

Extraction and Comparison of the Discharge Process in a Teaching Hospital

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Abstract

Background and Objectives: Lengthy discharge process is associated with delay in admitting new patients, increased waiting time, and extra costs of patient management. The aim of the present study was to develop a computational method for identifying discharge process pattern which can help reveal factors influencing the length of this process.

Methods: A the fuzzy model of the hospital discharge process and the hospital workflow pattern was developed based on the most frequent patterns in the data and experts' opinions. In the following, the dotted charts of the different sectors were extracted and analyzed using the process mining tools.

Findings: After analyzing the dotted charts, the delayed segments on the pattern of the workflow were specified based on which a number of potential solutions to delayed discharge could be identified.

Conclusions: It was revealed that the virtually all hospital departments are involved in the patient discharge process and thus to improve this process a holistic and systems view is required.

Keywords: Hospital discharge process, Workflow pattern, Process detection, Process improvement

Background and Objectives

In modern societies, healthcare and treatment is in the center of attention, and sometimes it is even considered as a matter of political, social and economic issue of the societ.¹ In a competitive market of healthcare, hospitals focus on the ways of streamlining their processes so as to provide higher quality services at the same cost.² In addition, on one hand, the government and on the other hand, the health insurance companies put more pressure on the hospitals to raise their efficiency as much as possible since it is anticipated that in the near future, there will be greater demands for the high-quality healthcare.³ Process mining offers new tools for improving the processes in a range of some different software.⁴ In fact, the aim of the process mining is to discover valuable information from the event log of the organizations and sometimes it does not work based on what is thought to occur in organizations.⁵ One of the most important processes that a patient is involved in during his/her stay in the hospital is the discharge

process.^{6,7} Incorrect implementation of the discharge process may lead to the patient and staff dissatisfaction, discharge unit congestion at certain hours, an increase in the pending cases, delay in the release time, and delay in accepting the new patients. On the other hand, improving the quality of the discharge process can lead to the increased level of the patient and staff satisfaction, reduction in the number of pending cases, reduction in the discharge time, and timely admission of the new patients which is of benefit to the patients and hospital's staff and it would result in a reduction in the hospital costs and an increase in its revenue. In order to improve the discharge processes, there is a growing need for the identification of the workflow patterns in the discharge processes. Among the advantages of identifying the workflow pattern is the improvement of the bed and hospital management through offering some solutions to facilitate discharge processes.⁸

In organizational terms, hospital dominates other components of the health system, so that the care provided at the hospital is not comparable at any level and no health system can serve without the existence of the hospitals.⁹ The patient discharge process is one of the influential steps with respect to the patient

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satisfaction.¹⁰ This process is the last point of the patients' and their companions' contact with the hospital system¹¹; the prolonged discharge time is not only a source of discontent in terms of the financial, psychological, treatment, and health grounds, but due to the high costs of treatment, it is not cost effective for the hospital. The challenge of quality assessment arises so as to find a way to balance the expectations of patients and providers of health services and its starting point refers to the issues valued by the patients and health service providers.^{12,13} With respect to the delayed discharges, the health select association declares that delay in release can be regarded as a symptom of weakness in the bed management in the hospitals.¹⁴ Since the discharge process differs among hospitals, the discharge time is also variable in different hospitals. The average length of the hospital discharge process in Shahid Beheshti hospital has been reported to be 229.31, 135.19, 149.57 minutes in the maternity, surgery, and neonatal units, respectively.¹⁵ The results of a study conducted at Kashani hospital in the city of Isfahan showed that patients stay in the hospital for an average of 3 hours after the discharge order; the average time of discharge after the physician order is about 2 hours in the morning and 4.5 hours in the afternoon.¹⁵ In a study in Imam Reza hospital in Mashhad, it was observed that the longest discharges last between 6 and 8 hours, and about 70% of the discharge cases range from 2 to 8 hours.¹⁶ In a hospital in Beirut, the average discharge time has been reported to be 132 minutes which was reduced to 102 minutes after the implementation of the intervention in the process.¹⁷ In Kaji hospital in India, the discharge time was reported 234 minutes; after the intervention, this time decreased to 135 minutes.¹⁸ Furthermore, in a study aimed to evaluate and analyze the quality of medical

