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A Comparative Study of the Use of Statistical Process Control in Monitoring Health Care Delivery

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ABSTRACT: To control and improve on the quality of products and services is an important business strategy. Hence, the yearnings for quality services in all sector is not just a call from the consumers, clients or patients but an act to maintain the integrity of the manufacturer or service providers. In this research, the importance of statistical process control to health care delivery is being re-iterated with application to a real data set. The p-chart is being used and results compared with other results/findings in the literature.

KEYWORDS: Health, Patients, P-chart, Quality, Services, Statistical Process Control.

1 INTRODUCTION

In the United States, the health care industry is now one of the largest industries employing over 13 million workers with a projected increase of over 3 million new jobs by the year 2014 [15]. Reverse is probably the case in Nigeria where the unsustainable downward trend in the health sector is worrisome both to the government and to the populace.

In Nigeria for example, the reasons for the deterioration in health care services in our own view can be attributed to two things. On the part of the government, it turns out to be that the only language the Nigeria government understands is strike action in order to listen to the demands from sectors; the incessant strike actions by the Doctors is a valid proof. Hence, patients are naturally forced to leave government owned hospitals (though, well equipped) to seek for treatments "elsewhere". On the part of the health workers, the waiting time for a patient to get just his/her file from the record office is worrisome especially in General Hospitals. Our government and health institutions can simply embrace technology and employ the use of statistical quality control to monitor this; bearing in mind that it is not only the first impression that lasts longer, the last impression lasts too. We have observed that when a patient experiences a moment of mystery due to lack of professionalism or poor services on the part of the health workers, he/she losses confidence and trust and thereby may want to seek for better services elsewhere. Hence, there is a need to continuously monitor and improve the delivery of health care services.

Statistical quality control is a technology widely used in manufacturing to improve quality of products and productivity of workers [6]. It was developed in 1924 by W. A. Shewhart. The Statistical Process Control (SPC) is a collection of tools designed so that we can continuously improve process performance and reduce variability. The SPC in its inception was used in manufacturing industries but in recent times, it is being increasingly applied to service industries including health care. Examples of notable application of SPC to health care with the aid of control charts include that of [7], [8], [9], [10], [12], [17] among others.

There are different control charts as available in the literatures, see [5], [14] and [4]. [9] also provided cases where the four commonly used control charts; c-chart, p-chart, u-chart and xmr-charts (also known as the individual charts) can be used in health care with detailed examples.

Selecting the appropriate control chart to be used is grossly dependent on the type of data set at hand. A report by [2] gave an example of a misuse of control charts in health care where an author used the c-chart where c-chart is not actually appropriate to analyze a given data set (though, the correct control chart to be used was not stated). The report further mentioned that the p-chart may probably not be applicable because of a condition not satisfied. Whilst still giving credit to [8] who analyzed the data by calculating the hazard ratio and treating the hazard ratio data as continuous data before plotting an xmr chart based on the median (not mean) control limits. The same data set shall be used in this article using the p-chart to know the exact conclusion we can arrive at in comparison to that of [1], [2] and [8].

2 The p-chart

The p-chart is an attribute control chart; hence, it is basically used to monitor the variation inherent in a discrete attribute data set. It plots the proportion of nonconforming units in a sample in which the sample sizes must necessarily not be the same for the data set. The attribute/characteristic of the data must be dichotomous in nature and it is usually described in the form of good/bad, dead/alive, defective/non-defective, e.t.c.

The data set used by [1] and [8] as data of surgeon specific mortality rates following colorectal cancer surgery shall be used in this article. The data provides the number of colorectal cancer surgery cases attended to by thirteen different surgeons and the number of deaths recorded. The summary of the data is provided in Table 1.

Table 1: Surgeon specific mortality rates following colorectal cancer surgery (Source: [8])

Surgeon	Number of Cases	Number of deaths
A	98	16
B	66	8
C	58	9
D	52	7
E	52	15
F	46	5
G	38	3
H	37	11
I	36	5
J	34	7
K	32	4
L	21	2
M	21	3

The aim is to verify whether variation in the mortality across the surgeons is consistent with common cause of variation. We shall make use of the proportion of deaths recorded per surgeon. Following Mohammed [9], the procedure for plotting the p-chart is given below;

Let Number of cases represent n_i
Number of deaths represent x_i

The Centre Line (CL) is given by;

$$\bar{p} = \frac{\sum_{i=1}^{n} x_i}{\sum_{i=1}^{n} n_i} \tag{1}$$

$$= \frac{95}{591} \cong 0.16$$

The Lower Control Limit (LCL) is calculated by;

$$LCL = \bar{p} - 3\sqrt{\frac{\bar{p}\left(1-\bar{p}\right)}{n_i}} \qquad (2)$$

The Upper Control Limit (UCL) is calculated by;

$$UCL = \bar{p} + 3\sqrt{\frac{\bar{p}\left(1-\bar{p}\right)}{n_i}} \qquad (3)$$

According to [4], a set of decision rule was suggested in [13] that a process is out of control if either

1. One point plots outside the three-sigma control limits.
2. Two out of three consecutive points plot beyond the two-sigma warning limits.
3. Four out of five consecutive points plot at a distance of one-sigma or beyond from the center line.
4. Eight consecutive points plot on one side of the center line.

