Process Efficiency

Redesigning Social Networks to Improve Surgery Patient Flow

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KEYWORDS

Social network analysis, patient flow, process efficiency, workflow redesign, IT.

ABSTRACT

We propose a novel approach to improve throughput of the surgery patient flow process of a Boston area teaching hospital. A social network analysis was conducted in an effort to demonstrate that process efficiency gains could be achieved through redesign of social network patterns at the workplace; in conjunction with redesign of organization structure and the implementation of workflow over an integrated information technology system. Key knowledge experts and coordinators in times of crisis were identified and a new communication structure more conducive to trust and knowledge sharing was suggested. The new communication structure is scalable without compromising on coordination required among key roles in the network for achieving efficiency gains.

Social network analysis has been applied in different disciplines for more than six decades. Recently, the relationship between network structure and organizational and individual performance has emerged as an important focus of this research.[1] The increasing formalization and quantification of social network analysis, as well as the wide availability of computing power, fostered works that examined the relationship between social network structure and group performance.[2] While social network analysis has been used frequently for analyzing medical applications such as spreading of infectious diseases and substance abuse,[3] little work has been done in correlating social network structure with individual and group performance of medical knowledge workers. This is where our study contributes.

An area where significant process efficiencies can be realized in a hospital is the surgery patient flow process that involves a number of intermediary departments. Since there are typically heavy infrastructure investments in the operating rooms and downstream ancillary departments, improving patient throughput will also result in significant cost savings.

The focus of this study is the surgery patient flow process of a large Boston-area teaching hospital. A dynamic Social Network Analysis[4] was conducted with the aim of observing communica-

tion patterns in social networks at the clinical workplace in the Post-Anesthesia Care Unit (PACU). The hypothesis being tested was that the pattern of social interactions will correlate with process efficiency, thus redesign of social networks in conjunction with redesign of workflow would help improve surgery patient process throughput.

Patients having completed surgery in the operating rooms and those not needing constant supervision, travel for "wake up" from anesthesia to the PACU. Patients typically stay in the PACU for several hours and then are transferred to their assigned beds in other parts of the hospital. The PACU is a critical intermediary step in the surgery patient flow process since delays here cause further hold ups upstream in the operating rooms resulting in surgery schedule disruptions, overtime work to staff and productivity losses. The PACU is susceptible to downstream delays due to problems with bed assignments in other parts of the hospital that patients are transferred to.

A social network analysis was conducted in an effort to demonstrate that process efficiency gains could be achieved through redesign of social network patterns at the workplace, in conjunction with redesign of organization structure and the implementation of workflow over an integrated information technology system.

PROBLEM IDENTIFICATION

For the period of March 1-31, 2007 the PACU received 1,398 patients, an average rate of 60 per day. The average length of stay was 3.1 hours. The PACU experiences considerably higher patient throughput and length of stay as compared to other same-day recovery areas of the hospital (In comparison, the adult same day surgery area receives an average of 48 patients per day with an average length of stay of 2.07 hours). Higher length of stay at PACU may be attributed to process inefficiencies; therefore length-of-stay data was analyzed over its weekly cycle (no surgeries on weekends) and plotted against time of departure from the PACU. (Fig. 1a).

It is observed that for each day of the week there are two peaks in length of stay between 1 p.m. and 5:30 p.m. The curves for Thursday are shifted forward by two hours since surgeries start two hours later on that day. Though there are peaks in length of stay outside this time window as well during some days of the week, the PACU staff corroborated our assumption of this time window for analysis with their observation that PACU was most stressed during this time period. Furthermore, within this time window it was analyzed that the first peak in length of stay occurs roughly between 1 p.m. and 3 p.m. and the second peak occurs roughly between 4 p.m. and 5:30 p.m. (except Monday, when both peaks occur between 1 p.m. and 3 p.m.).

Data analysis further revealed that delays due to bed unavailability in other parts of the hospital accounted for 99.6 percent (239 cases) of the total 240 cases of delayed patients. This delay occurs when the patient is ready to leave the PACU but there is no bed available for the patient to be transferred to in another part

Fig. 1a: Length of stay in PACU at different times of day.