services for inpatients in ten state and private hospitals in Nanjing, the findings were obtained using the technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method and cluster analysis.¹⁹ Therefore, the hospital discharge process needs to be considered as a common problem in the hospitals that prevents the optimal service delivery, wastes patients' time and leads to their dissatisfaction.²⁰ The hospital discharge process is associated with various sectors and to improve it, almost all parts of the organization should be involved. Given that the patient discharge process significantly affects the entire performance of a hospital, there is a need for deeper investigation of this process in order to reach effective results. Moreover, the discharge procedure varies according to the types of services delivered in the hospitals, types of insurances, etc. In the present study, considering the need of the target hospital, the discharge process of inpatients was selected and analyzed.

Methods

The present study aims to discover the processes involved in inpatient discharge system as well as the pattern and sequence of these processes. We also want to know how we can improve the discharge process. Figure 1 shows the general stages of the study.

First, the sectors which had the possibility of investigating the discharge process were reviewed and activities that had the potential to be recorded were identified. Then, the required data were collected and prepared to be used by the ProM software. Next, the fuzzy diagram of the discharge process was drawn based on the most frequent pattern of the workflow and according to the experts' opinions. Afterwards, the dotted charts of the discharge process in different sectors were drawn and analyzed.

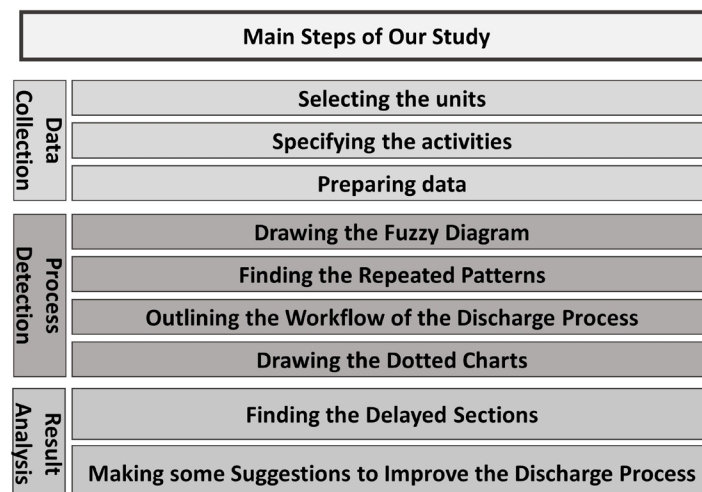


Figure 1. General stages of the study.

Finally, some suggestions were made in 4 different areas of the human resources, the process, the system, and the environment to improve the hospital discharge process.

Data Collection

As mentioned earlier, this study has been carried out in Hashemi Nejad hospital in Tehran and all data have been collected from this hospital.

1-Selection of the Units

There are 10 units in this hospital; however, due to the reasons listed in Table 1, only the first 4 units have been studied in terms of the discharge process.

2-Specifying the Activities

The required data for the present study were recorded from the information of 90 patients during 20 days as shown in Table 2. The activity number 1 was recorded using the patients' cases, the activities numbers 2, 3, 4, 5, 6, and 7 were recorded manually and the activities numbers 8 and 9 were recorded using the system. As listed in Table 2, an activity code is assigned to each activity. We will use these activity codes in the following figures and tables, for more convenience.

3-Data Preparation

In this stage, the collected data were transformed into an event log using Excel, so as to be used in the ProM software version 6.5.1.

Process Detection

After data preparation, we started the process detection phase. There are different perspectives on process mining

that are outlined as follows:

- Process perspective (workflow control)
- Organizational perspective
- Functional perspective
- Data perspective

The control flow perspective focuses on the sequence of activities and its purpose is to find a good description of all possible routes. The organizational perspective focuses on the relationships between the users in charge of different activities. The aim of this perspective is to structure the organization by classifying individuals in roles and organizational units or illustrating the social networks. In the functional perspective, the purpose is to identify the bottlenecks and calculate the performance indicators such as the operating time and the time of residence. The data perspective is concerned with the data that serve as the input and output for active cases.²¹ In the present study, the process perspective has been applied to discover and improve the discharge process.²² For the process analysis, the workflow pattern must be derived.²³ A workflow model consists of a set of activities, factors, and dependencies between them. In other words, the main purpose of a workflow model is to employ the right people at the right time to perform the correct activities.^{8,24,25}

1-Drawing the Fuzzy Diagram

Among the process mining algorithms which can be found in the plugins of the ProM software are alpha, heuristic, multi-stage, and fuzzy. The Alpha algorithm can detect large classes of WF-net.²⁶ This algorithm, at first, forms the primary relations, then, the derived relations and eventually, the Petri net.²⁷ The heuristic algorithm is used when the data are real and there are not a lot of activities.

