

**A STATISTICAL QUALITY CONTROL TECHNIQUE
FOR ASSURING JUST-IN-TIME PATIENT FLOW IN AN
OUTPATIENT SURGICAL SETTING: A CONCEPTUAL APPROACH**

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ABSTRACT

This study focuses on a sub-system process in an outpatient surgical clinic within a tertiary care hospital complex. Since the surgical staff provides services to the patients on a continuous yet sequential basis, just-in-time patient flow could significantly enhance not only the productivity of the process, but also the quality of patient care. When patient arrival times are out-of-kilter or not just-in-time, the entire surgical schedule can be thrown off balance. The objective of this paper is to develop a quality assurance mechanism to achieve just-in-time patient flow and better utilization of resources. The methodology of the study makes use of a Statistical Process Control (SPC) Chart, called the \bar{c} -bar chart, which is designed for countable or enumerable data. The study provides a conceptual framework for the use of SPC techniques as modeling methods in quality assurance and continuous improvement in a healthcare sub-system wherein the patient is the final product and the consumer of the product as well.

INTRODUCTION

In modern manufacturing systems, there are many sub-systems, which are highly dependent on quality control and assurance in a quest for optimality. Similarly, within a hospital system there are many sub-systems that have objectives such as the reduction of “defects” or the improvement of quality in that sub-system’s processes. With this goal of quality improvement in mind, we might study the sub-system processes in a tertiary hospital with outpatient clinics for several professional specialties such as pediatrics, obstetrics and gynecology, orthopedics, podiatry, gastroenterology, and surgery. Accordingly, a process may be thought of as a set of operations that repeatedly link together in a series of steps that transform inputs into outputs or outcomes. A hospital sub-system is an organized unit with a specific purpose, customer(s)/patient(s), technologies and professional practitioners who work directly with these customers/patients through processes that bring about successful outcomes.

Just as in manufacturing, processes in a healthcare sub-system are normally a part of a larger healthcare organization or system necessarily implying that the larger system is rooted in a legal, financial, and regulatory environment. In a manufacturing system, the inputs are raw materials (non-human) that go through a conveyance system and in the process are transformed into finished products. In a healthcare system, the people are the inputs and outputs! Donabedian (1980) refers to a healthcare delivery system as the “process of care” that does not reflect quality until the desired patient outcomes are established, perhaps more appropriately in a healthcare environment “just right” patient care. In a perfect world, a functional system would entail defect-free processes consisting of participants who know and understand their level of performance, how they can improve the quality of the product, barriers they encounter and how they deal with them, all of which requires the presence of an adequate feedback and quality assurance system. These concepts provide a general framework for developing a quality assurance system in the health care environment.

PROBLEM AND CONTEXT

The problem and context for this study is based upon the following account. At a hospital’s outpatient surgical clinic (which shall remain nameless), patient flow was affecting a patient’s progression through

the process (from preoperative nurse activities, to the anesthesia team, to operating room aids and finally to the scrub nurses and surgeon). There was general agreement that medical processes (operating room procedures) from the patient's perspective were achieving excellent outcomes. However, because patient's arrival times were out-of-kilter or not just-in-time, the entire surgical schedule was thrown off balance. The nurse manager was fully aware that managing patient flow through the facility was critical to the surgical clinic's operations. The manager also understood that patient flow with varying degrees of consistency can have consequences such as longer patient wait times, staff discontent, compromised patient safety and lost revenue. To diagnose and determine the deficiencies of this process, the nurse manager emphasized to the surgical clinic's staff that quality control and improvement was dependent on the process and the coordination of activities. The manager also tried to convey to staff members that providing timely patient care required awareness of each member's stress loads and resource constraints. In one particular staff meeting, the manager remarked that "it was imperative for the staff to foster collaboration and break down any barriers;" and, that it was "also important for the manager to ensure that the staff was empowered to the degree possible to achieve continuous improvement in quality-of-care".

