Original Research

Monitoring and assessing pre-labor obstetric practicesc using control charts: cesarean delivery cases

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Summary

Due to the increase of the cesarean delivery rates globally, several researchers focused their attention on the analyses and monitoring of these rates. Present research focuses on analyzing cesarean delivery rates from two contexts – elective and emergency cesarean delivery cases. Statistical control charts –Shewhart and repetitive control charts, along with clustered bar chart are used for analyzing cesarean delivery data from 19 maternity clinics in Ireland. By-product of the analyses is also to have an insight into the pre-labor obstetric practices and suggesting whether a review of the labor ward practices is warranted or not. Secondary data is used in the current research. Moreover a comparison of the Shewhart control charts, repetitive control charts, and clustered bar charts has been carried out in order to show the effectiveness and ease of use of the control charts in identifying the areas were reviews of the pre-labor obstetric practices are warranted. It is observed that proposed charts are more robust in identifying the trouble spots than the traditional methods.

Key words: Cesarean delivery rate; Clustered bar chart; Shewhart charts; Repetitive sampling: Obstetric practices.

Introduction

Due to the increase of the cesarean delivery rates globally, several researchers focused their attention on the analyses and monitoring of these rates. According to [1] and [2] that there is no evidence that rate yet peaked. According to [3] and [4] studied short-term and long-term clinical impact on rates. Since 1985, WHO recommended cesarean rate between 5% to 15% in all regions of the world but cesarean delivery rates are unevenly distributed see [1, 5, 6], [7]. It is a universally established fact that extreme high rates are a risk for bot the mother and the infant. For application of Quality control performance charts vis-e-vis the field of medicine see [8-11]. Traditional graphical form and league tables are used to measure and monitor cesarean rate; however other studies indicated that league tables misleads the obstetricians and public suggested to apply performance control chart to monitor variation [12-14].

According to another study, "Control charts emphasize quality improvement and are less threatening to service providers because they avoid stigmatizing poor performances by moving the emphasis away from the rankings of league tables" [15]. This paper will focus on three statistical tools-clustered bar charts, Shewhart control charts and control charts using repetitive sampling. Clustered bar chart is used as a preliminary visual summary tool to observe the general behavior of the data. The control chart is designed by Shewhart in 1924 for the monitoring of industrial data. The Shewhart control chart is based on average and standard devision of data, but is unable to detect small shifts in the process.

The use of this type of control chart outside the field of medicine is known [16]. The Shewhart control chart is designed to use single sampling. Control charts are efficient than other charts in indicating those hospitals for which obstetric practice should be reviewed [17].

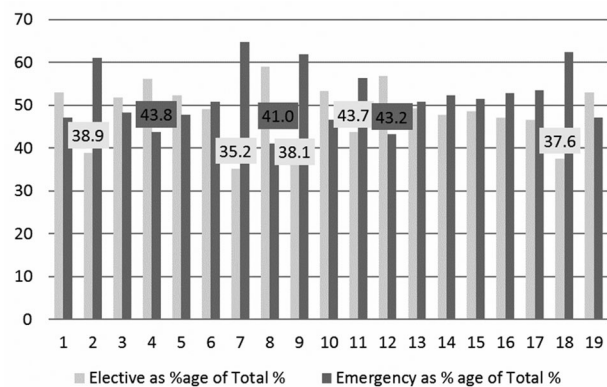Repetitive sampling is more efficient than single one in

