Quality Improvement for a Hospital Patient Transportation System

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Summary
This article describes a method for organizing and staffing a hospitalwide patient transportation system in such a way as to minimize patient waiting times. The method stems from a quality improvement project and includes a centralized communication system, a queuing model to determine staffing requirements, and a computerized data collection and monitoring system. A case study demonstrates improvements in waiting times, costs, and customer satisfaction.

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As pressure increases from health care purchasers to expedite the care of inpatients and accomplish more on a outpatient basis, it becomes incumbent on hospitals to improve the efficiency of all operating systems by reducing turnaround times and increasing overall throughputs. Of particular importance in this regard are those elements of the hospital that connect various departments transmitting information, materials, supplies, and patients. Over the years a great deal of attention has been given to computerized information and automated material transfer systems, but little attention has been paid to the task of moving patients from place to place within the hospital.

The hospital from which this case study is drawn has been involved in an organizationwide quality improvement program since March 1989 and is currently a participant in the Quality Management Network of the National Demonstration Project on Quality Improvement in Health Care. Early in the program a series of meetings were held with nursing and other hospital staff to identify processes within the hospital in need of improvement. The transportation service quickly came to the forefront as an area in need of attention.

Anecdotal reports from department heads suggested that transport time was not reliable and that patients frequently waited an hour or more for service. Patient transportation demands had increased as the hospital had grown, and there appeared to be little rhyme or reason for staffing patterns, shift assignments, or equipment inventory. In addition, there was no data available on volume of service by hour, day, or even year. Communication was poor, mostly by overhead page or digital pager, and accusations of slow service, personnel laziness, and lack of concern abounded.

A two-week sample (see Figure 1) revealed that anecdotal information regarding transport time was well-founded. While average time from call to delivery was about 25 minutes, the distribution histogram showed little central tendency. One-third of the transport times took longer than 30 minutes. Subsequent studies showed that the stories of transport times in excess of one hour were true. It was clear that the system needed to be redesigned from the ground up.

The system redesign involved three key elements: (1) an improved communication and control system, (2) a rational staffing model, and (3) a data base to monitor performance on a long-term basis. The goals were to reduce average transport time, significantly narrow the range of the distribution, reduce system operating cost, and increase customer satisfaction.

**Communication and Control**

Discussions with system users and transporters themselves indicated that a great deal of time seemed to be lost in the process of locating the transporters in the hospital and assigning them to duty. An experiment tested an approach
where a central dispatcher could communicate with transporters via two-way radios. Data collected over a two-week period revealed marked improvement (see Figure 2) in transport time, and this has now been made a permanent part of the transport system. The dispatcher has a control board that allows pinpointing the location of each transporter as transports are assigned or are completed. Pickups can then be directed to the transporter closest to a patient's location.

**Staffing Model**

Required staffing for the system is surely related to call loading (i.e., utilization), but the linkage was not at all clear. To gain insight into how this might work, we looked to a simplified steady state model derived from queuing theory (Saaty 1957). The equations used are summarized in the Appendix.

Using these equations, one can generate parametric data such as shown in Figure 3, that is, waiting time as a function of call loading and available staff. This particular data set is based on a mean service rate of three patients per hour.

The exponential shape of the curves in Figure 3 is perhaps the most important finding, indicating the dramatic rise in waiting time that occurs when call loading exceeds certain threshold levels. With this type of information it became clear that tales of one- to two-hour waits in some departments
were not imaginary but in fact could easily occur. For example, at 20 calls per hour and eight available staff, waiting time should be about ten minutes. However, if the call rate should surge by 10 percent or 15 percent to 22
or 23 calls per hour, waiting times will jump to 30 minutes or an hour. Or, if the system is designed to handle 20 calls per hour with eight people, and two of them are unavailable, waiting times will leap and the system will collapse. Given knowledge about the shape of the waiting time curve, the system manager (dispatcher) realizes that beyond certain call-loading levels or below certain staffing levels the entire system will be in crisis. More staff must be brought in or hospital departments should be contacted and advised of the impending delays. The system becomes proactive instead of reactive.

The analysis can be used another way, as shown in Figure 4. Here we have defined the staff required to hold waiting time below ten minutes at various call loadings (more or less the knees of the various curves). Two service rates are presented, three and four patients per hour. To use the queuing model for staffing, basic call-loading data is needed, such as that shown in Figure 5. Then, using Figure 4, staffing requirements by time of day can be developed, such as shown in Figure 6.

