Estimating how many flebotomists are required in the flebotomy unit: An artificial intelligence study

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Abstract

Objective: In this study, after the examination, most patients apply to phlebotomy units to perform the necessary examinations. Sufficient plebotomists should be taken to the phlebotomy unit to serve a large number of patients. The aim of this study is to determine the reguired number of phlebotomists in blood center using the artificial intelligence.

Material and Methods: This study was conducted in the Health Sciences University Tepecik Training and Research Hospital Blood center between the September-November 2019 . The required number of phlebotomists in the unit was determined with an artificial intelligence-based method. With this system, the number of patients coming to the phlebotomy unit is estimated in real time and considering the past performance of the working phlebotomists, how many phlebotomists are needed in real time is calculated.

Results: The number of phlebotomists who both serve patients as quickly as possible and use the personnel resources of hospital efficiently needs to be optimized. In order to solve this problem, an AI-based system has been developed. With this system, the number of patients coming to phlebotomy unit is estimated in real time and considering the past performances of the working phlebotomists, it calculates how many phlebotomists are needed in real time

Conclusion: The suggestions made by this AI-based system have made a great contribution to the management of the phlebotomy unit. Managers used hospital staff resources in the most efficient way and at the same time, they were able to ensure that patients receive phlebotomy service by following the system's recommendations.

Keywords: Phlebotomy, Phlebotomist count prediction, Artificial intelligence, Health

Introduction

The human factor is the center of healthcare; however, healthcare intuitions have shortcomings in managing this human resource. In a study, the strategies of human resources management of a university and a public hospital were examined and as a result it was reported that these two hospitals did not have clear strategic goals and there is no consistency and direction in human resources management (1). Distribution of hospital resources to various units of the hospital in accordance with the flow of different patient groups is defined as a complex problem that is difficult to manage. This problem is expressed as a dynamic problem due to the fact that patient applications and treatment processes are stochastic (2).Hospitals are searching solutions that improve both the quality of service and lower costs, such as reducing patients' waiting time (2). It is reported in the surveys that waiting time is the most important factor affecting patient satisfaction (3).

In a study, it has been stated that issues such as the role of human resources management in the health sector, its impact on employee welfare, and its contribution to improved health care outcomes have become important in recent years (4). Studies are carried out to enhance phlebotomy times for inpatients. Without using extra staff and eliminating only the defects in the study, there was a good recovery in phlebotomy time (5). The improvement achieved by regulating the model in the phlebotomy processes of inpatient also shows that lower waiting times are able to be achieved with personnel without extra staff in phlebotomy processes of outpatients. With s heuristic algorithm developed in a doctoral dissertation study, workhours of the day are divided into 15 time zones and weekly work plans of phlebotomists were in time intervals. With this study, it has been reported that the workload is able to be met with fewer phlebotomists.

At the same time, the decrease in service time is presented in the results of the study (6). In another study, by determining the number of patients at 14 different phlebotomy units from Monday to Friday every 30 minutes and how many phlebotomists were required for these patients. After the study, phlebotomy units that employ phlebotomists more or less than needed were determined. It has been reported in the in the results of the study that the waiting times of the patient also decreased. Patient satisfaction was noted with a questionnaire made to patients because of waiting time (7). We see that human resource management is vital in phlebotomy units when we examine the studies and results in this field. There are positive gains for both hospitals and patients when the work plans of phlebotomists are done well. We understand that different solutions have been tried for these achievements and with these studies, they have carried the service quality to a better point than their current status. In our study, by using the latest technologies, we have determined the number of phlebotomists needed in real time depending on the change in workload, using the data held in phlebotomy units and modern machine learning algorithms. Therefore, by estimating the patient load which will occur in the coming hours, we are able to suggest the number of phlebotomists at which the phlebotomy unit needs before the patient density is formed.