Table 1. The Names of the Units in Shahid Hashemi Nejad Hospital Along With the related Explanations

Unit	Has it been investigated in the study?	Explanations
Shafa (Female Urology and Nephrology)	Yes	-
Omid (Male Urology)	Yes	-
Dr. Rasouli (Male Nephrology)	Yes	-
Soroush (Male and Female Andrology)	Yes	-
Soheil	No	This unit does not have night hospitalization ward and due to the insurance issues, times are not recorded correctly
ICU	No	Patients of this unit are transferred to other units unless the patient has passed away; in case of patient's passing away, the discharge is done directly from the ICU
Surgery Room	No	There is no discharged patient
Sina	No	The number of discharged patients is insufficient
Peivand (Organ Transplantation)	No	The number of discharged patients is too low
Emergency	No	Patients of this unit are discharged on the spot

Table 2. Activities in the Discharge Process

No.	Activity Description	Activity Code	Performing Person
1	Issuing the discharge order	IDO	Physician
2	Writing nursing reports and other required information	WNR	Nurse
3	Writing the case summary	WCS	Resident
4	Entering the case information into the system	ECI	Secretary of the unit
5	Checking the taken medicines	CTM	Pharmacist
6	Checking the case	CCH	Head nurse of the unit
7	Case entry into the discharge unit	CED	Secretary of the unit
8	Conducting discharge operations	CDO	Person in charge of discharge unit
9	Paying the bill	PB	Patient companion
10	Searching and Finding the insured cases	SFI	Unit secretary
11	Transmitting the case to the discharge unit	TCD	Unit secretary
12	Sending bills to the cash desk	SBC	Person in charge of discharge unit
13	Separating insurance papers from the case file	SIP	Person in charge of discharge unit
14	Printing the bill	PrB	Cashier
15	Adding the medicine report about the case into the discharge unit system	AMR	Person in charge of discharge unit
16	Collaborating with the social work unit and discounting the bill	CSW	Social worker
17	Filtering the insurance papers	FIP	Person in charge of discharge unit
18	Delivering to the insurance unit	DIU	Person in charge of discharge unit
19	Delivering the files to the medical records unit	DFM	Unit secretary

This algorithm uses the alpha-assisted algorithms and its output has the potential to become a Petri net network. The multistage algorithm is used when the login information is simple and structured. As this algorithm contains overfitting mode, it is not useful for the complex processes.

The fuzzy algorithm is one of the young algorithms of process detection that was developed by Christian W. Günther in 2007. This is the first algorithm to deal with a lot of unstructured activities and behaviors. This algorithm is used when the input to the system is complex and unstructured, or when we want to describe the model in a simple way. Using the criteria of importance/correlation, the fuzzy algorithm can simplify the process of the model and this is one of the most important features of this model. In the present study, in order to be able to extract the workflow pattern, it was necessary to compare the different complexity levels of the process, so as to select the best level.²⁸

In this paper, the fuzzy algorithm was applied (using the ProM software) for extracting the workflow pattern.²⁹ Figure 2 (the right side) shows the best model that the software is able to provide and the left side shows the model with 0.7 of the edges.

If more than 0.7 of the edges were shown, the model would become extremely complex and similar to spaghetti model; and if less than 0.7 of the edges were represented, the model would become extremely simple and it would not give us an appropriate understanding to extract the

workflow pattern. In this model, the amount of blur edge is indicative of its flow.

According to Figure 2, various procedures are followed for patient discharge. It can be seen that the left side of the figure is much more complex than the right side. According to the represented fuzzy diagram, it can be found that there are different patterns for the patient discharge process.

