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COMPARATIVE STUDY OF HOSPITAL ADMINISTRATIVE DATA USING CONTROL CHARTS

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Abstract:

There are private and public hospitals in India. The data is collected from these two types of hospitals on the number of non-normal deliveries in gynaecology wards and length of hospital stay data. Control charts are drawn for this data and comparison of these hospitals is made. Conclusions are based on the performance of these charts. Standard control charts are often recommended for use in the monitoring and improvement of hospital performance.

Key words: p chart, $\bar{X}$ and R charts
Area of research: Statistics

1. INTRODUCTION:

ADMINISTRATIVE DATA:

Administrative data by definition is the data that is primarily collected for the purpose of the audit and other primary purposes and not for determination of the quality of hospital care. The daily records of patient records such as blood pressure, sugar levels; temperature along with the age and sex of the patient is collected. The hospital also records the number of surgeries, number of deaths, number of deliveries and number of patients admitted to a particular ward, etc.

Statistical Control Chart is a graph of observed data in chronological order. This graph has three horizontal lines called as Center Line (CL), Upper Control Limit (UCL) and Lower Control Limit (LCL). These charts were originally developed by Dr. Walter Shewhart in 1924 and since then it has become one of the primary tools of quality control.

Though originally developed for the industrial production, Statistical process control (SPC) charts are increasingly being used in healthcare to aid in process understanding, assess process stability, and identify changes that indicate either improvement or deterioration in quality. In health-care applications, the use of attribute data is much more prevalent. Also, there is much greater use of charts based on counts or time between failures with an assumed underlying geometric or exponential model.

Initially, the control limits are used to assess the stability of the process and to identify unusual events (outliers). Once the analyst is confident the data reflect a stable process (points falling within the control limits and showing no clearly non-random patterns), the parameters of the statistical model used to determine the control limits are estimated. These control limits then are used for on-going monitoring as new data are collected and plotted. The retrospective analysis of historical data is referred to as Phase I; whereas the prospective monitoring of future data is referred to as Phase II.

Essentially one checks whether the process historically was stable and consistent ("in statistical control" in SPC terminology) in Phase I and, if so, checks whether the process continues to behave consistently or whether any process changes are evident ("out of control" in SPC terminology) in Phase II.

Analysts have many types of control charts at their disposal. An appropriate choice of control charts depends on the type of data being analyzed, the behaviour of the data, and the assumed underlying probability distribution used for modelling. Appropriate chart and sample size selection often is difficult for practitioners due to the subtleties involved, but the correct choice is essential for meaningful results to be obtained.

2. LITERATURE SURVEY:

Shewhart control charts are often used in monitoring and improving the performance of the hospitals. William Woodall(2006)[4] suggests that the these charts may be used for monitoring infection rates, waiting time of different kinds, etc. Coory et al (2007)[2]

suggests that the use of control charts for cross sectional data. Benneyan et al[1] discussed how the statistical process control can be used as a tool in health sciences.

In this paper, we compare the proportions of non-normal deliveries in two hospitals in the year 2016. Also we compare the length of stay in the hospital after the delivery. The aim of this study is to compare the gynaecology wards of the two hospitals and to find out whether there is any difference.

3. METHODOLOGY:

We collected the data from the two hospitals called as Hospital A and Hospital B for the year 2016. The data is about the total number of deliveries and the number of non-normal deliveries in it each month from both hospitals, and also the number of days of stay of all patients in a month from both hospitals.

The number of total deliveries and non-normal deliveries from it for hospital A are given in the following table.

Table 1

Hospital A

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Total no. of deliveries	280	275	269	324	297	253	246	297	233	247	212	357	3290
Non Normal deliveries	95	87	76	82	96	76	72	89	81	79	127	105	1065

We calculated the proportions for each month for both the hospitals. As the total number of deliveries in each month is different in each hospital, we use variable control limit chart where we estimated value of the parameter P.