The result for the data in Table 1 is given below;

Table 2: Table of Result

Surgeon	**Number of Cases (n_i)**	**Number of Death (x_i)**	**Proportion of Deaths (x/n)**	**LCL**	**CL**	**UCL**
A	98	16	0.16	0.15	0.16	0.17
B	66	8	0.12	0.14	0.16	0.18
C	58	9	0.16	0.14	0.16	0.18
D	52	7	0.14	0.14	0.16	0.18
E	52	15	0.29	0.14	0.16	0.18
F	46	5	0.11	0.14	0.16	0.18
G	38	3	0.08	0.13	0.16	0.19
H	37	11	0.30	0.13	0.16	0.19
I	36	5	0.14	0.13	0.16	0.19
J	34	7	0.21	0.13	0.16	0.19
K	32	4	0.13	0.13	0.16	0.19
L	21	2	0.10	0.11	0.16	0.21
M	21	3	0.14	0.11	0.16	0.21

The corresponding p-chart is as shown below;

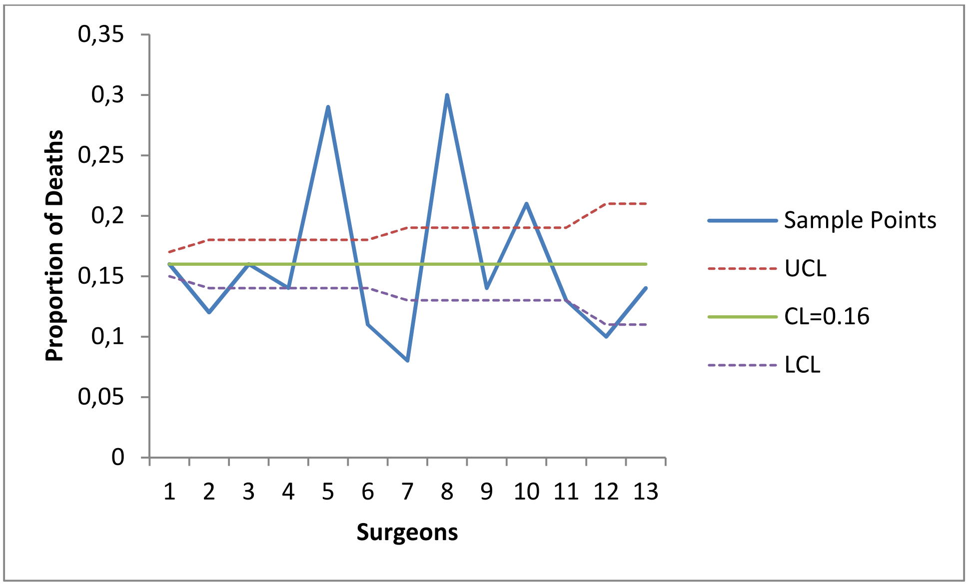

Fig. 1: P-Chart for the Surgery Mortality Rate

The control chart in Figure 1 shows that there are sample points that fall outside the control limits which indicate that the process is out of control. Hence, investigations and corrective actions are required to find and eliminate the assignable cause or causes responsible for this behavior. It is also good to note that the control limits; LCL and UCL are not given in straight lines (as shown in Figure 1), this is as a result of the differences in the samples sizes (as shown in Table 2).

2.1 Limitations Of The Result Provided

1. According to [11], the approximation used above is good as long as $n_i \bar{p}\left(1-\bar{p}\right)>5$ and $0.1 \leq \bar{p} \leq 0.9$. The first condition is not fully satisfied by the data used, in that, from Surgeons A to H, $n_i \bar{p}\left(1-\bar{p}\right)<5$ while from Surgeons I to M, $n_i \bar{p}\left(1-\bar{p}\right)<5$.
2. Based on the arguments of [2], using p-chart, we might be violating the third assumption given by [5] that "Let 'p' be the probability that an item has the attribute; 'p' must be same for all 'n' items in a sample (e.g., the probability of a participant meeting or not meeting the requirements is the same for all participants)

3 Conclusion

The p-chart in Fig. 1 shows that the process is out of control and there is a presence of assignable causes of variations in which efforts must be made by the hospital or health institution to know the causes and eliminate as appropriate. The result given by [1] means that the sample point corresponding to the first surgeon, Surgeon A indicates an out of control situation and concluded that the reasons for the high mortality rate of Surgeon A compared to other surgeons should be investigated by the concerned health institution. In contrast to that, we shall rather conclude that based on our results in this article, together with that of [2] and [8]; Surgeon H has the highest mortality rate (taking into consideration the number of cases attended to by each of the Surgeons and not just the number of deaths recorded). The xmr control chart given by [8] shows that only one sample point is outside the upper control limit (i.e Surgeon H) while the p-chart in this article reveals that three sample points (i.e Surgeons E, H and J) are outside the upper control limit. [8] added that Surgeons with hazard ratios more than 1 are considered hazard to the patients, we shall add that Surgeons corresponding to sample points outside the control limits shown in Fig. 1 are hazardous to the patients. Besides, they are hazardous to the health institution where they work for because the image of an "organization" is important. Bad services should not be tolerated and competent hands should be allowed to handle cases.

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