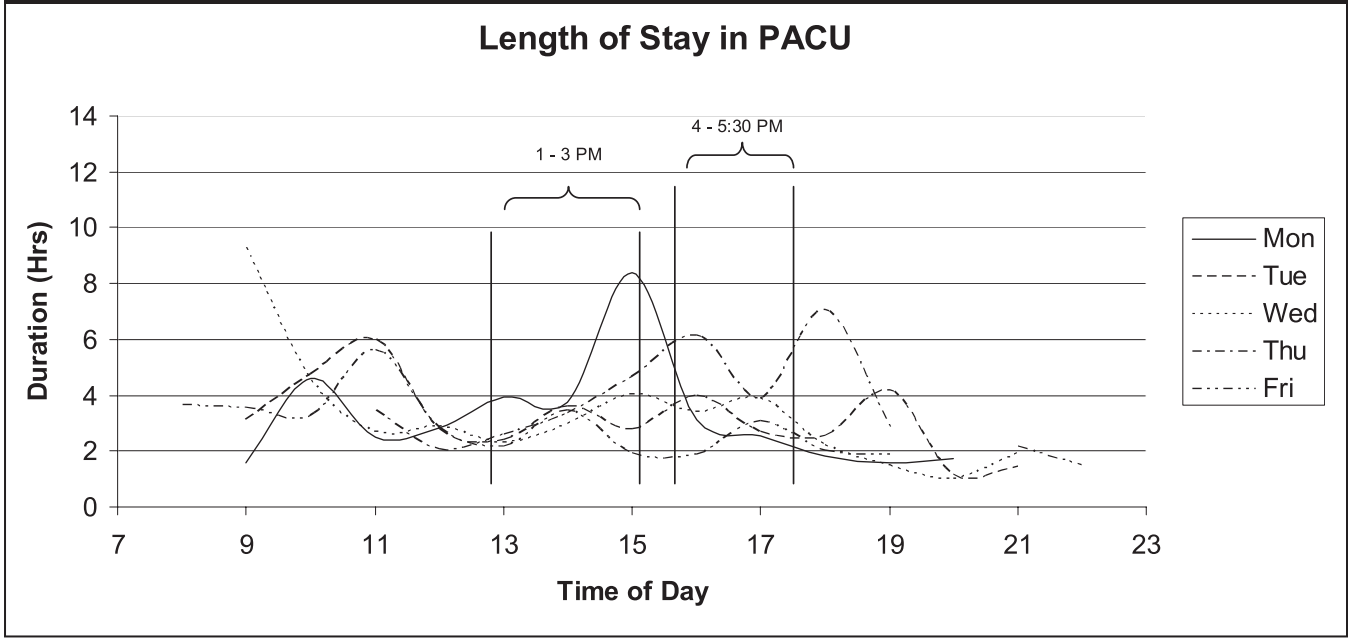
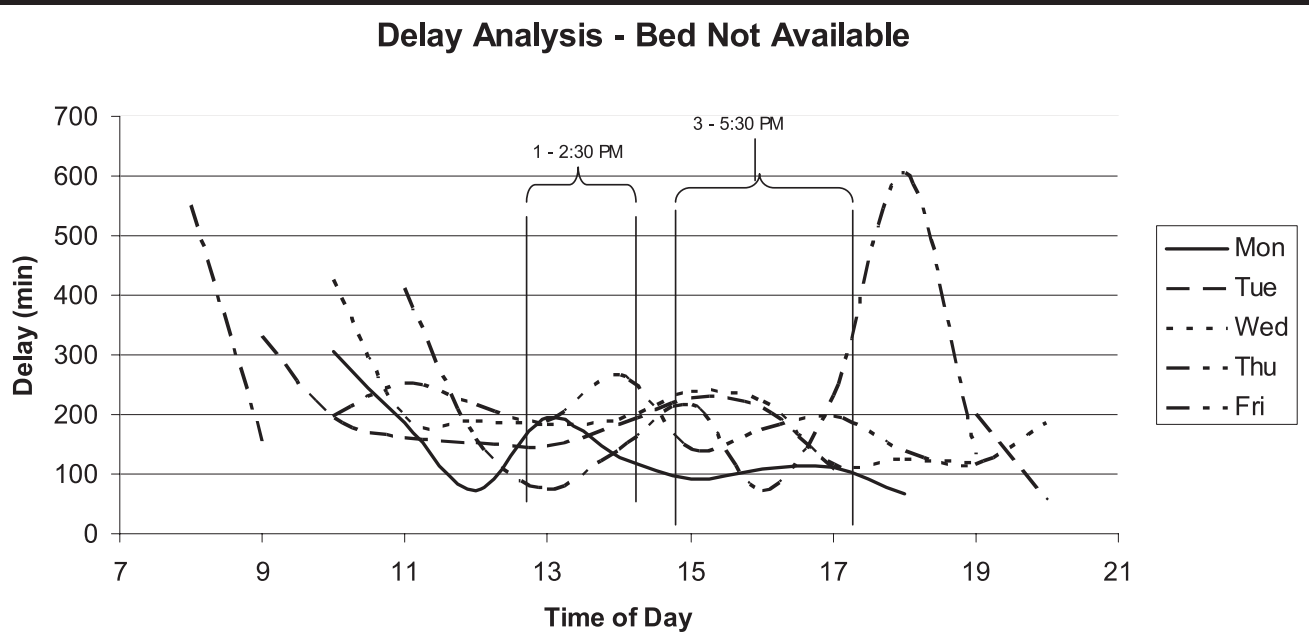


