Using Bayes Chart to control the qualitative characteristics of newborns

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ABSTRACT

In this study, we will deal with a set of measurable variables (properties) in the quality control charts in this study. There are many qualities whose quality cannot be determined by a single variable, but by a combination of variables that collectively describe the quality of the unit under consideration. Because abnormal children account for a specific number of newly born children, it is necessary to investigate measurement rates for newborn children in order to understand the child's health, which is the foundation of society's health. As a result, the purpose of this study is to create a control chart that uses Bayes statistics, specifically a Bayes chart for qualitative. We will utilize the values of the final distribution in this chart because it incorporates all of the information accessible during the decision-making process. In this research, a Bayes chart for the (Bnp) number is used to determine the quality of the examined unit. The unit examined in our research represents this newborn child. The research includes how to use the Bayes Theorem to find Bayes estimators for the parameters of the binomial distribution. The study of the control Chart (nP-Chart) uses Bayesian method, including five variables that represent the measurements of newborns, namely (weight, length, head circumference, chest circumference, arm circumference), where these measurements are recorded for (100) cases (child) randomly in Ibn Al-Baladi Hospital in Baghdad for the year (2017) and these observations are divided into (20) samples (set), and the set includes (5) views and these views consist of (52) males , (48) females. We find that predicting the final distribution of any number of observations is the mainstay in building a Bayes chart and making decisions about the progress of the process.

Keywords: EWMA, MEWMA, Control Charts, The Traditional Chart

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1. Introduction

Statistical control charts are one of the most significant tools and methods used in the statistical control process, which is based on statistical drawing and monitoring techniques. It can be said that qualitative control of newborns cannot be considered a process that aims to formulate conformity in newly born children with international medical standards to indicate deviation from that or exceed the permissible range, but rather it is a broader process than that when there is a preventive or cautionary control that alerts to a defect before it appears in order to reach the best medical services according to the required specifications.

2. Previous studies

In the year (1993), the researcher (Abu Naqous) [1] presented the Bayes chart (chart - B) based on the theoretical basis of Bayesian statistics and linear dynamic models for the purpose of controlling the rate of quality of the produced material. The values plotted on this chart represent the final distribution average values.

The researcher (Al-Rasam) [2] created three charts in the year (1996), the first of which is (chart B_σ) and is used to control the variance in the quality of the produced material, and the second is (chart $B_{\mu\sigma}$). It is a two-dimensional chart used to control the rate and variation of the quality of the material produced at the same

time, and the third panel is (chart $B_{\mu1\mu2}$), which is also a two-dimensional chart used to control the rates of two quality characteristics of the material produced at the same time.

In the year (1997), the researcher (Al-Zubaidi) [3] established two special charts for controlling qualitative characteristics, namely the formation of a P-Chart for the defective ratios (P-Chart) and the formation of a P-Chart for the number of defects corresponding to the Shewhart chart. In the formation of these charts, the number of defects (C-Chart) is determined using the Bayesian method and general kinetic models.

In the year (2002), researcher (Al-Ani) [4] used qualitative control to study the effect of the blockade on newborn weights and congenital malformations.

In 2005, the researcher (Al-Ani) [5] presented a paper on the use of qualitative control charts for traits to study newborn measurement rates. As the qualitative characteristic here represents the number of abnormal children in the studied sample, the researcher used a Bayes chart for the defective number ($B_{np} - Chart$).

In the year (2007), the researcher (Al-Zubaidi) [6] developed a qualitative control chart for the singular value that used the sequential Bayes method in its formation and decision-making rather than the classic statistical method used in the Shewhart chart.

In (2008), the researcher (Al-Ani) [7] calculated the birth measures for newborns, which are (weight, length, head circumference, chest circumference, arm circumference), through which the child's health status is determined using the Bayes method based on the subsequent distribution, using the previous distribution with standard information, and its comparison with the traditional estimation method based on sample information only.

In (2011), two researchers (Al-Rasam and Khalil) [8] developed a multivariate control chart called the (X^2) chart for multivariate Bayes to control the quality rate of the produced material. The chart was applied to real-world data, which included the results of concrete model examinations. In the Mosul province, asphalt is used as the base layer in the construction of streets.

3. The objective of the study

The goal of this study is to create a control chart that uses a Bays statistic to measure the qualitative characteristics of newborn children, so that it is possible to know whether these qualities conform to international medical specifications.

