A Real-Time Computer Simulation Program for Reducing Outpatients Phlebotomy Wait Time

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Background: Our goal was to enhance the productivity of phlebotomists and reduce outpatient wait times. Here, we aimed to develop a computer simulation program in which resources would be shifted from the laboratory to assist with phlebotomy. We evaluated the efficacy of computer simulation approaches for phlebotomy wait time and provide phlebotomy help time. **Methods:** We evaluated the performance of the following three approaches: no helping system (NHS), the conventional assistance system (CAS), and the computer simulated helping system (CSHS). The CSHS predicted the phlebotomy waiting times based on computer simulation approaches, decided the assist times, and sounded an

alarm. **Results:** The wait time for the NHS was significantly longer than that of the CAS and the CSHS ($P < 0.05$). We divided the wait time into the three parts: <5 min, 5–10 min, and >10 min. Significant differences between the three systems were detected ($P < 0.05$). The phlebotomy computer simulation system significantly decreased the help time of the phlebotomists (CAS was 93.3 ± 19.7 min vs. CSHS was 79.5 ± 17.7 min, $P = 0.03$). **Conclusion:** We designed a computer-based predicted alarm system. This system could effectively decrease help time for phlebotomists and outpatients phlebotomy wait times. J. Clin. Lab. Anal. 29:255–258, 2015. © 2014 Wiley Periodicals, Inc.

Key words: computer; phlebotomy; simulation; wait time

These long wait times are a major source of dissatisfaction with medical care delivery and a barrier to the further use of healthcare facilities by affected patients (1, 2). In one study, the proposed changes, including the relocation of a department, significantly decreased the average patient turnaround time by ~ 4 min (3). Another study demonstrated that an active phlebotomist phlebotomy system decreased patient waiting times and improved the productivity of the phlebotomy services (4).

We could transiently move the medical laboratory technologists from the laboratory room to the phlebotomy room as part of a phlebotomist helper system during the busy times. Our goal was to enhance the productivity of the phlebotomists and, ultimately, to reduce outpatient wait times. We attempted to simulate predicted wait times using computer programs. Here, we aimed to develop a computer simulation program and a system in which resources would be shifted from the laboratory to assist with phlebotomy. We evaluated the efficacy of computer simu-

lation approaches for phlebotomy wait time and provide phlebotomy help time.

The study was conducted from February 1 to October 30, 2012, at an 850-bed university hospital in Seoul, Korea with $\sim 1,200,000$ phlebotomy outpatients per year. Forty-five medical technologists worked at our

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hospital, including six in the phlebotomy room and 39 in the main laboratory room. The entire phlebotomy process included different combination of the following events: outpatients for a day and patients by appointment. The phlebotomy wait time (i.e., the time between waiting ticket issuance and the moment the phlebotomy started) was measured.

We evaluated the performance of the following three approaches: (1) the no helping system (NHS), from February 1 to April 30, 2012; the phlebotomists working without assistance. (2) The conventional assistance system (CAS), from May 1 to July 31, 2012; and the phlebotomists making decisions when to call for help. The phlebotomist decided what constituted a phlebotomy patient jam and then called for assistance; it took a long time for the helpers to move to the phlebotomy room. (3) The computer-simulated helping system (CSHS), from August 1 to October 30, 2012; the calculation of the number of waiting phlebotomy patients was based on a computer simulation system that was carried out using a work flow analysis.

We proposed the following time-based formula:

$$N_t = aN_r + \sum_i c_i N_{t-i} + dN_{tr}.$$

We calculated the sum of every department. The classifications were made at 10-min intervals and depended on the day of the week. It is implemented using X-internet tool MiPlatForm V3.3 (TOBESOFT, Korea) on personal computer.

While building the model, the following decisions were made:

- The data for the four factors were classified according to time (assorted in 10-min intervals) (N_t).
- The number of patients who receive phlebotomy with a reservation (N_r).
- The number of days of payment for a phlebotomy patient (N_p).
- The number of phlebotomy patients about a minute ago (N_{t-i}).
- That is a gap in the number of patients who receive phlebotomy between now and 10 min ago (N_{tr}).
- Constant 1(a) was calculated to factor in the number of patients with reservations who made real visits to the phlebotomy room.
- Constant 2(b) was calculated to factor in the number of days patients visited when they paid but had not yet visited the phlebotomy room.
- Constant 3(c) was calculated to factor in the weighted value. We multiplied by 0.2, 0.15, and 0.1 to indicate the effect of 10, 20, and 30 min ago, respectively, of the estimated formula.
- Constant 4(d) was calculated to factor in the weighted value according to the time and number of patients who visited the phlebotomy room. After we calculated the difference in the number of paid patients between the two times (before 10 min), if there was an increase, we multiplied by a constant 4 factor. These factors were scored by time. Usually, we applied 1.1 during the busy times (from 08:50 to 10:40) and 8 during the other times. If there was no increase or decrease, we multiplied by zero.

Those were our two important terms for alarm, composed of limitation values that were the sum of the above formulae and the number of waiting outpatients. The sum at present was 10.85, which was used to calculate the limitation value applied to Table 1 at present. The limitation values were calculated as the sum of the at-present data plus the 10-min-ago data $\times 0.2$ plus the 20-min-ago data $\times 0.15$ plus the 30-min-ago data $\times 0.1$ (Table 1). We empirically defined cut-off levels for the two factors depending on the day of the week; if both exceed the cut-off, the alarm sounded.