As a starting point, the manager utilized two tools: a deployment flowchart and a lead time analysis to document and identify weaknesses in the process and rectify inefficiencies. The manager found that the deployment flowchart revealed that pre-op nurse activities delayed other activities and interactions in the surgical process. These findings prompted the nurse manager to conduct a lead time analysis, which revealed that patients were spending fifteen minutes or more finding their way to pre-op. In addition, the nurse manager utilized results from a root cause analysis conducted by another manager in an outpatient services clinic within the hospital complex. This analysis revealed that originally the clinic's location and design was chosen because it was close to a public entrance with automobile access. Even though well intended, the result brought confusion in connection with parking locations. In addition, because other patients and staff frequently used the same hospital entrance for various activities, many patients lost their way and as a result arrived late for surgery pre-op registration.

Armed with these data, the nurse manager implemented a system such that each patient was given a registration packet from his/her surgeon's office one week prior to surgery. Staffs from pre-op services were to contact the patients one or two days before surgery to assure their understanding of the process, surgical procedures, transportation assistance, and the need to be prompt. This included a post-op evaluation in which patients were asked specific questions about the process. After these changes were introduced, the manager sought to examine the new data collection in order to isolate any assignable variation in the process due to late arrivals. The nurse manager felt that tracking and comparing performance over time would help bring the process back into control so that just-in-time patient flow met specified standards of quality assurance. It is in this context that this study proposes a statistical process chart (SPC) method as a way of displaying performance data so as to identify the performance variation (late patient arrivals) of the process over time.

THE LITERATURE AND QUALITY CONTROL IN HEALTHCARE DELIVERY

Over the past several decades, the literature on a systems approach to management has grown immensely with contributions pertaining to both the healthcare and manufacturing sectors. Some of these are briefly discussed below. Such a review will aid in understanding some of the differences in the processes of the two sectors. The research revealed in the literature will also explore some fundamental ideas pertaining to complex, dynamic systems and reasons for their unpredictability as a theoretical proposition. In terms of cause that leads to effect, the implications of variation about predicted values results from as yet unexplained causal factors (non-random or assigned variation). As more is understood about unexplained

random variation, defects (just-in-time) or less than desirable patient flow will diminish. This contention is compatible with that found here and throughout the literature.

The systems approach to management has helped the healthcare sector synthesize new knowledge and theories. But, it doesn't tell managers exactly what the significant elements of their organization are; instead, it tells them that their organization consists of many sub-systems and is an open system that interacts with its external environment. Not recognized in the systems approach are the specific variables that affect management functions. Furthermore, it specifically does not single out what in the environment affects management and how both the internal and external environments influence the overall performance of their organization. In combination with the contingency approach, the identification of relevant performance variables and their impact on organizational effectiveness has helped to logically extend systems theory. Since organizations are contrived, human-engineered systems, there are internal variables that are principally the result of the decisions made management itself. However, this does not mean that all internal variables are under the control of management. Nonetheless, there are key internal variables that management must consider, including objectives, structure, tasks, technology and people and the interrelationships among them, in improving the performance of the organization (Mescon, Albert and Khedouri, 1985).