2-Finding the Repeated Patterns

To draw the pattern of the overall workflow of the process, the observed patterns are arranged based on their frequency. Figure 3 shows these patterns.

3-Outlining the Workflow of the Discharge Process

Based on Figure 3, according to the most frequent pattern as well as the experts' opinions, the discharge process workflow diagram was drawn. Figure 4 shows the workflow of the discharge process in Hashemi Nejad hospital.

4-Drawing the Dotted Charts

In this phase, the dotted charts were drawn using the ProM software. In all figures, the left-hand side shows the relative time and the right-hand side represents the real time. Figure 5 shows the dotted chart of the data for all units.

As is shown in Figure 5, the start time and end time of the discharge process differs among patients. The duration of this process is also very different. Therefore, in

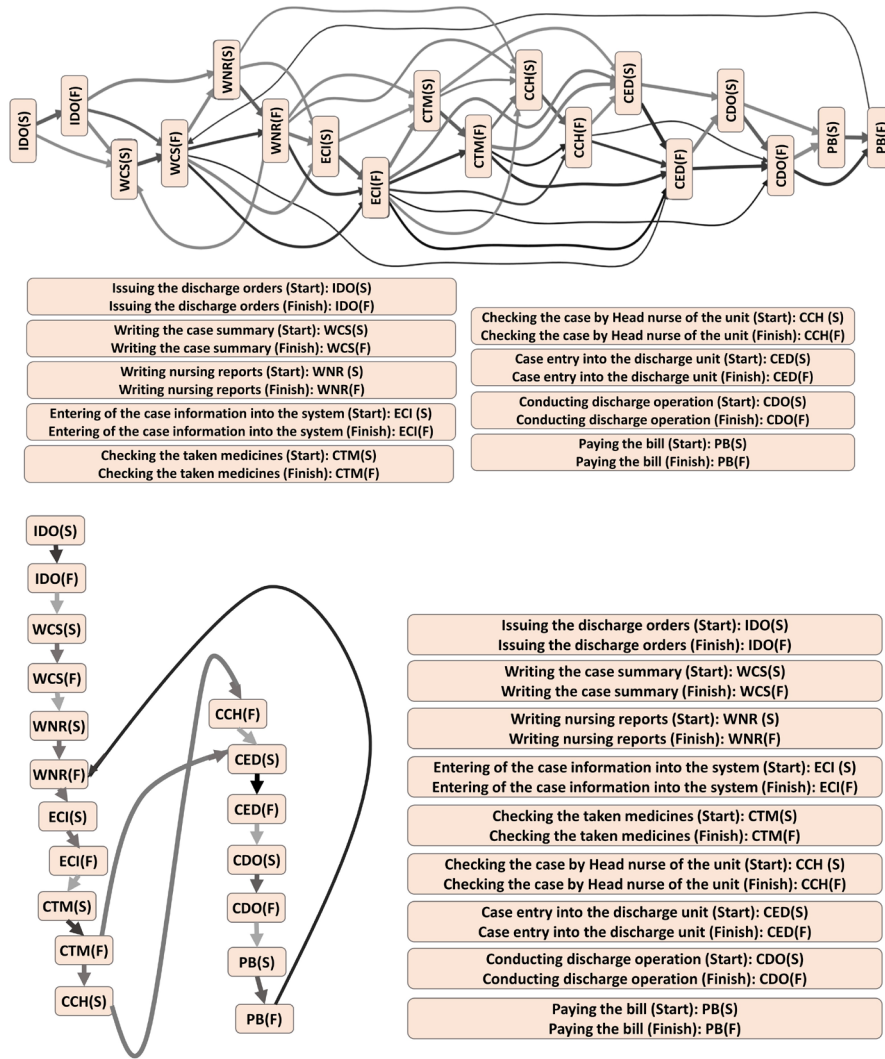


Figure 2. The Fuzzy Model of the Discharge Process for the Entire Data; (a) the Best Model, (b) the Model With 0.7 Edges.