For Hospital A,

The parameter P is the proportion of non-normal deliveries.

$$\hat{P} = \frac{\sum_{i=1}^{k} p_i}{\sum_{i=1}^{k} n_i} = \bar{p} = 0.3237 \qquad \text{.....(1)}$$

Then the 3σ limits for p chart with separate control limits are

$$\left.\begin{aligned} \text{C.L.} &= \bar{p} \\ \text{UCL} &= \bar{p} + 3\sqrt{\frac{\bar{p}\,\bar{q}}{n_i}} \\ \text{LCL} &= \bar{p} - 3\sqrt{\frac{\bar{p}\,\bar{q}}{n_i}} \end{aligned}\right\} \qquad \text{.....(2)}$$

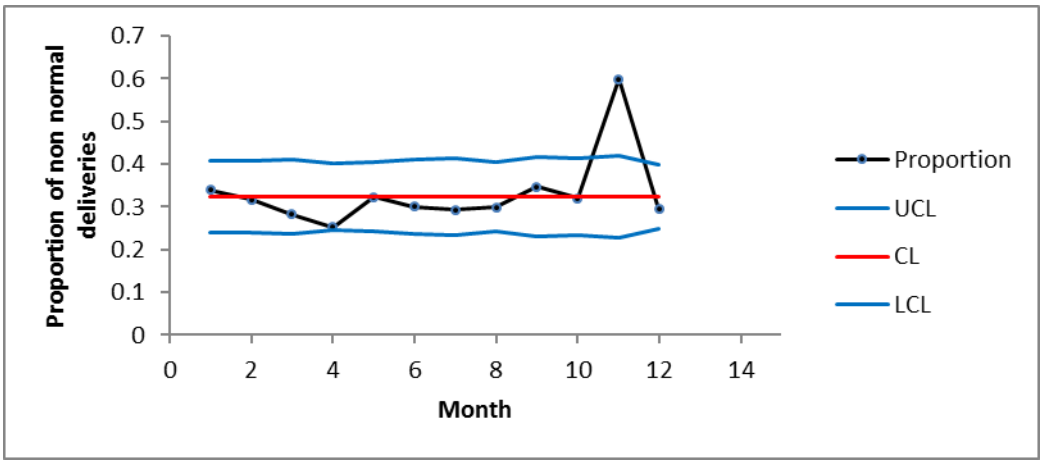
We get the limits in the following table for each month along with proportion for that month.

Table 2

Month	Proportion	UCL	CL	LCL
Jan	0.339285714	0.4076	0.32371	0.23982
Feb	0.316363636	0.40835	0.32371	0.23907
March	0.282527881	0.40929	0.32371	0.23813
April	0.25308642	0.40169	0.32371	0.24573
May	0.323232323	0.40516	0.32371	0.24226
June	0.300395257	0.41196	0.32371	0.23546
July	0.292682927	0.4132	0.32371	0.23422
Aug	0.2996633	0.40516	0.32371	0.24226
Sept	0.347639485	0.41567	0.32371	0.23175
Oct	0.319838057	0.41302	0.32371	0.2344
Nov	0.599056604	0.42011	0.32371	0.22731
Dec	0.294117647	0.398	0.32371	0.24942

The p chart is drawn as below using the values in Table 2.

Graph 1



One point for the month of November is out of control for Hospital A as the proportion of non-normal deliveries is more than the upper control limit.

For Hospital B, the table below gives the total number of deliveries and the number of non-normal deliveries.

Table 2

Hospital B

Table 3

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Total no. of deliveries	75	84	52	48	87	79	46	52	54	74	73	83	807
Non Normal deliveries	42	57	36	25	47	31	21	32	37	42	38	37	445

Using equation (1) and (2), we get the proportions for each month and the control limits.