The Committee on Quality of Care in America (2001) reported its confidence that Americans could have a healthcare system that provides the quality they need, expect and deserve. Yet, the Committee also stated their awareness that a higher level of quality could not be achieved by further stressing current systems of care. The current care systems cannot do the job, they say. Attempting to achieve a higher level of care by doing the same things over and over will not accomplish the changes and improvement in systems needed to bring about better outcomes. In its wisdom and in an effort to contrast healthcare systems, the committee speaks to the idea of complex biological species (for example, human beings) evolved through evolutionary processes such as genetic mutation, and random variation. In complex biological species, they contend, changes that are useful to survival tend to persist. In a parallel manner, the report illustrated and pointed out that human beings rely on two processes in order to evolve: (1) processes that generate variation and (2) processes that "prune" the resulting evolutionary tree. As such, the Committee translated this insight to the task of designing the 21st-century health care system(s) as a means of combining the many systems that generate and test ideas with avenues for enhancing the spread of "good" ideas and impede the spread of "not so good" ideas According to the Committee's report, these concepts of evolutionary design are innately contributing to the rapid-cycle improvement methods currently being widely utilized in healthcare. Of course, healthcare cannot claim exclusivity to the ideas of evolutionary design, since private sector manufacturing firms have also utilized these ideas for years. But, like manufacturing organizations, healthcare institutions are also complex systems. Their complexity is often less obvious than in the manufacturing and high technology service systems. For instance, healthcare institutions are frequently developed as models for their effectiveness in safety and delivery of "defect-free" patient care because of the nature of their services. In manufacturing and high technology service processes, performance standards and quality control are important for the long-term survival of a company because of the global competitive environment. Although healthcare systems emphasize a people orientation, they can gain valuable insights from manufacturing and high technology services. In a similar tone, O'Neill (2007) argues that solutions can be found in proven strategies designed for improving complex systems. He says that Toyota is a leading example of highest quality/lowest cost manufacturing and has demonstrated the capacity of quality management principles for a number of years. O'Neill (2006) says that he adopted them at Alcoa. He goes on to say when applied in the right way, these tools drive an elementary reorganizing and generalization of work processes, rather than transitory improvements toward perfection. For healthcare, these concepts have compelling applications says O'Neill (2007). His reasoning is simple since improving work processes would let doctors and

nurses do something about the frustrating things that are keeping them away from their patients. In essence, it would allow them the opportunity to get back to delivering quality care to patients. When participants are left to do their jobs and design and implement the solutions, it prevents medication errors before they occur, O'Neill (2006) insists. It is the power of utilizing the quality management principles approach that pushes forward perfection in systems. But, he admits best practices in health care settings are somewhat daunting (<http://rand.org/publications/randreview/issues/summer2006/perspect.html>).

Healthcare organizations are striving to improve patient care and the minimization of “defects” that affect quality assurance (just as manufacturing companies do with customer service). The Joint Committee on Accreditation of Healthcare Organizations (JCAHO), for example, has published a leadership standard (LD.3.15) to manage patient flow and prevent overcrowding. It centers on the importance of identifying and justifying impediments and levels of stress to efficient patient flow throughout a healthcare organization (www.jointcommission.org). JCAHO's demand for performance improvement has driven health care organizations to gain as much knowledge as possible about continuous quality improvement. In fact, over the past two decades, these institutions have undertaken initiatives such as: teams and facilitators with training on problem solving, which has seen wider utilization of statistical tools and standardized problem-solving procedures; data collection, including patient, physician and employee surveys; process management using clinical algorithms and practice instructions with training on conduit development; and planning using balanced scorecards and performance measurements (Méndez, 1999). With continuous quality improvement often delegated to levels below senior management, organizations have struggled to integrate and justify their many initiatives. The Baldrige National Quality Program (BNQP) Healthcare Criteria for Performance Excellence assists managers in choosing performance indicators utilizing a systematic approach including a vehicle for initiating continuous discussions with regard to organizational performance. The BNQP model provides the most current structure for organizational effectiveness. Thus, healthcare organizations have to be aware of the unique attributes in patient care delivery processes and procedures. If not, the processes may create an environment more prone to “defects” (Kelly, 2007). In this regard, Stacey (1993) in Rosenhead (2001) maintains that “extraordinary management” is the prescription if the organization is to be able to transform itself in situations of indefinite change and systems' adaptability within the organization. Here rational-based forms of decision making are largely broken, he maintains, since these require as their starting point precisely those “givens” which must now be disputed. Again and according to Stacey (1993) as revealed in Rosenhead (2001), the innovation is the concept of “extraordinary management”.