Material and Methods

It was carried out by using the data of patients applying to the phlebotomy unit of Health Sciences University Tepecik Training and Research Hospital and data of phlebotomists serving in the phlebotomy unit between September 2019 and November 2019. Test requests of patients, coming time to phlebotomy units, waiting time in phlebotomy unit, the blood test done by the polyclinic, patient priority information and individual information were anonymized. Database of phlebotomists were matched with unique id information, average phlebotomy times, the working hours they started and stopped were used. Phlerobo: Artificial Intelligence and Blood Collection Unit Management System (8) used in the phlebotomy unit of the Health Sciences University Tepecik Training and Research Hospital was used in collecting these data. This system is important in keeping reliable health records and conducting the study with reliable data.

Phlerobo has the characteristics of recording the data of the phlebotomy process with all details. The first step of the bloodletting process starts with the physician requesting the laboratory tests to the patient. The physician directs the patient to the phlebotomy unit to give blood, after he completes the test requests. The patient coming to he phlebotomy unit has stated that he came to the phlebotomy unit by using the kiosks at the entrance of the phlebotomy unit. Then, the patient is announced to give blood and the patient goes to phlebotomist. When the patient sits in the seat of the phlebotomist, the phlebotomist verifies the ID of the patient. Later, bloodletting is performed, and barcodes of the blood-drawn tubes are read and recorded. All steps of this process are instantly recorded by Phlerobo system. These data with high resolution and reliability are vital for the success of the study.

All factors which affect the process must be determined well in order to clarify the number of phlebotomists required for hospitals to achieve their service quality targets. Each institution tries to determine the number of phlebotomists to be assigned in the phlebotomy unit by making some calculations. In these calculations, all the patients who applying to the phlebotomy unit is taken into consideration. The additional number of phlebotomists is tried to be determined by adding extra personnel if the waiting time in phlebotomy unit begins to be above hospital targets. It is rarely seen that more than one phlebotomist has been directed and the quality targets have been achieved however the staff is not used effectively. The total number of patients admitted to the phlebotomy unit is undisputedly the most important factor in determining the required number of phlebotomists. It is easily calculated the average number of patients have applied to the phlebotomy unit from patient records. However, the distribution of arrival hours of patients to the phlebotomy unit during the day is as vital as the total number of patients applying. It is usually seen that in the morning when the polyclinic services are more intense, the patients applying to the phlebotomy units are more and this density decreases greatly in the afternoon. It suggests that instead of assigning a fixed number of phlebotomists, assigning varying number of phlebotomists in the phlebotomy unit depending on the workload will be more appropriate. Another difficulty in determining the number of phlebotomists correctly is the variability among the performance of each employee. Without doubt, every phlebotomist is not able to complete blood withdraw in the same period. Even the same phlebotomist is able to perform differently on different days. It clearly shows that individual performances must be considered when calculating the number of phlebotomists needed. Determining the changing need for phlebotomist during the day is not an easy task. By following the need at all times and making predictions enough phlebotomists should be started before the crisis or the qualify targets are exceeded. In this study, the information required to estimate the number of phlebotomists are needed have been evaluated under two main headings. The first is the number of the patients applying to the phlebotomy unit within a certain period and the other is how long it will be possible to serve the waiting and incoming patients with the current number of nurses. In order to determine the number of incoming patients stated in the first main title, calculations and estimations should be made in many subtitles, for instance, the number of patients requested for testing, the past behavior of the patients, the time of transportation of the patient from the polyclinic to phlebotomy unit, revisiting of patient the next day or certain day when the test is studied. In the second main title, by learning the bloodletting performance of the working staff based on past and current behaviors, the calculation of waiting time can be provided to the current patient flow. The calculations and estimations under these two main titles were made and the number of phlebotomists were needed based on the hospital quality targets was instantly estimated.