Fig. 1b: Minimum delay of 1.4 hours for 99.6 percent of all delayed patients.



of the hospital. The trigger for calculating this type of delay time occurs when the attending nurse (PACU Registered Nurse) makes an entry in a log maintained by the PACU Charge Nurse that the patient is "ready to leave."

Patient delay time, when plotted against time of departure from PACU, shows seasonality roughly similar to patient length of stay time during same time intervals. The first peak occurs between 1 p.m. and 2:30 p.m. and the second peak between 3 p.m. and 5:30 p.m. (Fig. 1b) The curves for Thursday are shifted forward by two hours since surgeries start two hours later on that day. Therefore, it is evident that variations in patient length of stay are directly related to delays occurring due to beds not being available downstream in other parts of the hospital.

To translate this patient delay into a process flow problem, the length of stay and delay times were mapped with the occurrence of the IN waitlist and OUT waitlist. The IN waitlist comprises patients waiting to enter PACU from the upstream operating rooms and the OUT waitlist comprises patients waiting at PACU to be transferred to other parts of the hospital. It was found that the waitlists also peaked during the two time bands of 1 p.m. to 3 p.m. and 4 p.m. to 5:30 p.m. which corresponds roughly with the peaks in patient length of stay and patient delay times. (Fig. 1c)

Further analysis revealed that though both waitlists always occurred simultaneously the OUT waitlist (black) had greater magnitude and persistency than the IN waitlist (grey). This suggested the OUT waitlist as the cause of the IN waitlist. Therefore, the process flow problem of build up of OUT waitlist could be directly attributed to causing the increase in patient length of stay due to delay in transferring patients out of the PACU.

METHODS

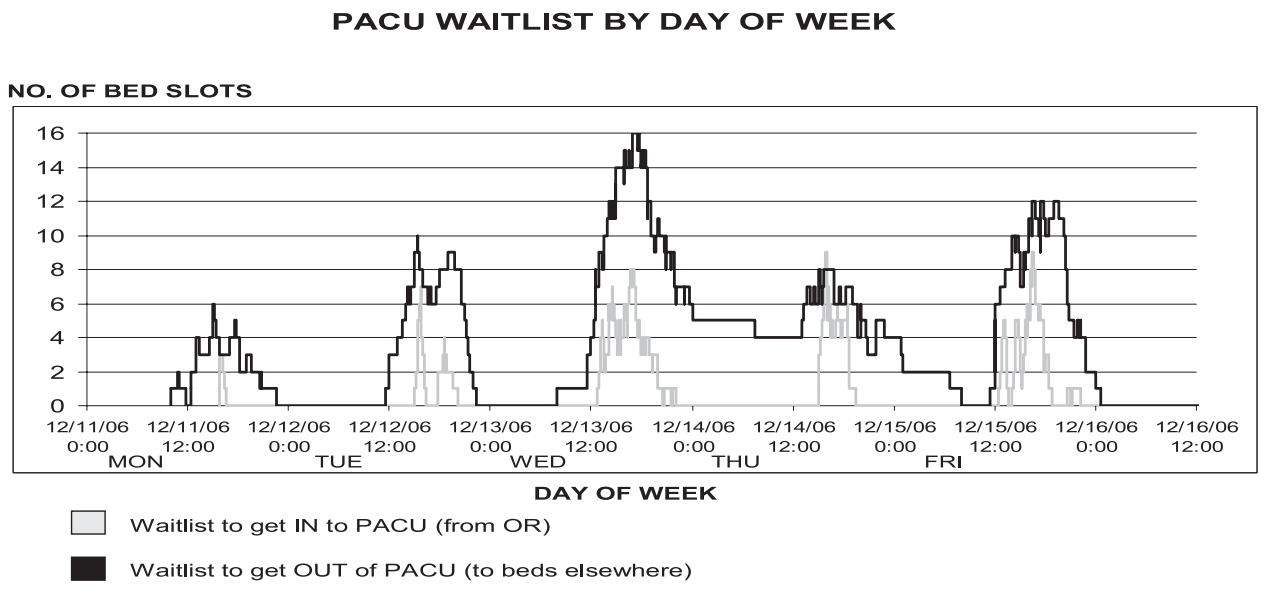
Workflow Analysis. The downstream workflow between the PACU and the other hospital floors was analyzed in order to identify issues that result in the formation of the OUT waitlist. The following three areas in the hospital were involved in the workflow for transferring patients out of the PACU—the PACU itself, Admitting Office and the other hospital floors.