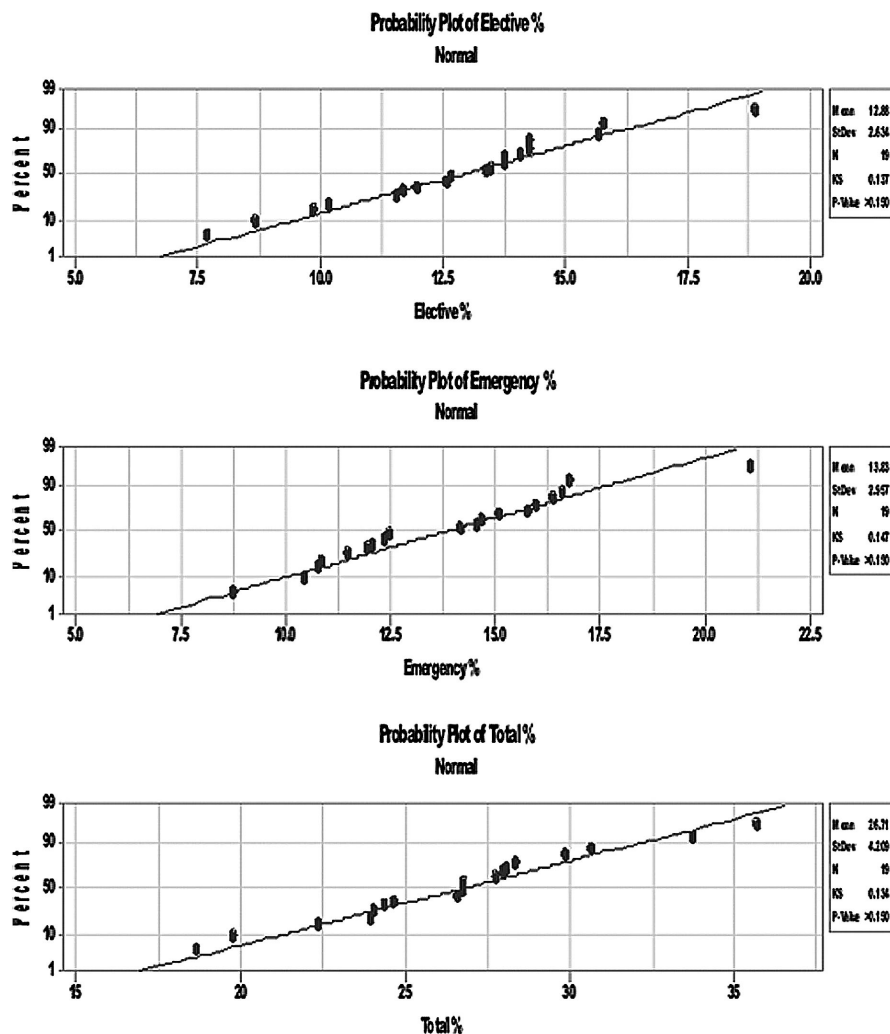Figure 1. — Cesarean elective and emergency rates expressed as percentages of the total.

Figure 2. — Probability plot of elective percentage normal .

terms of sample size [18] and can be applied to monitor healthcare issues. The present authors designed a performance control chart using repetitive sampling as an alternative to league tables in the comparison of cesarean rates among 19 hospitals in Ireland. It is expected that the proposed charts will be more efficient to compare rate than an actual analysis.

Materials and Methods

The data of cesarean rate was collected from hospital Impatient Enquiry System of Economics and Social Research Institute, Dublin, Ireland. The data was collected from 19 funded national maternity units $n = 19,326$ (26%) cesarean deliveries from a total of 74,278 deliveries in 2009 which is a fairly large figure hence emerges the raison d'etre for the current research. The data was classified into elective and emergency cesarean delivery cases. An emergency cesarean was defined as one that had not been considered previously and that was required because of an emergency situation (e.g. obstructed labor or fetal distress). An elective cesarean was defined as one that was carried out as a planned procedure before the onset of labor or following the onset of labor when the decision had already been made. The data of 19 hospitals follows the normal distribution. The more details about the data can be read in

a study [17]. For simple reference, data is reported in Table 1.

Results and Discussion

Figure 1 shows the elective and emergency cesarean deliveries as percentage of the total which are approximately evenly distributed in 11 out of 19 maternity clinics and exhibiting only the maternity clinics which does not warrant review. Difference in the option of cesarean deliveries exists in seven maternity clinics: 2, 4, 7, 8 9, 12, and 18. These differences are discussed in the next two subsections.