The process of patients which come to the phlebotomy unit is started by the physicians making the laboratory test

request. Knowing the patients requested to test means knowing the patients applying to the phlebotomy unit. However, the problem is how long the patients will apply to the phlebotomy unit. At this stage, we usually encounter two different processes. In the first one, the patient whose test request is made by physician, goes directly to the phlebotomy unit. In this process, the patients apply to the phlebotomy unit after a certain period of time, depending on the distance between the clinic and the phlebotomy unit. In the second process, it is a kind of process that patients apply to the phlebotomy unit the next day or the following days although a laboratory test request is made, due to reasons such as the necessity of the patient to be hungry and the working hours of the test. The number of patients in this group increase especially at noon. Ratio of patients applied to the phlebotomy unit with a polyclinic examination in the afternoon is high because these tests generally require 8 hours of fasting. With the developed algorithm, the potential patient flow is calculated by estimating how many of the patients who undergo a laboratory test but have not applied to the blood collection unit within a certain period of time. The algorithm calculates how many new applications will be available in the next at time period by estimating the time to reach the phlebotomy unit and the number of patients to arrive in the following days. Especially in the first minutes of the phlebotomy unit, it is seen that the patients from previous days applied to the phlebotomy unit. The algorithm also considers the estimation of these patients from the previous day and calculates the number of phlebotomists needed. In Fig 1 and Fig 2, the points below zero show the patients from previous days. Especially in the first hours of the day, we see that a lot of patients from previous day applied to the phlebotomy unit. The present load of the phlebotomy unit is calculated by summing the estimated potential patient load and the number of patients waiting in the hall. Serving this patient burden is a necessity in a time that complies with the quality targets of the hospital. However, in order to calculate how long this patient load can be served, it is necessary to know the performance of working phlebotomists. It is known that the period of bloodletting differs depending on the experience of phlebotomists (9). It can be learned from past records. Therefore, the differences among the phlebotomists are also taken into account. Since the same person may have a performance difference day-by-day, the algorithm also takes into consideration the working performance of the phlebotomist that day. Thus, it is able to be calculated how long the current patient flow can be served with the current staff. Other factors affecting the speed of phlebotomists are the demographic characteristics, diagnosis and the number of tests requested by the patients. It takes longer for an elderly patient to sit at the phlebotomy table, prepare for bloodletting and get off the table than a young patient. It may take longer to find the vascular access of a patient receiving treatment in the oncology unit than other patients. As the number of tubes to be taken from the patient increases the phlebotomy duration increases. Parameters varying from patient to patient must be taken into account as well as the number of patients.

The chart below illustrates the variation in phlebotomy duration and mean phlebotomy duration among patients. As seen in the Fig 3, phlebotomy duration varies between 0.5 minutes and 7 minutes, while the average phlebotomy duration varies between 1.5-2.0 minutes in a much narrower duration.

Statistical Analysis: The data were stored in the MongoDB database in JSON (Javascript Object Notation) format. Algorithms and calculations are made using Javascript programming language

Results

We have compared the values of the average waiting times, the maximum number of waiting patients and the number of working nurses in Sağlık Bilimleri University Tepecik Training and Research Hospital phlebotomy unit between September-November 2019 when the suggestion was made and was not made. We have observed how feasible the number of phlebotomists recommended by the one, responsible for phlebotomy unit. We have compared the average waiting time and the maximum number of waiting patients in the days when the person who is responsible for phlebotomy unit, was able to implement the recommendations of the system and in the days when he or she was not.

The number of phlebotomists suggested by the system should be evaluated in two ways. The first one is to make instant resource planning based on the recommendations made by the system in real time. However, it is not easy to apply this instantaneous variability in the field with same sensitivity.

The other form of evaluation should be the spread of real time suggestions to the general. For instance, the system recommends that 2 or 3 phlebotomists should work until 9:00 every morning. With this proposal not varying greatly among days, a general conclusion can be made about the time of personnel to begin to work and the number of phlebotomists which should work. Similarly, it is seen from the recommendations that 1 or 2 phlebotomists are enough for the afternoon. This suggestion can be transformed into a general practice and more staff can be evaluated more efficiently in another unit.