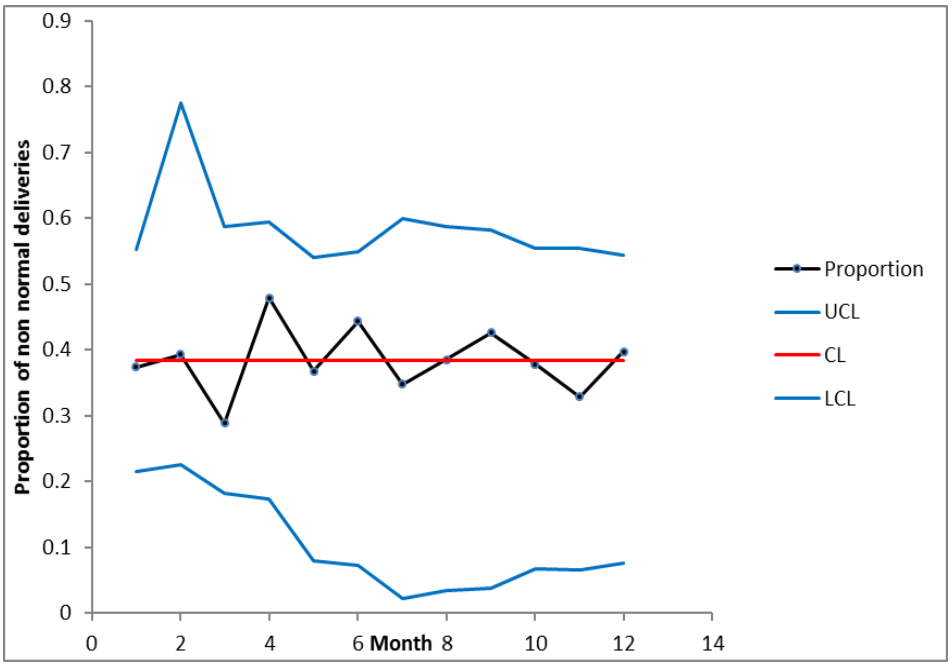
Table 4

Month	Proportion	UCL	CL	LCL
Jan	0.37333333	0.552631	0.38414	0.21565
Feb	0.39285714	0.775069	0.38414	0.22493
March	0.28846154	0.586491	0.38414	0.18179

April	0.47916667	0.594754	0.38414	0.17353
May	0.36781609	0.54058	0.38414	0.08014
June	0.44303797	0.54831	0.38414	0.07241
July	0.34782609	0.599283	0.38414	0.02143
Aug	0.38461538	0.586491	0.38414	0.03423
Sept	0.42592593	0.582708	0.38414	0.03801
Oct	0.37837838	0.553766	0.38414	0.06695
Nov	0.32876712	0.554923	0.38414	0.06579
Dec	0.39759036	0.544305	0.38414	0.07641

The p chart for Hospital B is given below:

p chart



2

The chart is in control as there are no points outside the control limits and there is no pattern is seen.

We also have collected the data for the number of days the patients stays in hospital after delivery. We calculated the average number of days stayed at the hospital and the range for each hospital.

The table below gives the average and the range of days for hospital A

Table 5

Month	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Average number of days stayed	5.1	4.3	4.7	5.3	2.3	3.6	3.8	2.9	3	2.8	4.1	3.2
Range	3	2	2	4	3	3	2	2	2	3	3	4

As the data is a variable data we draw $\bar{X}$ and R chart. As the standards are not known, we use the control limits as below:

$$E(R) = \bar{R} = d_2 R \quad \therefore \hat{\sigma} = \frac{\bar{R}}{d_2}$$

.....(3)

The 3σ-limits for R-chart will be

C. L. = E(R) = $\bar{R}$

U. C. L. = E(R) + $3\sigma_R$ $= \bar{R} + \frac{3d_3\bar{R}}{d_2} = \left(1 + \frac{3d_3}{d_2}\right)\bar{R} = D_4\bar{R}$

.....(4)