It was found that lack of process discipline in updating the information technology systems at the downstream hospital floors resulted in inaccurate data on bed availability or expected discharges being displayed upstream at the IT systems in PACU. Therefore, manual coordination between PACU, Admitting Office and floors was required to overcome deficiencies arising from performing bed assignments/scheduling based on inaccurate data in the IT system. Manual coordination requires extra process steps as compared workflow performed on the integrated IT system. Such extra process steps caused patient delay that in turn caused holdups of PACU beds (buildup of OUT waitlist); thereby making upstream patients having completed surgery in the operating rooms to go on the IN waitlist. This reason for delay accounted for 99.6 percent of delayed patients at PACU.

The critical roles in the surgery patient flow process were identified. In the PACU these were:

- Operations Assistant who performs bed assignments at PACU and monitors the IN waitlist.
- PACU Charge Nurse, who liaisons with downstream Admitting Office and other hospital floors to perform manual bed assignments/scheduling and reduce buildup of OUT waitlist.
- PACU Registered Nurses who, once their patients start getting delayed, liaison with the PACU Charge Nurse, and also sometimes directly with the other hospital floors.

Fig. 1c: Wait list data from a previous study. (Data courtesy Tor Schoenmeyr, MIT Sloan.)



In other hospital areas the critical roles were OR Nurse and OR Desk for the operating rooms(OR) that are upstream and charge nurse and operations assistant for individual floors that are downstream as well as the admitting office.

SOCIAL NETWORK ANALYSIS

The goal of the social network analysis was to find a relationship between group interaction patterns in the PACU and workflow processes. A survey was conducted in the PACU to log the face-to-face, phone, page and email interactions that different roles have with each other during the course of their daily work. Respondents filled out survey sheets to report all interaction and also indicated whether they were feeling "Not Busy At All," "Somewhat Busy," "Really Busy" or "Maxed." The roles covered by the survey were the PACU Charge Nurse, Operations Assistant and PACU Registered Nurses. These are the critical roles identified earlier in the workflow analysis. All other roles had only clinical responsibility and did not affect workflow throughput. Only a representative sample of five PACU Registered Nurses was surveyed at any time, but they were sufficient to report interactions with all nurses in the PACU.

The survey was administered to capture the weekly cyclicality of PACU workflow over a period of two weeks between March 26 and April 6, 2007. Survey responses were collected over two successive 30-minute intervals during periods of OUT waitlist build-up identified earlier as the two time bands of 1 p.m. to 3 p.m. and 4 p.m. to 5:30 p.m. during the weekday.

A total of 2,258 interactions were logged among 119 actors. Survey results were analyzed using CONDOR, social network analysis software developed at the Massachusetts Institute of Technology (MIT). CONDOR depicts graphical plots for three computed variables that offer interpretation of the network dynamics.

Betweeness Centrality (BC). BC can be computed individually or for networks. For networks (Group BC) it is 1 in a star network where several peripheral nodes (persons) interact exclusively through one central node; and 0 in a fully connected network where all nodes communicate equally with one another. For individuals (individual BC), an example of high BC is the node (person) at the center of the star network while the nodes at the periphery have low BC.

Density. This is network specific and refers to the total number of interactions out of all possible interactions between all the nodes (persons) in the network. Therefore, high network Density is experienced during occurrence of high waitlist at the PACU when communication between the nurses increases.