In Fig 4, the average waiting time in the last column with the number of working and suggested phlebotomists throughout September is presented. In the phlebotomy unit in which the study was conducted, 8 minutes for routine patients and 3 minutes for priority patients were determined as the quality aim. In accordance with these aims, the number of phlebotomists was proposed to be less.

When we look at the mean waiting time column, it can be seen that the number of phlebotomists recruited, and the quality aims are successful. According to these figures, we can review the quality aims and we can aim shorter waiting times, or we can conclude that with less phlebotomists serving, we achieve the quality aims.
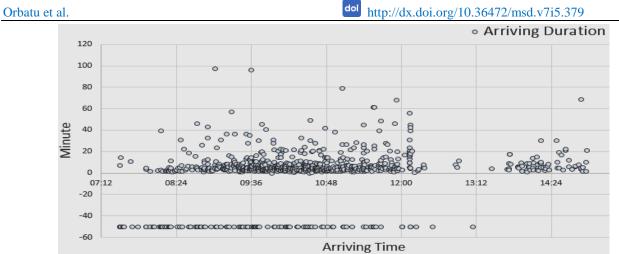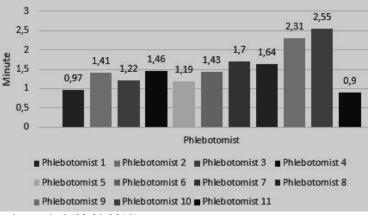
Figure 1: Reaching time to the phlebotomy unit (02.09.2019)

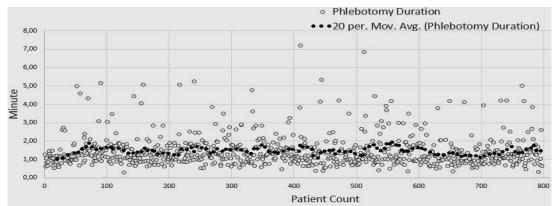**Figure 2:** Average bloodletting period (02.09.2019)

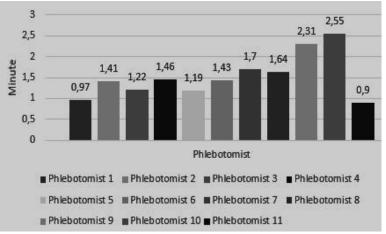**Figure 3:** Phlebotomy duration (02.09.2019)

Figure 4: September 2019 Actual/Predicted Phlebotomist Count

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Discussion

First, the responsible staff must follow the recommendations during the day for the number of phlebotomists suggested by the system to be implemented in the field. It is not always possible to reach the needed staff although the suggested number of phlebotomists is regularly monitored. This kind of problems were evaluated as administrative problems, not systemic. However, the system triggers the emergence of administrative problems and necessary actions to be taken for its solution. Taking instant actions is not that easy in practice. However, a general working pattern must be created from instant recommendations. After the general order is provided, it will be easier to implement instant recommendations. In the later stages of the study, when the resources available to the system is introduced, it can be controlled completely which staff will start working at the phlebotomy unit at what time, when and how long take a break and what time to complete the work by the intelligent system (8). When the number of phlebotomists is not enough, a call message can be sent to the phlebotomists chosen by the system and the next phlebotomists can be determined. If the phlebotomist expected to be next one does not start within the expected time, the system is able to invite new phlebotomists automatically (9). When the number of phlebotomists is high, it can be suggested by the system that they will take a break, or they have completed their work for that day. Thus, we are able to create phlebotomy units at which the entire process is managed by artificial intelligence and human errors are minimized.

Conclusion

In conclusion, this AI-based system have made a great contribution to the management of the phlebotomy unit. Managers used hospital staff resources in the most efficient way and at the same time, they were able to ensure that patients receive phlebotomy service by following the system's recommendations.

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