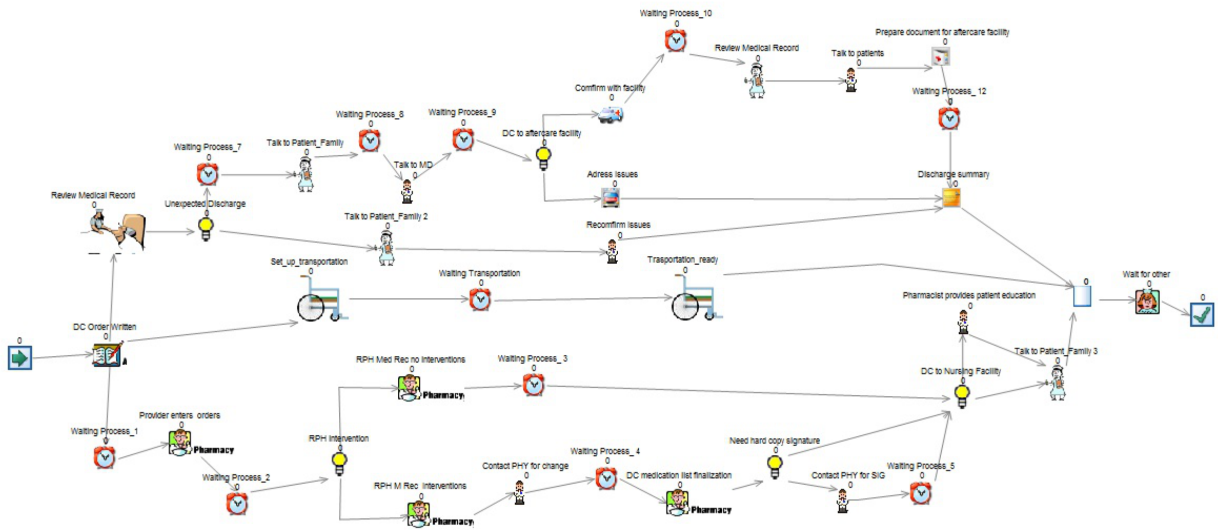

Figure 2: Illustration of simulation model

4.1 Results of what-if analysis

Percentage of RPH intervention: In the current model, 60% intervention is observed. As we change it to 50% and 40% levels, as one can see from Table 1, the discharge time is changed to 351 and 343 minutes, respectively. Thus, there is no significant change in discharge time.

Table 1: Impact of RPH intervention

Intervention	60% (current)	50%	40%
Discharge time	353	351	343
Improvement	0	0.57%	2.83%

Reducing RPH working time: If the working time of RPH is reduced to the 90%, 70%, and 50% of its current value, there will be a slight decrease of discharge time, reducing to 353, 351, and 349 minutes, respectively (see Table 2). Therefore, the discharge time is not sensitive to RPH working time change.

Table 2: Reducing RPH working time

Reduction to	90%	70%	50%
Discharge time	353	351	349
Improvement	0	0.57%	1.13%

Reducing SW/CM working time: When the working time of SW/CM are reduced to its 90%, 70% and 50% levels, the discharge times are still at the 352 minutes level. Thus, there is no change in total discharge time even if SW/CM working time is reduced.

Change of expected transportation time: The expected transportation time is set up by the SW/CM based on physician's discharge order. To study the impact of reducing transportation time, we reduce it to the 90%, 70%, and

50% of its current value. The corresponding discharge time changes to 339, 310, and 289 minutes, respectively. As shown in Table 3, about 20% improvement can be achieved if the transportation time can be reduced by half. Thus, setting the expected transportation time earlier is helpful in reducing the discharge time.

Table 3: Reducing expected transportation time

Reduction to	90%	70%	50%
Discharge time	339	310	289
Improvement	4.13%	12.18%	18.13%

Reducing the time waiting for physician's order: In the current model, on average, it takes about 207 minutes from the end of morning-rounds meeting to a discharge order being issued by the physician. Clearly, reducing such waiting time can significantly decrease the discharge time since all other activities are triggered by this order. By reducing this time to its 90%, 70% and 50% levels, the discharge time is changed to 339, 310, and 285 minutes, respectively. Again, the improvement could be substantial (about 20%, see Table 4).

Table 4: Reducing waiting time for physician's order

Reduction to	90%	70%	50%
Discharge time	339	310	285
Improvement	4.13%	12.18%	19.26%

Moreover, since the expected transportation time is set up based on agreement from the physician, shorter waiting time for physician order can also lead to setting up transportation earlier. When both times (waiting for physician's order and the expected transportation) are reduced to their 50% levels, the resulting discharge time is cut to 204 minutes only, which is more than 42% reduction.

4.2 Discussions

From the above results, it can be seen that the time waiting for physician's order and the transportation time are the main bottlenecks of the discharge process. Since the expected transportation time is directly related to when the physician's order can be ready, the most critical factor to reduce discharge time is "waiting for physician's order." As the physicians dominate the discharge process by making the final discharge decision, they are viewed as the "captain of the ship" in the discharge process. Thus, if the physician's order can be prescribed at an earlier time, the whole discharge process can be shortened significantly. Then the SW/CM can set up the expected transportation arrival time earlier so that the transportation time is also decreased, leading to reduced discharge time. As one can see from previous subsection, reducing waiting time could reduce discharge time substantially. In some cases, such long waiting times are due to waiting for lab results. Thus, reducing lab turn around time for the discharging patients is important and needs further investigation.

In addition, to make the discharge process more efficient, dedication of RPH to the discharge process in the morning could be helpful. Currently, the RPH has many interventions during the discharge period. In the current discharge process, the RPH is not the bottleneck. However, if the physician can prescribe the discharge order earlier and the SW can set up the expected transportation earlier as well, then the discharge process will be more sensitive to RPH's work due to the complex duties he has. Therefore, keeping the RPH focusing on discharge process will be important.

Moreover, the delay factors in discharge process are very complicated, either due to medical or non-medical reasons. They could be either internal or external, or psychological issues. Thus, coordination among the discharge team members is important. The nurses can play a crucial role in the process. In particular, nurse involvement in coordination with physicians, therapists, lab, pharmacists, case managers, etc., can play a critical role to achieve timely discharge.

5. Conclusions and Future Work

Delays in hospital discharge process is a nationwide problem. Although substantial studies have been carried out, most of them emphasize on a certain phase or one aspect of the process. There is no quantitative analysis discovered studying the process from a system point of view in the current literature. Modeling the processes to predict the impacts of various improvement strategies is of significant importance. In this paper, a simulation study of the hospital discharge process in University of Wisconsin Hospital and Clinics is presented. The simulation model can accurately emulate the discharge process and analyze the impacts of potential improvement.

Using this model, we analyzed the effects caused by parameter changes in each procedure (SW/CM, RPH, and transportation) within the discharge process. It is shown that both waiting time for transportation and waiting time for physician's order are the system bottlenecks, while the latter one is the dominant one since the former is dependent on it. This result provides a direction of possible solutions to reduce the discharge time.

In future work, in addition to studying more units, such as surgical units, in the hospital, we plan to extend the model to include more factors that may affect the discharge process, such as lab testing time, coordinations among providers, communication with aftercare facilities, patients, and their families, etc. We may also investigate the specific processes for different patient groups who may have special needs and characteristics. The successful development of this work will provide hospital professionals and management a quantitative tool to improve the efficiency of health care delivery.

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