Consider the following example:

9:30 formula = (9:50 number of reservation patients for phlebotomy $\times$ 9:50 constant 1) + (9:30 number of payment days for a phlebotomy patient $\times$ 9:30 constant 2) + (09:20 estimation data $\times 0.2$ + 09:10 estimation data $\times 0.15$ + 09:00 estimation data $\times 0.1$) + [if (09:30 number of payment days for a phlebotomy patient—09:20 number of payment days for a phlebotomy patient) $> 0 \times$ constant 4 or if (09:30 number of payment days for a phlebotomy patient—09:20 number of payment days for a phlebotomy patient) $< 0 \times 0$].

During the study period, the mean number of phlebotomy patients was 296.5, 296.7, and 296.1 per day during the morning (from 07:00 to 12:00 h) for NHS, CAS, and CSHS, respectively ($P > 0.05$). The mean wait time for the NHS, CAS, and CSHS were 4.6 ± 0.6 , 4.2 ± 0.8 , and 4.0 ± 1.1 min, respectively. The wait time for the NHS was significantly longer than that of the CAS and the CSHS ($P < 0.05$). We divided the wait time into the following three parts: < 5 min, 5–10 min, and > 10 min. Significant differences between the three systems were detected ($P < 0.05$). In particular, the number of wait times > 10 min dramatically decreased.

The phlebotomy computer simulation system significantly decreased the help time of the phlebotomists. The mean help time with the CAS was 93.3 ± 19.7 min, while that of the CSHS was 79.5 ± 17.7 min ($P = 0.03$). Our hospital has always received patient complaints. We received seven complaint cases in 3 months with the NHS, three cases in 3 months with the CAS, and no complaint in 3 months cases with the CSHS.

TABLE 1. The Limitation Values that were Calculated by the Sum of Data

Time on 2012.09.10	At present	10 minutes ago $\times 0.2$	20 minutes ago $\times 0.15$	30 minutes ago $\times 0.1$	Limitation value (sum)
07:21	0	-1.40	0.00	0.00	-1.40
07:31	0	0.00	-1.05	0.00	-1.05
07:41	0	0.00	0.00	-0.70	-0.70
07:51	0	0.00	0.00	0.00	0.00
08:01	0	0.00	0.00	0.00	0.00
08:11	1.19	0.00	0.00	0.00	1.19
08:51	2.67	0.00	0.00	0.00	2.67
09:01	4.25	0.53	0.00	0.00	4.78
09:11	9.42	0.85	0.40	0.00	10.67
09:21	6.26	1.88	0.64	0.27	9.05
09:31	16.88	1.25	1.41	0.43	19.97
09:41	18.9	3.38	0.94	0.94	24.16
09:51	10.8	3.78	2.53	0.63	17.74
10:01	15.36	2.16	2.84	1.69	22.04
10:11	13.57	3.07	1.62	1.89	20.15
10:21	10.85	2.71	2.30	1.08	16.95
10:31	14.24	2.17	2.04	1.54	19.98
10:41	16.35	2.85	1.63	1.36	22.18
10:51	12.37	3.27	2.14	1.09	18.86
11:01	18.41	2.47	2.45	1.42	24.76
11:11	21.39	3.68	1.86	1.64	28.56

Reducing outpatient wait times had been the focus of a large number of studies (5, 6), because wait times and treatment times are usually regarded as indicators of service quality (7–9). In our alternative system, wait times decreased. Although the mean number of phlebotomy patients was not significantly different, the mean wait time of the NHS was longer than that of the CAS and CSHS. In particular, the number of wait times >10 min dramatically decreased in the CSHS compared to the NHS and CAS. It was a very important finding because when outpatients wait for over 10 min, these wait times were linked directly to patient dissatisfaction. Unfortunately, we did not conduct a survey to assess patient satisfaction before and after the implementation of the real-time computer simulation predicted system. However, when we examined hospital data on patient complaints about waiting for a phlebotomy, we found that the number of complaints decreased. However, it is still necessary to conduct a survey to assess patient satisfaction before and after the implementation of such a system and then compare survey results.

This study had several major limitations that were similar to those of another study (8). First, the research period was not sufficiently long. This was because the phlebotomy room was not always available for research, due to the continuous flow of patients. Second, although we reviewed problem documentation, detailed data on the

quality of the phlebotomy service, such as the rate of side effects or nonsuccessful venipuncture could not be obtained. Third, it was not possible to compare the satisfaction of outpatients before and after the system change at our hospital. Fourth, we employed set constant factors and weighted values, based on our experience. In the future, we need to collect a huge database comprising more accurate data. We continue to use the CSHS and have attempted to search for more accurate and precise constant factors. Despite these potential limitations, our predicted system had merits. First, to develop this system, we did not incur much additional cost; the largest additional cost was that associated with analyzing and interpreting the data. Second, the use of this system does not require additional manpower. Third, the CSHS was an efficient and satisfactory means of predicting the number of waiting patients. By developing these systems, we continue to modify intervention strategies according to hospital conditions to further improve the usability of the CSHS and make the phlebotomy process convenient for outpatients and phlebotomists. In our opinion, this system was very effective for ~1,200,000 phlebotomy outpatients per year.

In summary, we designed a computer-based predicted alarm system. This system could effectively decrease help time for phlebotomists and outpatients phlebotomy wait times.

CONFLICT OF INTEREST

None declared.

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