Hospital at serial numbers 4, 8, and 12 warranted review regarding individual obstetrics practices where the percentages of elective cesarean rates were 56.3%, 59.0%, and 56.8%, respectively, whereas, hospital at serial numbers 2, 7, 9, 11, and 18 were considered safe regarding pre-labor obstetric practices with percentages ranging from 35.2% to 43.7%. Hospital at serial numbers 2, 7, 9, 11, and 18 warranted review regarding collective obstetric practices where the percentages of emergency cesarean rates were 61.1%, 64.8%, 61.9%, 56.3%, and 62.4%, respectively. Whereas, hospitals at serial numbers 4, 8, and 12 were considered
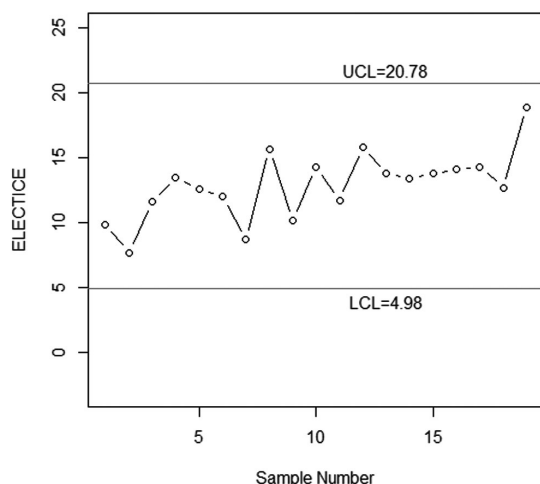
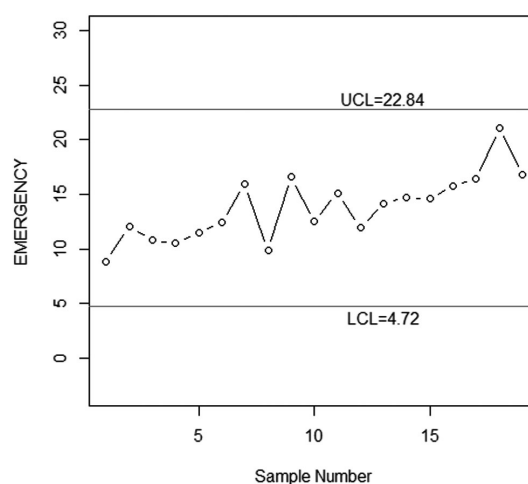Figure 3. — Shewhart control chart for monitoring elective cesarean rate.

Figure 4. — Shewhart control char for monitoring of emergency cesarean rate.

safe regarding pre-labor obstetric practices, with percentages ranging from 41.0% to 43.8% as reported in Table 2.

Normality Assumption as a prerequisite for applying parametric tests normality of the data must be diagnosed for the said purpose of the Kolmogrov-Smirnov test (KS test), which is generally applied and shown in Figure 2.

If the *p*-value of the KS test is greater than 0.05, it is considered that the null hypothesis in not rejected i.e. the data follows the normal distribution. For elective, emergency, and total data, the *p*-value of 0.150 is greater than 0.05 therefore, the data is normally distributed and fit for the application of parametric tests.

There are two limits in Shewhart control, lower control limit ($LCL = \mu - k\sigma$) and upper control limit ($UCL = \mu - k\sigma$), where μ is mean and σ is standard deviation of process.

The mean rate per hospital for elective, emergency, and total cesarean patients along with standard deviation (SD), control limits coefficients and control limits are shown in Table 3. Figures 3-5 exhibit Shewhart control chart limits. Figure 3 presents the monitoring of elective cesarean rate, Figure 4 presents the monitoring of emergency cesarean rate, and Figure 5 depicts the monitoring of total cesarean rate. From these figures, it can be seen that elective cesarean rate, emergency cesarean rate, and total rate are within the control limits. For elective delivery rate, the 19th hospital was near UCL. While for emergency delivery rate, the 18th hospital was near the UCL. Overall, Shewhart control indicate that three rates, i.e; elective, emergency and total are within the control limits and as such do not warrant a review in their clinical practices.