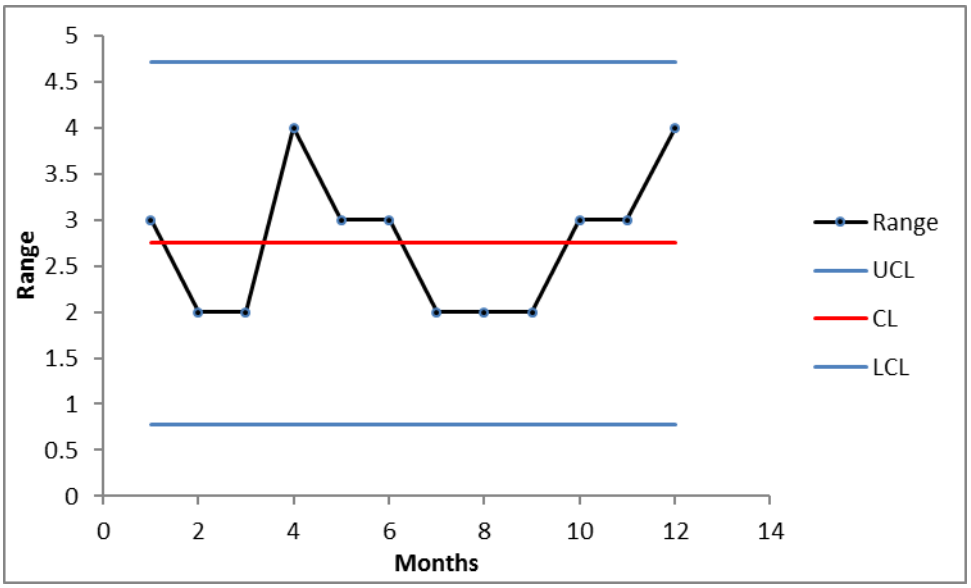
L. C. L. = E(R) - $3\sigma_R$ $= \bar{R} - \frac{3d_3\bar{R}}{d_2} = \left(1 - \frac{3d_3}{d_2}\right)\bar{R} = D_3\bar{R}$

Thus $\bar{R}$ = 2.75

The values of D_3 and D_4 from the table are 0.284 and 1.716 respectively.

CL = 2.75, UCL = 4.719 and LCL = 0.781

R chart



Graph 3

The 3σ-control limits for $\overline{\overline{X}}$-chart will be

$$\text{C. L.} = E(\overline{X}) = \hat{\mu} = \overline{\overline{X}}$$

$$\text{U. C. L.} = E(\overline{X}) + 3\sqrt{V(\overline{X})}$$

$$= \overline{\overline{X}} + \frac{3\overline{R}}{d_2\sqrt{n}} = \overline{\overline{X}} + A_2\overline{R}$$

$$\text{L. C. L.} = E(\overline{X}) - 3\sqrt{V(\overline{X})}$$

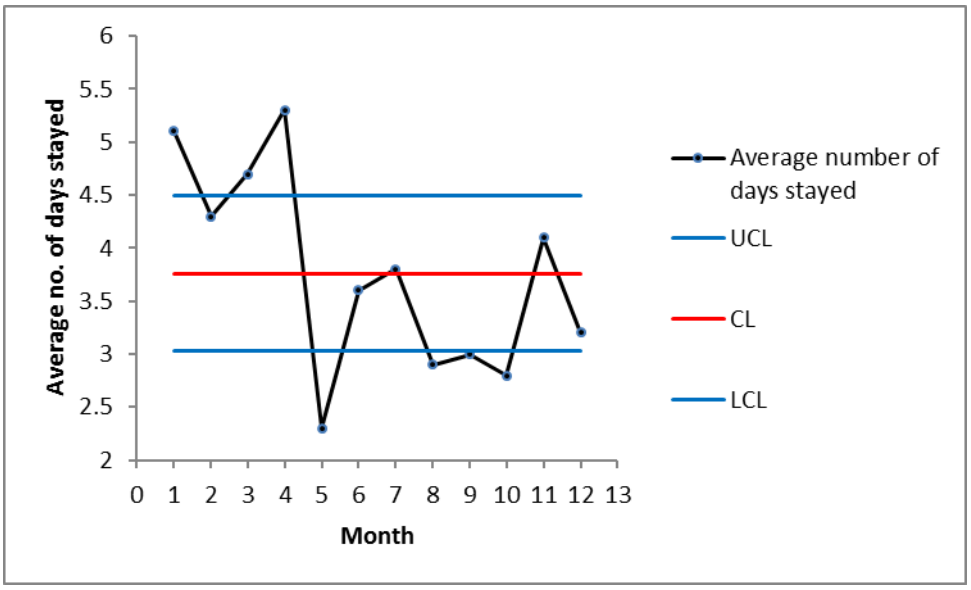
$$= \overline{\overline{X}} - \frac{3\overline{R}}{d_2\sqrt{n}} = \overline{\overline{X}} - A_2\overline{R}$$