Extraordinary management requires the activation of the implied knowledge and creativity available within the organization. This necessitates the encouragement of informal structures, for example, that are centered round particular issues and/or processes. Formation of informal structures should be essentially spontaneous, provoked by contradictions, variance and conflicts originating in the process of normal management. They need to be self-organizing and adaptive, capable of redefining or extending their efforts rather than being constrained by fixed terms of reference, which would have the effect of sub-optimality (Rosenhead, 2001). Obviously, in a healthcare setting there must be a focus on understanding team or staff performance and the maximization of that performance as a basis for measurement. For example, Headrick et al. (1998) points to the increasing numbers of professionals directly involved in healthcare delivery processes and the significance of cooperative functioning relationships and the delivery of patient care. As mentioned previously, patients are not only the consumers or recipients of health care services. They are also the raw materials used in the “process,” as in the manufacturing or the construction industries. Unlike the raw material inputs or final products in entertainment, energy or electronics industries, patients are not standardized commodities in the sense that their characteristics are highly heterogeneous. That is, they may be ill, injured, old, or very young. No two patients are alike, and indeed, there may be many differences between one patient and the next. These differences make them much less able to participate in their “consumption of care” and more susceptible to being seriously damaged or injured through mistakes or medical errors. Even when patients are receiving safe and

appropriate care, some may have underlying physical conditions that may make the care hopeless. Such outcomes are not the same as adverse events, which are the corollary of improper and risky care. This also points to the increased emphasis on the consumer/patient in healthcare.

In addition and according to Headrick et al. (1998) the variety of interactions by healthcare professionals that range from coordinated collaborative relationships at one end of the continuum to more tightly organized work teams at the other, often within the same time interval, makes the team concept a preferred method of delivery. Schaefer et al. (1994) have noted that 70 to 80 percent of health care mistakes caused by human factors tend to be associated with interpersonal interactions (Page 2004). Also, Page (2004) cites the issue of wide variation in team makeup, which ranges from those composed of senior clinicians overseeing residents to those involving representatives of multiple professions from various organizations. Clearly and concurrent with these and other researchers, differences exist from a situational standpoint especially when team makeup is motivated by hierarchical learning and/or accountability systems as opposed to those in which team members have equal sway on team performance and results. Again, Page (2004) summarizes what Hambrick and D'Aveni (1992) report by concluding that difficulties also arise when determining whether the failure of a team's performance is the cause or the result of a single team member's behavior. Researched by Hambrick and D'Aveni (1992) and reported by Page (2004) is the indication that deteriorating team performance is a back-and-forth pattern developed between member performance and overall team performance as top management teams began to fail. In addition, the mode of health care delivery is different from usual private sector transactions. Hambrick and D'Aveni, (1992) in Page (2004) continue by stressing the processes, products and services of other private sector industries are usually delivered in a more impersonal "few-to-many" manner. Because of this, not many individuals are involved in communicating the service to many others, perhaps many times in a mass market. Page (2004) also discusses Hambrick and D'Aveni, (1992) explanation that health care delivery is largely "one-to-one" or "few-to-one" communication. As such, health care delivery is very personal requiring face-to-face contact with a detailed orientation, which must be embedded within effective and efficient processes. As a result, characteristics and attributes of healthcare professionals are likely to contribute more to service delivery (operational processes) and (clinical/medical processes) than in the manufacturing sector. Whether or not the health care professional chooses to go the extra mile is likely to have a far greater impact in health care than elsewhere.

Healthcare delivery also has to contend with inexact scientific knowledge and incomplete patient information in a quickly changing world with rapidly shifting population demographics. Developing cultural competence is a growing problem because without it healthcare professionals cannot understand how to communicate with and effectively interact with people across cultures. Consequently, developing a culturally competent approach to healthcare systems requires a patient-centered approach. According to Clarke and DeGannes (2008), cultural competence includes four mechanisms: awareness of one's own cultural worldview; attitude toward cultural differences; knowledge of different cultural practices and worldviews; and cross-cultural skills. These authors contend that the main idea behind the patient/provider encounter is to obtain information and educate the patient for the creation of a treatment plan that suits the patient's cultural values and expectations, which will likely lead to less variation and a more optimal system(s). Differences in patients' and providers' verbal and nonverbal communication styles are different and expectations of the patient/provider relationship and understandings of illness and treatment may present barriers to achieving the objective and can contribute to sub-optimal system(s) and health outcomes. There is a high degree of uncertainty and there is no room for mistakes (variation). When acquiring medical knowledge, both healthcare delivery professionals and their patients have to face the reality that any acquired medical knowledge is not complete. Accidents and mistakes in economic sectors other than healthcare are usually newsworthy and have good investigative potential with widely disseminated consequences. In contrast and with few exceptions, accidents and mistakes in healthcare