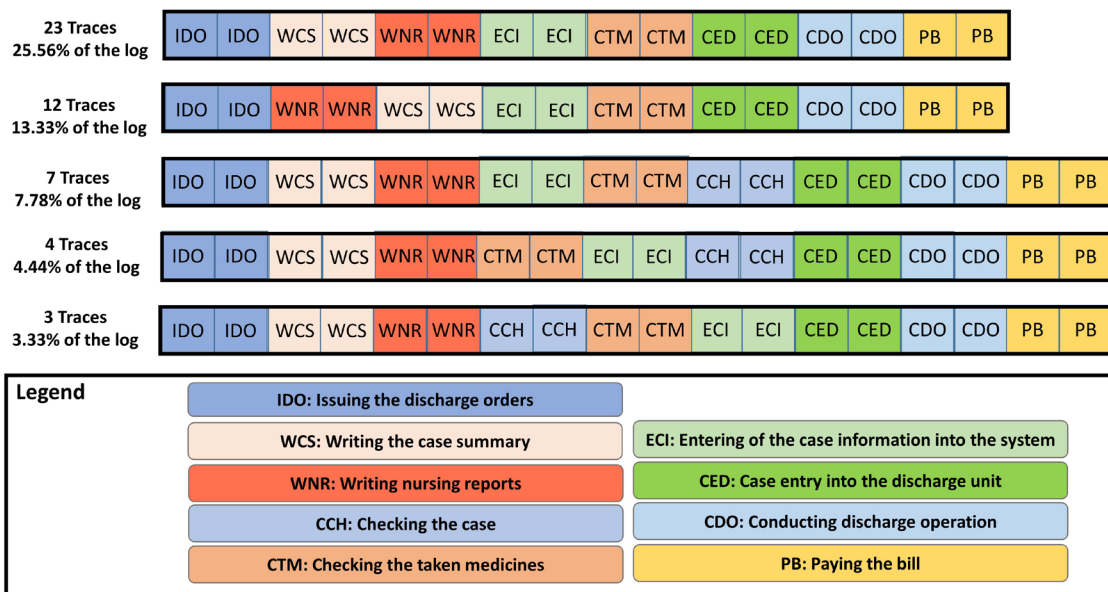


Figure 3. The Observed Workflow Patterns Based on the Frequency.

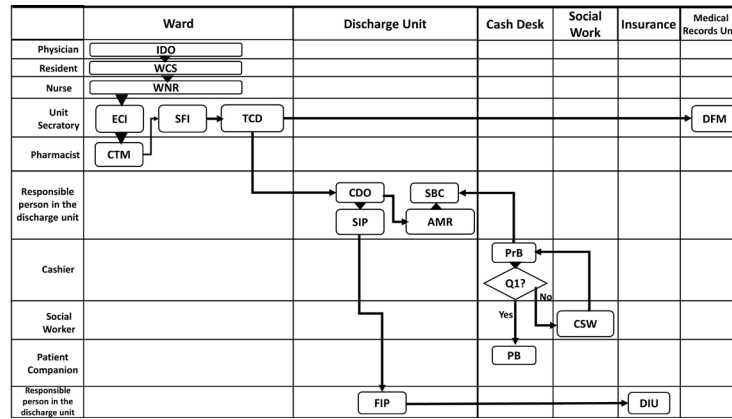


Figure 4. The Workflow of the Discharge Process in Hashemi Nejad Hospital.

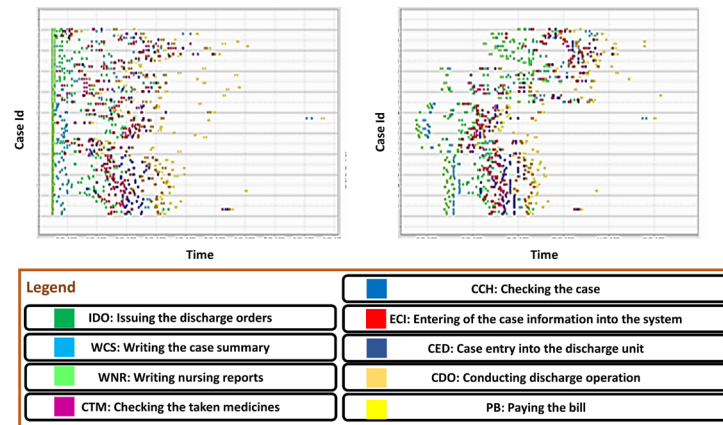


Figure 5. The Dotted Chart of All Units.

the next step, the dotted diagrams of different units have been plotted to be analyzed in an accurate manner. Figure 6 shows the dotted chart of Omid Unit.