.....(5)

Since, $\overline{\overline{X}} = 3.7583$ and $A_2 = 0.266$

CL = 3.7583, UCL= 4.4898 and LCL = 3.0268

$\overline{X}$-chart



Graph 4

The points are out of control above UCL months of January, March, April and for the months May, August and October below the LCL.

We have used the same equations (4) and (5) for Hospital B data. The data is given as below:

Table 6

Month	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Average number of days stayed	5.2	5.3	4.9	4.8	3.9	5.1	4.6	4.8	4.7	5	4.9	4.8
Range	2	5	3	4	3	4	4	3	5	4	3	3

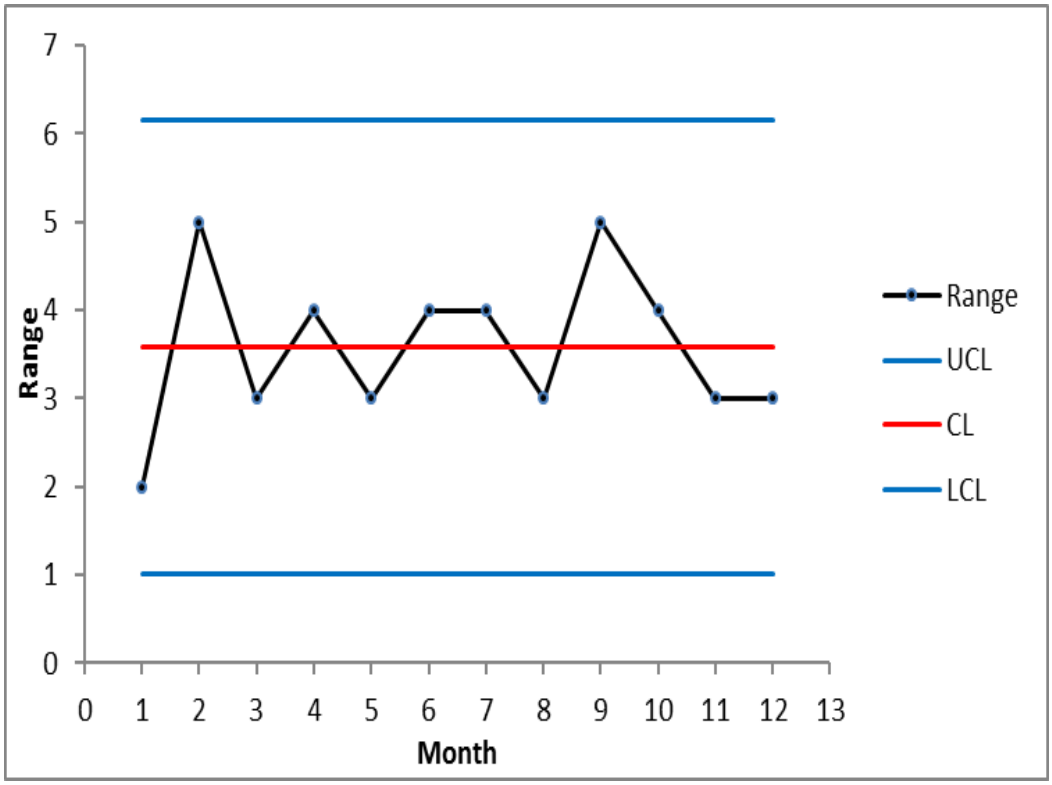
The 3σ-limits for R-chart are

Thus $\bar{R}$ = 3.5833

The values of D_3 and D_4 from the table are 0.284 and 1.716 respectively.