tend to be investigated quietly with a local perspective. Even today, findings are not shared widely for public consumption and scrutiny. Since there are many variables and various sources of variation including people, materials, machines, methods, measurement and environment, we can collect data over time from these sources to study the behavior and development of the processes. Yeung and MacLeod (2004) rely on modern quality-management experts such as Deming (1982), and assert that variation can originate from random causes (common causes) and assignable non-random causes (special causes). According to Deming (1982), random causes are inherent in every process. Since random variation is a physical attribute of the process, the only way to reduce it is to design a new process that exhibits a new level of random variation. Assignable variation, on the other hand, is attributable to causes that somehow found their way into the process and could be identified.

In addition, Yeung and MacLeod (2004) say that (according to Deming, 1982) if there is only common or random cause variation in the process, then the process is said to be “in control” or steady toward an optimal outcome. Alternatively, if variation due to assignable causes is identified, then it said to be “out of control” or unsteady toward a sub-optimal outcome. The level of random variation is a physical attribute of a process. Separating the random from assignable variation, requires the use of Statistical Process Control Charts (SPC), which can be utilized to reveal control limits, runs, trends and other patterns of longitudinal data. As Deming (1982) pointed out, variation in a process is ubiquitous and further, the variation caused by random causes can be predicted within statistical limits or boundaries. Therefore, in order to reduce random variation it is necessary to find a new process with a new level of random variation, which is superior to the original process. In most cases, the new process is a modification of the previous process. Of course, management may also design a completely new process. This perhaps can be accomplished in a trial with a small test group. After this step, management would study the results attempting to answer the question: does the new process have a level of performance and/or random variation that is superior to that displayed by the old process? Lastly, management would act by applying the analyzed alternative, and then may modify it, try again, or perhaps discard it (Mundorff, 2007). These process modifications are best thought of in terms of the Deming (1982) or Shewhart PDSA cycle, which is based on the scientific method (Kelly et al. 1997). However, Gawande (2002) and Rosenhead (2001) view the scientific method as imperfect, since it involves a venture in acquiring knowledge that is tentative with imperfect healthcare professionals who have a responsibility for saving and preserving life.

Gawande (2002) also alludes to the gap between what we know and what we aim for, as a basis for complicating everything in health care delivery. Accordingly, this tends to affect both operational/patient flow processes and clinical/medical processes and thus effectiveness and quality assurance. The assumption is that you are supposed to get rid of a problem they give you and not create another one reports O’Neill (2002), which is actually defeating the purpose of adaptability and perfection in the system(s). Such an approach would also add to the cost, a cost without value, suggesting a sub-optimal system. In a similar manner, O’Neil (2002) contends that we can look at benchmarking, which he says is not the best method to track systems at least in terms of improving the process. If you benchmark you hold up a standard, which may be less than what may otherwise be an optimal system. In striving to attain perfection and improvement in systems and conditions and outcomes, benchmarking may create sub-optimal systems. With this proposition, O’Neill (2002) declares that if you look at what’s happening in American medical care today, a nurse spends 50 percent of his/her time doing non-value added work. Nurses are racing around doing things that have to be done because the design of the system is flawed. In other words, the hospital outpatient surgical clinic would not be well served by such disorganization under any conceivable circumstances (<https://www.carlsonschool.umn.edu/Page5382.aspx>).