**Monitoring Subsystem**

Over time the monitoring subsystem becomes the instrument by which throughput is improved for the entire system. Data is collected via transporter transport/dispatch records and entered into a personal computer by

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**Figure 4**
Staff Required to Maintain Waiting Time less than 10 Minutes

![Graph showing staff required vs. average call loading](image_url)

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the dispatcher. The computer sorts and analyzes the data using customized software and produces the following reports on a monthly and quarterly basis.

Transport time report. This report details requests for transport services by hour of the day and provides average times used in calculating the total transport time. The total transport time is defined as the elapsed time between receipt of a request for transport services and the completion of the transport. Subparts of the total transport time are assignment time—defined as the elapsed time between receipt of a request and the assignment of an available transporter; and travel time—defined as the elapsed time between a transporter’s receipt of an assignment and completion of a transport.

Summary report. This report presents the number of transports completed with total transport time grouped in five-minute intervals. Also, presented is the average total transport time and its standard deviation.

Tolfrom reports. On demand, a report is available showing transports and total transport time by time of day, to and from requesting departments.

Transporter report. The number of transports assigned to and completed by each member of the transport service is included on this report, with the average total transport time, assignment time, and travel time.

Delay report. This report presents the number of delays incurred in the transport system and reason for delay, by requesting department and accumulating the total delay time. This report is useful in pinpointing additional improvement opportunities.
Results

Average transport time has indeed been reduced to about 19 minutes, as shown in Figure 7, which spans the first nine months of 1991. More important, however, the histogram now has a strong central tendency with a significantly narrowed range. Transport times in excess of 30 minutes have decreased from 30 percent of the total to 8 percent. This data is fairly close to the sample collected during the early experimental phase of the project. Clearly the dispatcher and two-way radios have a great effect on system improvement.

Initially, system costs increased as a dispatcher was added and other staff realigned to match call loading. However, an unexpected benefit resulted from analyzing the first batch of monitoring reports. These revealed that 16 percent of transports involved moving patients from emergency room to x-ray, and back again. Discussions with both departments led to the decision to locate an x-ray machine next to the emergency room. This eliminates 8,100 transports per year and almost two full-time employees from the transporter staffing requirements. It also reduces waiting time in the emergency room for patients needing x-rays by 50 minutes on the average, a circumstance that will unquestionably increase patient satisfaction. Although we have no
hard data relative to customer satisfaction with the new system, complaints have virtually ceased.

Information gathered from a continuing review of monthly and quarterly performance reports has been helpful in adjusting shift assignments and further refining the transport process. For instance, early delay reports revealed that significant numbers of transports were delayed because inadequate information regarding the patient’s condition was being relayed to the transport dispatcher when a request for service was registered. The dispatcher was not told whether a given patient had an intravenous bottle, needed oxygen during transport, or should be transported by cart and not by wheelchair. This shortcoming required the assigned transporter to report back to the Transport Department to secure the necessary equipment. Recognizing the need to reduce these delays, the Transport Department equipped every wheelchair and cart with an intravenous pole, stationed a cart on every nursing unit, and provided each transporter with a portable liquid oxygen unit. Such modifications substantially reduced delays that resulted from these commonly occurring situations.

The transporter report, originally designed to track transporter performance, has become an incentive tool used by the staff in competing against each other. Although management recognizes the best-performing transporter, the peer recognition received exceeds management’s expectations in encouraging superior performance.
While the transport staff and departments served by the transport service were initially suspicious of the new system, successes during the first year of operation have lead to relief and appreciation. A redesign of the transport system proved to be a success for the hospital.

Reference


Appendix

Queuing Equations

In this model the standard, steady state, queuing equations\(^{(1)}\) express waiting time for service as:

\[
W = \frac{L_q}{\lambda}
\]

where \(L_q\) is the number in the queue, given as:

\[
L_q = \frac{\rho (c \rho)^c p_0}{c! (1 - \rho)^2}
\]

with \(\rho = \frac{\lambda}{c \mu}\)

and \(\lambda\) = mean call rate, assumed Poisson distributed
\(c\) = number of channels
\(\mu\) = mean service rate

The term \(p_0\) (the probability of no calls) is defined as:

\[
p_0 = \frac{1}{\sum_{n=0}^{c-1} \frac{(\rho c)^n}{n!} + \frac{(\rho c)^c}{c! (1 - \rho)}}
\]

where \(n\) = the total number of customers in the system.

\(^{(1)}\) This article, submitted to the Journal November 15, 1991, was revised and accepted for publication August 3, 1992.