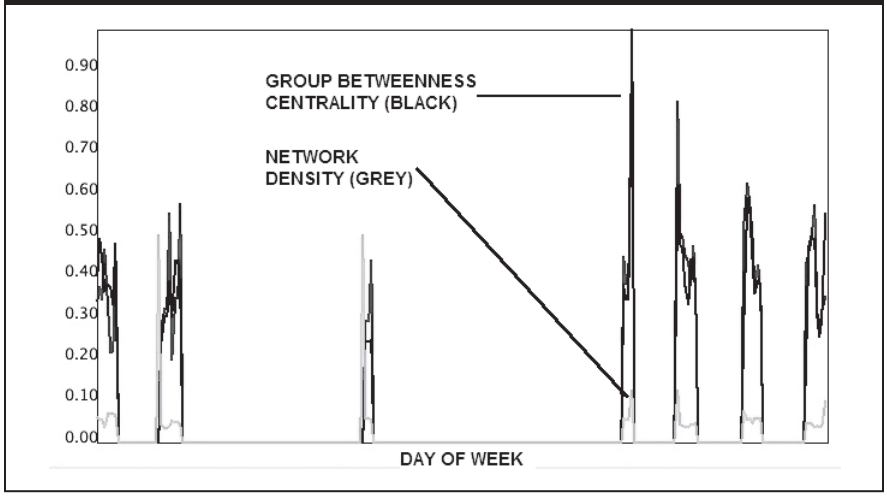
Degree. This is individual specific and refers to the total number of incoming interactions and outgoing interactions for any individual. An interaction occurs when a person is being talked to or communicated with on a one-to one basis. In any network, certain individuals will have higher degree than others.

RESULTS

The Group BC for the PACU social network showed a consistently high value during occurrence of the OUT waitlist. This means that there is a consistent cluster of highly central people in the network; like a star network with one or more central roles dominating communication with peripheral roles. This is typical of a hierarchical organization structure.

Furthermore, a time plot of the Group BC, Density and Degree reveals the evolution of the social network dynamics during periods of high OUT waitlist. (Fig. 2) Each spike represents one of the days for which the survey was conducted. The OUT waitlist

Fig. 2: Group BC and Network Density plot by day of week during study time period.



occurred only on the last four days of the seven plotted here (last four on right).

The following are observed: During occurrence of OUT waitlist, there is a sharp increase in Group BC (black) and a corresponding drop in network Density (gray). During occurrence of the OUT waitlist both the PACU Charge Nurse and Operations Assistant have high individual BC and also high individual Degree (both not shown in Fig. 2).

We found that during the occurrence of the OUT waitlist the PACU Charge Nurse and OA become more central (high individual BC) and interact increasingly with other roles (high individual Degree). Also the network Density drops indicating that the other roles interact less amongst each other (and more with the network central roles). However this does not preclude the possibility of other roles being central in the star network as well.

Further analysis revealed the names of seven PACU Registered Nurses that exhibit the same characteristic variation in individual BC and individual Degree. Therefore, these seven PACU Registered Nurses are also central in the star network structure within the PACU during occurrence of waitlist. The central nodes (PACU Charge Nurse and seven PACU Registered Nurses) serve as gateway points for the other PACU roles. The gateway points in turn interact with the Admitting Office and other hospital floors to perform manual bed assignments/scheduling in order to reduce build up of OUT waitlist.

Furthermore, the social network analysis also made it possible to identify external roles that link to the PACU during OUT waitlist formation. These external linkages form strongly when the PACU is stretched to capacity and nurses indicate times of feeling "Really Busy" or "Maxed." It was found that these roles were also critical from the workflow analysis presented earlier. They are the OR Room Nurses, OR Desk, Floor Charge Nurses, Floor Operations Assistants and Admitting Office.

This finding served as an indication that the social network pattern correlates with the underlying workflow processes. A test for correlation was performed between Group BC and Number of patients delayed per day (area under OUT waitlist curve in Figure 1) that provided the value for correlation coefficient as – 0.506 (R sq = 0.256, n = 15). This indicated an inverse relationship between the formation of a hierarchical network structure in the PACU and the magnitude of the OUT waitlist, therefore by the reasoning presented earlier, the duration of patient length of stay and patient delay times. On days when the social network structure for communication within the PACU is more hierarchical there is lower patient delay time. This happens when the PACU Charge Nurse and seven PACU Registered Nurses tightly channel all communication between PACU and other areas of hospital (i.e. become highly central in a star network).