QUANTITATIVE METHODOLOGY

In order to monitor and continuously improve the quality of processes, a statistical process chart (SPC) is utilized. Specifically, a control chart is a time-ordered sequence of data, revealing a center-line (or the

measure of central tendency, mean) of a process variable and the upper and lower limits for that variable. It also serves as a tool in tracking variations in the process variable. As a quantitative exercise, constructing control charts involves collecting data from several same-size samples and obtaining estimates of the center-line and the lower and upper control limits. There are three different types of charts used in industry (Dondeti, 2005) based on three different types of variables: (1) variables measured on continuous scales (such as length, weight, volume, etc.), (2) variables built on the dichotomy of attributes, and (3) variables based on simple counting (Dondeti, 2005). Variables based on simple counting arise frequently in manufacturing. Consider a workshop where the manager might ask “how many machines are down today?” The reply to such a question would entail a simple counting of those machines that have broken down (Dondeti, 2005). Similarly, in a population of patients scheduled for outpatient surgery there may be late arrivals (defects), which could cause delays in the process. If the number of defects (number of late arrivals for outpatient surgery) exceeds a specific limit, then depending upon the causes (common or special causes) the process itself may be considered out-of-control and may require greater scrutiny as to what action(s) might be necessary. Whether it is in a manufacturing context or healthcare setting, the focus of quality control/assurance efforts will be on the number of defects in the process. Of course, in healthcare the idea of “defects” concerns the human element. These “defects” or late arrivals affect the entire process of continuous improvement.

It is clear that in the context of late patient arrivals, we are dealing with a variable whose value is based on simple counting. For this variable, the \bar{c} -bar chart is the more appropriate control chart, which is useful for countable or enumerable data. It permits the observation of the process and the detection of the variation in the process over time (Yeung and MacLeod, 2004). Here, the observable data is time-ordered and sequenced. It should also be noted that the number of patients scheduled (i.e., customer arrivals in the parlance of Queuing Theory) per eight hour day involves a discrete variable over a fixed interval of time and thus follows a Poisson distribution. The assumption of Poisson arrival rates is commonly used in simulation models (Stevenson and Ozgur, 2007). More specifically, the probability distribution involves a discrete random variable representing the number of events occurring during a fixed time period with a known average rate. If the arrival rate is Poisson, the average time between the arrivals follows a negative exponential distribution (Stevenson and Ozgur, 2007).

In the \bar{c} -bar chart, the interest lies in the number of non-conforming units (late patient arrivals). The number of non-conforming units would be plotted on the y-axis and the number of days on the x-axis. Suppose the clinic operates five days per week, eight hours per day; the nurse manager may be interested in determining the total number of late patient arrivals (defects) or the number of non-conforming units per day. The appropriate statistical technique is described in Dondeti (2005). In general, c denotes the number of defects observed in the process on a given day; and, K the number of days for which the data is collected. The formulation is shown below:

Step 1- Find the mean number of defects (number of late patient arrivals) \bar{c} for a predetermined number of days K (generally, K should be 30 days or more):

$$\bar{c} = (c_1 + c_2 + \dots + c_k) / K$$

Step 2- Calculate the upper and lower control limits for c as follows:

$$s = \sqrt{\bar{c}}, \text{ UCL}(c) = \bar{c} + 3s, \text{ LCL}(c) = \bar{c} - 3s, \text{ or}$$

$$\text{UCL}(c) = \bar{c} + 3\sqrt{\bar{c}}, \text{ LCL}(c) = \bar{c} - 3\sqrt{\bar{c}}$$

Where:

$$c = \text{number of late patient arrivals in a day}$$

\bar{c} = mean

K = number of days for which data is collected

s = standard deviation of c

As an illustration, suppose that Table 1 below shows the data collected by the manager of an outpatient surgical facility. The first row is the day number and the second row is the number of late patient arrivals on a day. In this case, $K = 30$.