CL = 3.5833, UCL = 6.1489 and LCL = 1.0177

R chart



Graph 5

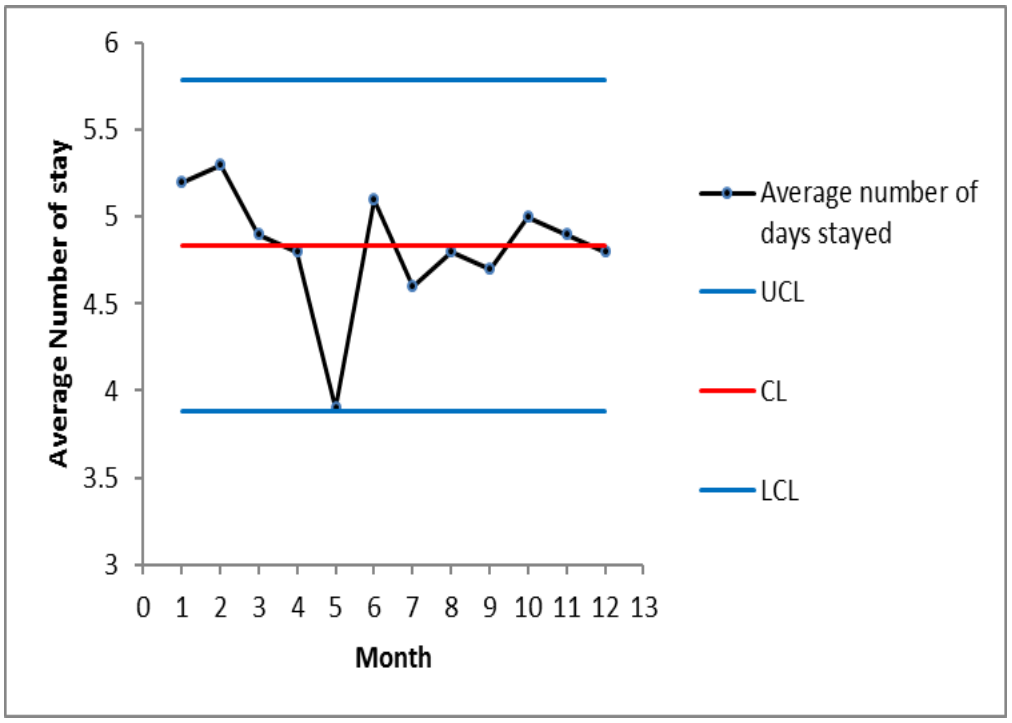
All points in R chart are under control and there is no pattern seen.

The 3σ-control limits for $\overline{X}$-chart will be

Since, $\overline{\overline{X}} = 4.8333$ and $A_2 = 0.266$

CL = 4.8333, UCL= 5.7865 and LCL = 3.8801

$\overline{X}$-chart



Graph 6

$\bar{X}$-chart for Hospital B is under control with most of the points near center line.

CONCLUSION:

When the charts for proportion of non-normal deliveries (p chart) and number of days of stay in the hospital ($\bar{X}$ and R charts) are considered together, we can conclude that even though the proportion of non-normal deliveries are in control for Hospital A except for one point the average number of days stayed at the hospital after delivery is not under control. Management has to look for the special reasons. Whereas for Hospital B, the proportion of non-normal deliveries is very much close to 0.40 and both $\bar{X}$ and R charts are under control. There is no reason for the management to worry as long as the system remains the same.

It will be necessary to collect the data for the next year from these two hospitals to check whether all these charts are under control. Similar exercise can be done for other wards for example cardiac ward.

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