As shown in Figure 6 (the left side), the start time of the discharge process is virtually identical for all data, while the end time is different. According to Figure 6 (the right side), it can be found that the discharge process is delayed in two cases, i.e. writing the nursing reports and paying the bills. In the former case, physicians start to visit the patients around 6:30 and specify the discharged patients. Once the shifts are handed over between 7 and 7:30, patients are assigned to the nurses and they start writing the nursing report. This leads to a time delay in the discharge process. The latter case is related to the paying of bills that leads to a prolonged discharge process. This delay is due to the late notification of the head of the unit to the patients' companions for settlement (paying the bill). Figure 7 shows the dotted chart of Rasouli Unit.

Since the time of the visits of the nephrologists and issuing the discharge order are different (Figure 7) in this unit, the discharge process begins at a different time. According to the left-side figure, the duration of the process is also very different. This can be due to the different times of issuing

the discharge order, as it causes the next activities to be done in an irregular order. In addition, as it can be seen in Figure 7 (the left side), writing case summaries by the residents (which has been marked with the light green) is another reason for the delay. Figure 8 represents the dotted chart of Shafa Unit.

According to Figure 8 (the right side), in this unit due to the existence of the urology and nephrology patients and different times of the visits by the physicians, the discharge process occurs at different intervals. However, according to Figure 8 (the left side), if we don't consider the bill payment, the duration of the process will be nearly constant. Figure 9 shows the discharge process of Soroush Unit.

Since the patients are examined early in the morning and the discharged ones are specified at this time, the discharge procedure is also more regular and this is obvious in the figure. Furthermore, in this unit, the duration of the discharge process is almost constant and same for all patients. In this unit, due to the long waiting lines, different attempts are made to discharge the patients before 11:00 AM, so that new patients can be admitted.

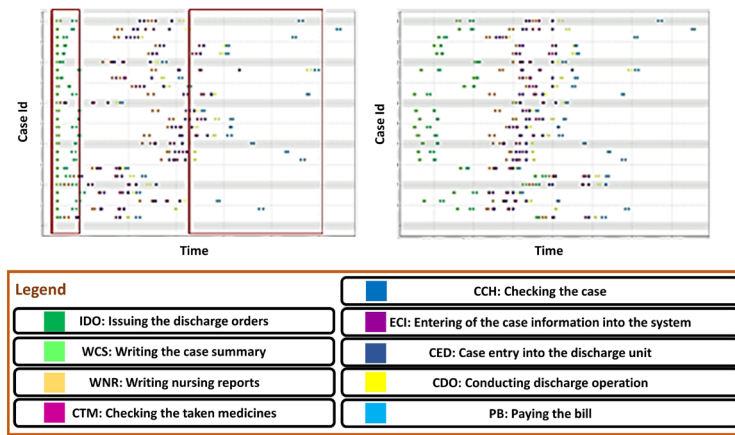


Figure 6. The Dotted Chart of Omid Unit.



Figure 7. The Dotted Chart of Rasouli Unit.

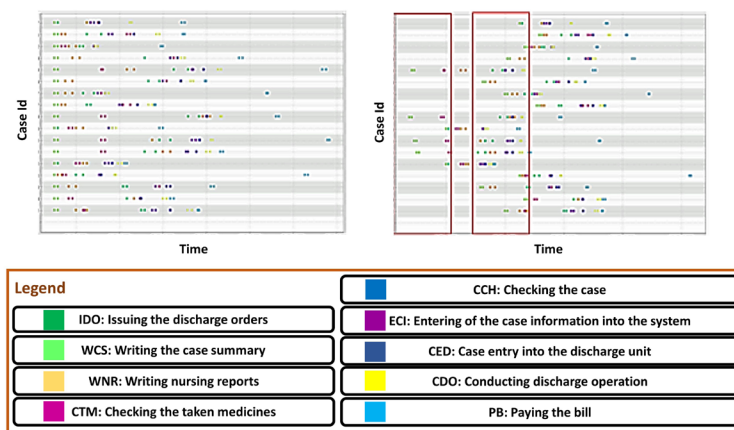


Figure 8. The Dotted Chart of Shafa Unit.