The control chart using repetitive sampling consisted of two inner control limits and two outer control limits which are the following: $LCL_1 = \mu - k_1\sigma$ (1), $LCL_2 = \mu - k_2\sigma$ (2), $UCL_1 = \mu - k_1\sigma$ (3), and $UCL_2 = \mu - k_2\sigma$ (4), where k_1 and k_2

Table 1. — *Cesarean delivery rate in Ireland, 2009.*

Hospital no.	Elective %	Emergency %	Total %
1	9.9	8.8	18.7
2	7.7	12.1	19.8
3	11.6	10.8	22.4
4	13.5	10.5	24.0
5	12.6	11.5	24.2
6	12.0	12.4	24.3
7	8.7	16.0	24.7
8	15.7	9.9	26.6
9	10.2	16.6	26.7
10	14.3	12.5	26.8
11	11.7	15.1	26.9
12	15.8	12.0	27.8
13	13.8	14.2	28.0
14	13.4	14.7	28.2
15	13.8	14.6	28.4
16	14.1	15.8	29.9
17	14.3	16.4	30.7
18	12.7	21.1	33.8
19	18.9	16.8	35.6

($k_1 > k_2$) are control chart coefficients.

The process is said to be under control if plotting statistic is between LCL_2 and UCL_2. Figures 6-8 are drawn using repetitive sampling. Figure 6 monitors the elective cesarean rate using repetitive sampling, Figure 7 presents monitoring of emergency cesarean rate using repetitive sampling, and Figure 8 depicts the monitoring of total cesarean rate using repetitive sampling. In Figure 4, it can be seen that for elective rate, several hospitals fall beyond LCL_2 and UCL_2. It is clearly seen that in seven hospitals, pre-labor obstetric practices warrant review. From Figure 5, it can be seen that for emergency rate, again several hospitals are beyond LCL_2 and UCL_2. It is clearly seen that in eight hospitals,
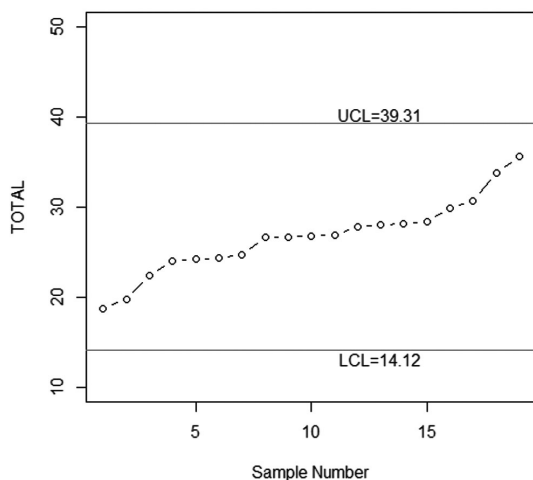
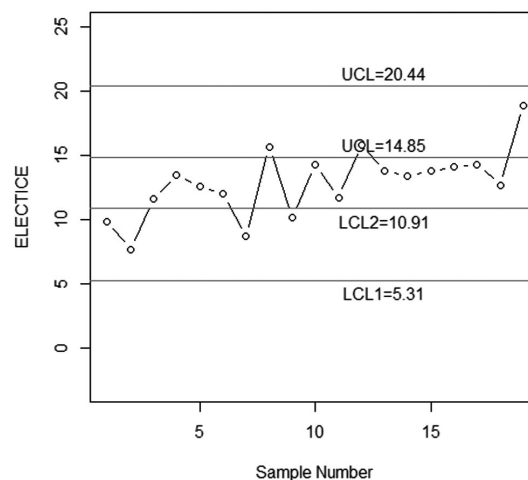Figure 5. — Shewhart control chart in monitoring the total cesarean rate.

Figure 6. — The proposed control chart for monitoring the elective cesarean rate.

labor practices should be reviewed. In Figure 6 which shows the overall data, indicates that seven hospitals pre-labor obstetric practices warrant review. Additionally it is observed in Figure 8 from repetitive sampling control chart that the hospitals at serial numbers 1, 2, and 3 have less percentage of cesarean cases than the hospitals at serial numbers 16, 17, and 18, and this can be due to rural-urban location of the hospitals. This fact needs more elaboration and the same is highlighted in future implications. Since the data were collected from 19 out of 20 maternity clinics for n = 19,326 (26%) cesarean deliveries in a total of 74,278 deliveries in 2009, therefore the results can be easily applicable to the entire population of cesarean cases.

Conclusions

Application of appropriate statistical tools coupled with correct interpretation is key that comprise a study and render its results trustworthy and applicable in healthcare.