Table 1 -- Simulated Sample Data for a C-bar Control Chart

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
No. of Late Arrivals	4	6	3	5	4	3	6	9	2	5	3	6	3	5	4	2	1	5	4	3	5	2	4	3	2	3	4	3	5	2

For the data in the table, $K = 30$

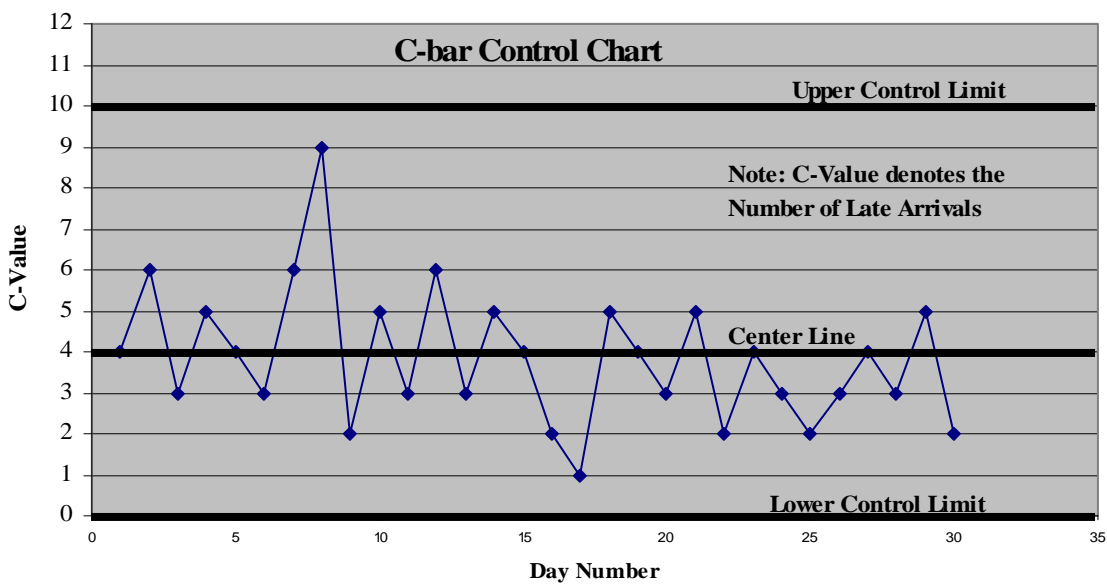
$$\bar{c} = (4 + 6 + 3 + 5 + 4 + 3 + 6 + 9 + 2 + 5 + 3 + 6 + 3 + 5 + 4 + 2 + 1 + 5 + 4 + 3 + 5 + 2 + 4 + 3 + 2 + 3 + 4 + 3 + 5 + 2) / 30 = 3.867$$

$$s = \sqrt{\bar{c}} = \sqrt{3.867} = 1.966$$

$$UCL(c) = \bar{c} + 3s = 3.867 + 3 * 1.966 = 9.765,$$

$$LCL(c) = \bar{c} - 3s = 3.867 - 3 * 1.966 = -2.031 \cong 0.00$$

Because c can never be negative, if the calculated value, LCL is negative, the LCL must be set equal *zero*. The control chart is given below.



Of course, once the c-chart is constructed, the process variation can be monitored by plotting the daily values of *c*. If any *c* value falls outside the upper control limit, the reasons for it must be carefully investigated. Suppose that one day the *C* value was 12, value that is outside the control limits. But, if that happened because of a snow storm, there is nothing anyone can do about it. On the other hand, if several patients said that they were held up at the front desk, then something needs to be done. In other words, look for assignable causes that can be corrected. In this case, somebody may say that the Upper Control Limit of 9.765 is rather high. If this is the case, the system would have to be designed by making several improvements. As such, the Upper and Lower Control Limits must be recalculated so that the system would be more optimal.

CONCLUSIONS

This study provides a conceptual framework for demonstrating the use of control charts as a management tool for internal performance measures. Specifically, a *c*-bar chart based on countable or enumerable data is utilized to determine the variation in processes and to monitor quality assurance, principally as a method for monitoring the just-in-time patient flow. Moreover, the performance of the patient flow process is captured in the statistical technique. Operationally, it is shown that the *c*-bar chart may allow a manager to isolate any assignable variation in the process variable. Although burdened with many variables, this system allows the manager to track and compare performance over time and bring the process back into control and meet specified standards of quality assurance. It may also demonstrate a need for creative efforts in the development of a theoretical framework, especially if it supplements and contributes to similar conceptual analyses found in healthcare literature.

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