Results

After reviewing the dotted charts of the units, the discharge process was analyzed as a whole and some recommendations were made in order to improve the process.

1-Finding the Delayed Sections

According to the investigations conducted on the dotted charts of the different units, delayed parts of the process can be specified on the discharge workflow pattern diagram of the hospital. Figure 10 shows the delayed

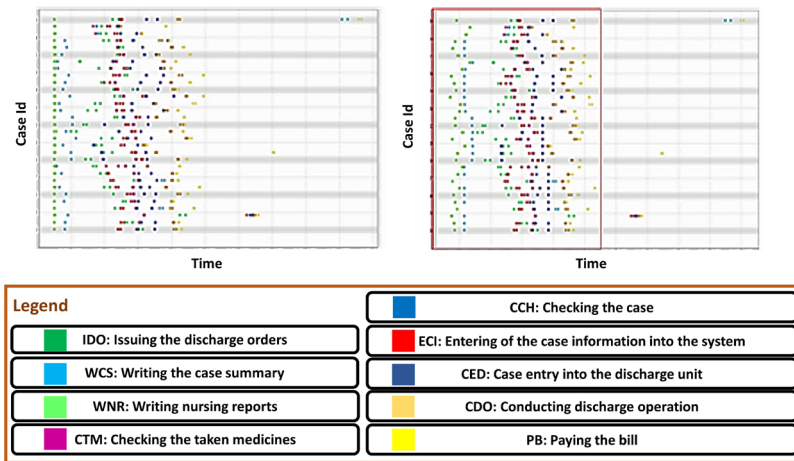


Figure 9. The Dotted Chart of Soroush Unit.

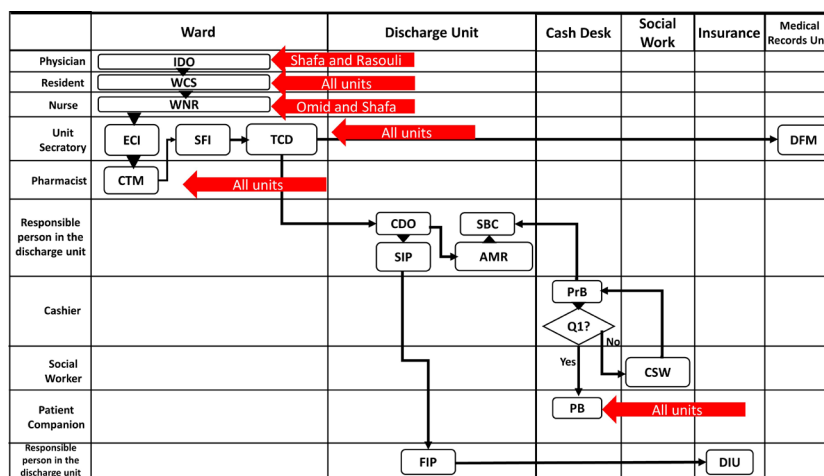


Figure 10. Delayed Parts of the Workflow Pattern.

areas of the workflow pattern.

2- Some Recommendations to Improve the Discharge Process

According to the information obtained in the previous sections, some suggestions can be made to improve the discharge process. These suggestions have been offered in the 4 areas of the human resources, the system, the environment, and the process. Table 3 lists these recommendations.

In Table 3, for instance, one common problem of all units (in the process section) is the lack of a proper notification for the discharge process (marked green) to the companions of the patients; this leads to their confusion between the fund, the discharge unit and the hospitalized unit. According to the dotted charts of the units, it seems this issue affects the process of bill payment more than other processes. Using a display in the waiting room, the condition of the discharged patients can be described, so that their companions can be informed about the process

and be prepared to pay the bills.

Discussion

As mentioned in the previous sections, in order to improve the workflow pattern of the discharge process, we need to identify this process. Among the advantages of identifying the discharge processes is that some solutions can be provided to facilitate the release processes, to improve the bed management and hospital management.