Since this relationship is established it is inferred that re-designing social networks for improving communication is an important criterion for improving workflow process efficiency.

DISCUSSION

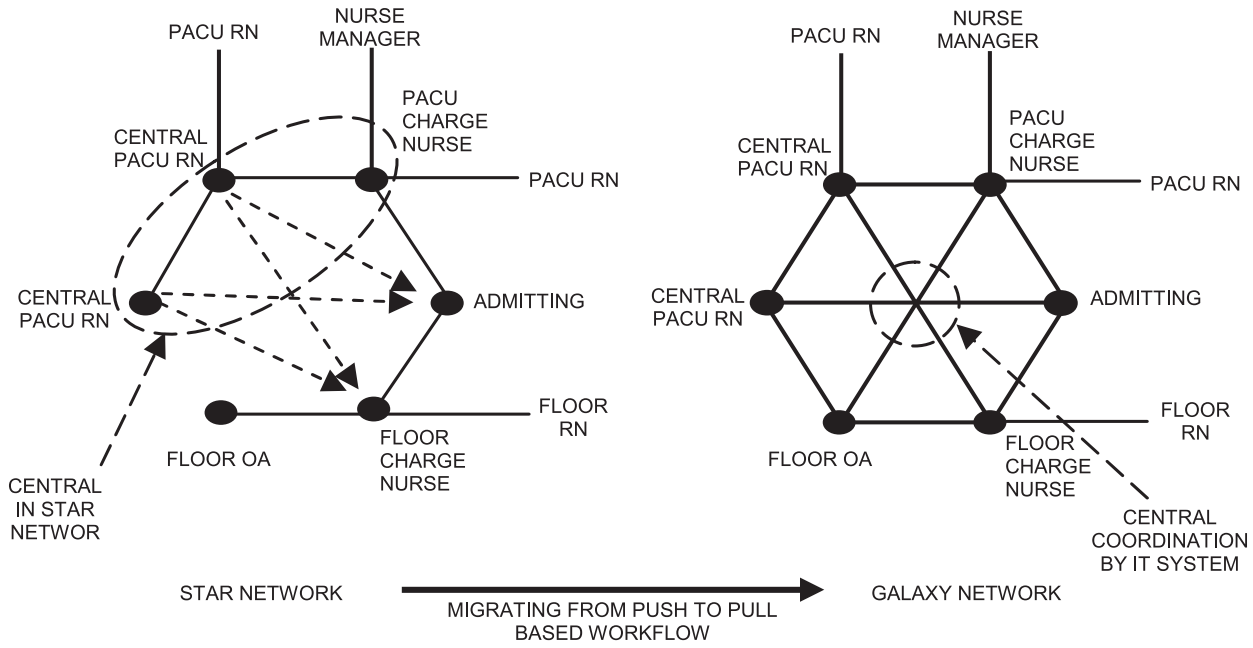
Since the causality between OUT and IN waitlist has been established, the ensuing discussion will focus on reduction of the OUT waitlist since this effect will ripple upstream and impact overall patient throughput.

The hierarchical management structure at PACU centralizes all manual coordination thereby preventing individual PACU Registered Nurses from interacting directly with roles in downstream areas of hospital. The result is lower patient delay due to elimination of redundant process steps and improved coordination. Manual coordination is necessary since there is inaccurate data on bed availability or expected discharges displayed on the IT systems at PACU. This owes to lack of process discipline at the downstream hospital floors for updating the integrated IT system with accurate data.

However, the social network analysis also indicates the central role (PACU Charge Nurse) getting stressed during times of occurrence of waitlist due to increased volume and frequency of interactions. This since all communication between PACU and other areas of hospital is channeled through this central role (both high individual BC and Degree). This is a bottleneck situation and is partially alleviated when the seven PACU Registered Nurses informally take on the role of the PACU Charge Nurse and start acting as parallel gateway points for communication with other areas of the hospital.

Identifying key knowledge experts, formalizing and re-defining their importance is a well-established social networking "best practice." Furthermore, an effective crisis prevention technique is to identify key coordinators in times of crisis and to increase their availability. The seven central PACU Registered Nurses identified through the social network analysis can be considered for such formal roles.

Fig. 3: Migrating from Star to Galaxy network structure with improved coordination performed on IT system.