A previous study revealed that only two hospitals were outside the 2σ control limits, but when Shewhart control charts were employed, it specifically pinpointed the area i.e. elective or emergency option and the maternity clinic where review is warranted. Data is not an opinion but if interpreted from the right perspective can become an effective tool for molding or driving public opinion in healthcare.

Results of the current study will be beneficial to mothers, babys, fathers, hospital administration, and last but not, least the community at large.

It was observed that numerical figures provide a cursory probe but as the Clustered Bar charts and Shewhart control charts were incorporated, a more meaningful situation has

Table 2. — *Percentage of the total percentage.*

Elective as	% Emergency as	Total
% age of total	% age of total %	%
52.9	47.1	18.7
38.9	61.1	19.8
51.8	48.2	22.4
56.3	43.8	24.0
52.3	47.7	24.2
49.2	50.8	24.3
35.2	64.8	24.7
59.0	41.0	26.6
38.1	61.9	26.7
53.4	46.6	26.8
43.7	56.3	26.9
56.8	43.2	27.8
49.3	50.7	28.0
47.7	52.3	28.2
48.6	51.4	28.4
47.2	52.8	29.9
46.6	53.4	30.7
37.6	62.4	33.8
52.9	47.1	35.6

Table 3. — *Measures of proposed chart.*

			Shewhart Chart		Proposed Chart			
			k=2.999673		k1=2.8734; k2=0.7486			
Data	Mean	SD	LCL	UCL	LCL_1	LCL_2	UCL_2	UCL_1
1	12.8789	2.63387	4.9781	20.7797	5.3107	10.9072	14.8506	20.4471
2	13.7789	3.02022	4.7192	22.8386	5.1006	11.5180	16.0398	22.4572
3	26.7105	4.19892	14.115	39.3059	14.6453	23.5672	29.8538	38.7757

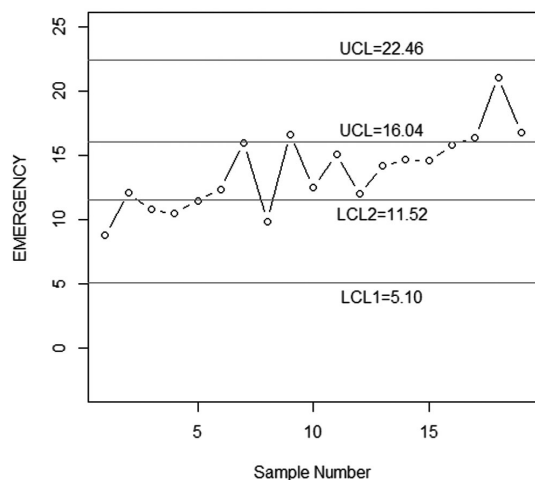Figure 7. — The proposed control chart for monitoring the emergency cesarean rate.

Figure 8. — The proposed control chart for monitoring the total cesarean rate.

emerged. Continuous monitoring of the pre-labor obstetric practices will not only enhance the quality of service in the maternity clinics, but will also encourage the medical staff for periodic reviewing of the said practices.

In future, data collection should also assess the educational, social economic condition, and rural-urban background of the patients. It is recommended that the results from the present and the ongoing research may always be looked into, along with the league tables in order to have a meaningful insight into the issue of pre-labor obstetric practices.

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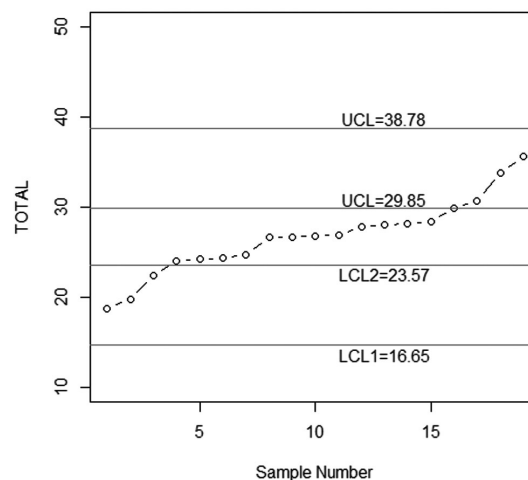
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