In the present study, the discharge process was studied using the process mining tools. To this end, first, the required data were gathered from the hospitalization units and then, the fuzzy diagram of the whole process was extracted. As the process followed different patterns, first, the frequent patterns were identified and the workflow pattern of the discharge process was discovered using experts' opinions. Afterwards, the discharge processes of the different units were analyzed using the dotted charts. Finally, based on the conducted analyses, some recommendations were made to improve the discharge

Table 3. Some Recommendations for Improving the Discharge Process

Unit Name	Main Causes of Delays in Discharge Process	Proposed Solutions	Category of the Proposed Solution
Omid and Soroush	The patients are visited in the early morning, therefore, the delay of the discharge process is mainly due to the nursing report.	With regard to discharge process, late preparation of the nursing reports doesn't create any problems with the patients' cases and it can be written later.	Process
	Slowness of the PCs or lack of them in the unit is one factor slowing the discharge process.	Increasing the number of PCs and enhancing their software and hardware performance or replacing the fast tablet can reduce the delay.	System
All Units	Lack of proper notification on the discharge process to the companion and his/her confusion in the cash desk and discharge unit may cause the delay in paying the bill.	Through putting a monitor at the waiting room, the conditions of the necessary information for discharging patients can be described.	Process
	Patients who have been hospitalized in several units, get into trouble in finding the prescribed medicines.	For patients who have been hospitalized in several units, their medicines should be packed a day before their discharge.	Process
	Sometimes, lack of the description of the operation and the used equipment may cause some problems.	Making the operating room to complete the case report immediately after the operation may reduce delays of this type.	Process
	For some types of documents, the discharge unit may have difficulty in entering them to the system and this may slow the discharge process.	Making a particular person such as the unit secretary or the head of the discharge unit to enter the documents is a solution.	System
	Inconsistencies in the insurance tariffs and their frequent changes can slow the discharge process.	Unification of the tariffs can improve the discharge process.	System
	In many situations, the exact number of the discharged patients is not specified in the system before delivering the bed.	It is recommended that the patient status in the system changes to discharged as soon as the discharge process for the patient is initiated.	System
	The pharmacist of the drugstore is also in charge of checking the medicines of the operating room and this causes a lot of problems and successive commutes, while the operating room doesn't have a separate drugstore and pharmacist.	More coordination should be made among the operating room staff, secretaries and pharmacist.	Human Resources
	When the discharge order is issued, there is no need for the patient to occupy the bed, sometimes patients may be visited and hospitalized in the evening and they need bed.	It is recommended to provide a room for discharged patients whose discharge order is issued but their discharge process is not completed.	Environment
Little space in the hospitalization unit for the staff for entering the patient information into the system.	Providing the appropriate place for the staff for entering patient data can reduce the discharge process time.	Environment	
Shafa and Rasouli	Monthly replacement of the residents of the nephrology units cause to delay in training, receiving seals and so on. It created some difficulties in the discharge process.	The time of residents' stay should be increased as long as possible; otherwise, they are given more complete trainings and the importance of the discharge process must be stressed.	Human Resources
	The physicians' visit time is different and sometimes they visit the patients after the 12 o'clock. It may lead to many problems.	In the future researches, planning and prioritization for medical affairs of physicians can be done to reduce the negative effects of unplanned visits.	Human Resources
	Sometimes, only the summary of the case is left for the discharge process to be completed but the resident is not available to complete the case summary.	As writing the case summary is a system process, the residents can be asked to insert the summary in every situation using simpler ways such as tablets.	Human Resources

process of the units.

Conclusions

Based on the results obtained in the present study, it is recommended that the following items to be considered for future researches:

1. In the proposed suggestions, the physician is known as delay source. In future studies, it is suggested to prioritize the daily plans of the physicians, e.g. going to the operating room, visiting the inpatients, outpatients, etc.
2. The arguments used in this study can be applied to other hospital processes such as the admission, the operating room, and other parts of the hospital.
3. Future research can focus on different weekdays to conduct a better and deeper analysis of the discharge process.
4. Planning and scheduling can be done to prioritize the completion of the case summary by the residents and improve the hospital discharge time.

Competing Interests

The authors declare no competing interest

Authors' Contributions

The authors made equal contributions to the present study.

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