Though this is a viable solution in the short run, it suffers from the inherent drawback of a lack of scalability. If the bed capacity of the PACU were to be increased, the number of key coordinators/knowledge experts will also have to be increased to handle the extra communication load. This cannot happen indefinitely, since there are inherent co-ordination and division of responsibility issues between the key coordinators/knowledge experts themselves. Only when the number of such network central roles is small are such issues manageable. Another factor is physical location; incase the PACU were spread over different areas of the hospital rather than at one location, the coordination between such network central roles will be impacted adversely.

Based on our analysis, the overall patient flow process should be improved by moving from the current star network structure to a galaxy network structure. (Fig. 3) The network diagram on the left hand side represents the existing star (hierarchical) network communication structure at PACU. The PACU Charge Nurse channels all communication downstream thereby becoming overloaded. During situations like this other PACU Registered Nurses become central in the star network by interacting informally with the other areas of hospital (depicted by dashed lines in the star network).

Migration to a galaxy network communication structure will entail reducing the dependence on network central roles to perform centralized coordination. This centralized coordination (high Group BC) was the key factor in reducing OUT waitlist therefore patient delay. The coordination can be better performed by the integrated IT system of the hospital provided the users follow process discipline in updating accurate information. Such process discipline is fostered by an environment of trust and information/knowledge sharing. Currently the users at the downstream floors of the hospital do not update correct bed availability or expected discharges data on the IT system thus necessitating manual coordination between PACU, Admitting Office and floors.

Furthermore, the transparency introduced through sharing of accurate information will result in converting the current patient "push" workflow to a patient "pull" workflow. Floors downstream would now pull patients from the PACU into available vacant beds by sharing accurate information on bed availability; thereby reducing unnecessary manual coordination initiated by the PACU to push patients downstream.

The galaxy network communication structure is depicted on the right hand side of Figure 3. The integrated IT system takes on the task of centralized coordination thus reducing dependence for the same on a hierarchical communication structure around the PACU Charge Nurse. Therefore a democratic communication pattern will result since all central PACU Registered Nurses will have equal access to bed availability information on the downstream floors. Such a communication structure is scalable since any number of additional nurses can be given access to the IT system that performs coordination irrespective of the number of users.

The above discussion points to a holistic methodology for reducing patient delay at the PACU. This methodology necessitates a common process oriented functioning of disparate hospital departments (PACU, hospital floors etc.) brought about by implementing common workflow processes over an integrated IT system. An environment for trust and sharing of information enables process discipline among users to update accurate information on the IT

system. This coordination approach among team members fosters a galaxy network type communication structure whereby information is available universally (democracy as opposed to hierarchy) yet coordination is centralized on the IT system backbone.

LIMITATIONS

The survey was limited to the PACU and a representative sample of five PACU Registered Nurses was administered out of a possible 24 at any given time. There may be other central PACU Registered Nurses in the star network who were not covered by the survey. The survey responses may suffer from a recall effect since the nurses' clinical duties took priority over entering survey responses. Also the short survey sampling time frame may be insufficient to capture complete network dynamics and there may be personality specific variations in communication patterns of the roles.

Furthermore, administering the survey in the other areas of the hospital may reveal new insights into the external linkages with the PACU network.

CONCLUSION

Given its limitations, this analysis demonstrates a linkage between social network patterns in the PACU and workflow process efficiency. Manual workflow processes at PACU necessitate a hierarchical communication structure that suffers from inherent bottlenecks causing build up of OUT waitlist thereby resulting in patient delay. This delay propagates upstream thereby causing schedule disruptions at the operating rooms and translating to financial loss. It was calculated that eliminating the minimum delay of 1.4 hours (Fig. 1) for all delayed patients in March, 2007 would increase patient throughput by 19 percent. This can only be attempted though the holistic methodology presented earlier that includes redesign of social networks, inculcation of process discipline and implementation of common workflow processes across departments.

A follow up study is currently under way wherein wearable social tags are being used to continuously log all interactions within the PACU. This is intended to corroborate these preliminary results and also form the basis of a future follow on study that tests the effects of reconfiguration of social network patterns.

Patient care processes in healthcare environments possess a sufficiently large element of human involvement and this will continue to be in the future. This is not the case with some other industries where processes can be completely automated. Therefore, the design and performance of social networks is an important factor in improving process efficiencies within hospital organizations. Workflow redesign and implementation over an integrated IT backbone has to complement social network design in order to achieve an efficient integrated healthcare delivery system. **JHIM**

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