4. Method

One of the major criteria that determines the future of newborns' health is the study of newborn measurement rates to identify the health of the newborn child, on which the community's health depends. Qualitative control charts are used in the medical field, and Bayesian statistics are used to form a control chart on the qualitative characteristics of newborns.

4.1. Bayes method

Given the significance of statistics and their application in many areas of life, researchers have taken care of, studied, and developed it over time, as two schools branched out from it, where two schools branched off from it, the first relies on information taken directly from observations (samples) and is called sample information, and the sample is treated as an undefined constant, and this is called the classical school, and statisticians are at the top of the list of supporters and founders of this school (R.A.Fisher , J.Neyman , E.S.Person).

While the second relies on information derived from observations or samples, it also relies on personal information (derived from experience) and is referred to as primary information (prior information), as well as treating the parameters in probability distributions as random variables. This school is known as the Bayes School because it has a probability distribution (Bayesian School). The founder of this school is the British statistician (Thomas Bayes), who presented the Bayes Theorem, which is based on conditional probabilities. In this paper, we will design quality control charts using the Bayes method [2].

4.2. Bayes theorem

Bayes' theory is described in probability law as the probability of an event occurring based on prior knowledge of conditions that may be relevant to the event. In its most basic form, the Bayes theorem can be written as follows[2]:

$$p(A/B) = \frac{p(A).p(B/A)}{p(B)} \, , \; p(B) \neq 0, \quad \ldots\ldots\ldots(2\text{-}1)$$

We suppose that $X = (X_1, X_2, \ldots\ldots X_n)$ is a vector of n random observations with probability distribution $p(X/\theta)$ which depends on the (k) values of the parameters. Suppose that the random variable has a probability distribution, then the probability distribution of the parameter if given the values of random observations (x) is as follows:

$$p(\theta/X) = \frac{p(\theta).p(X/\theta)}{p(X)} \ldots\ldots\ldots \ldots\ldots\ldots ..(2-2)$$

4.3. Prior probability distribution

$p(\theta/I)$ is called the prior probability or (distribution) of the parameters (θ), (I) is the previous information and for making it easy, we use $p(\theta)$ to denote the initial probability of the parameter θ without previous information (Prior Probability) and it is the main pillar of the Bayes method which is the probability distribution for the parameter θ where it measures the degree of personal belief about the parameter θ. In other words, it is a belief probability derived from prior experiences or personal experience and expressed in a probabilistic manner. Also, the initial distribution of the parameter θ tells us whether it contains no information (or only a little information) and is referred to as (non-informative prior distribution) or contains significant information (informative prior distribution), and these two types of probability can be clarified the first [2].

4.3.1. Non-Informative prior distribution

This type of distribution can be either standard or non-standard, with standard implying that everyone uses the same probability distribution with varying value parameters. This type was developed by statisticians (Geffery 1961) [9] based on Fisher's information theory, or it is non-standard when the distribution utilized varies from one person to the next, and it is homogenous and regular over a portion of the sample space [2].

4.3.2. Informative prior distribution

This type is usually standard, in the sense that everyone uses the same distribution but with somewhat varying parameters. It provides data on the parameter, and this probability is usually derived from previous research in the same field [2].

4.4. Posterior probability distribution

$p(\theta)$ is named the probability (distribution) for the parameter θ, and it contains all of the information about θ where it provides us with the final information about θ and after taking the observations, since it alters the information for θ which we acquire from the initial probability to make it more accurate [2].

As a result, the inference about θ expresses all available information about θ up to the last observation taken, as it summarizes all available information about θ concentrated in a part of this distribution, and the Bayes estimator can be expressed by anticipating the final distribution.

In addition to the conventional beginning information accessible from previous experiences or (experience and personal belief), the Bayes method relies on sample information about the parameter θ. As a result, the final data is expressed as a probability distribution known as the posterior distribution.

4.4.1. Finding the Posterior Distribution for the Parameter of the Binomial Distribution Using the prior distribution with little information (Non-informative Prior Distribution)

The standard prior distribution can be derived using Geffery's law and has the following form [4,6]:

$$p(\theta) = \theta^{\frac{1}{2}}.(1-\theta)^{-\frac{1}{2}}$$

By applying Bayes Theorem, we obtain the following posterior distribution:

$$p(\theta/X) = \theta^{X-\frac{1}{2}}.(1-\theta)^{n-x-\frac{1}{2}}$$

and the mentioned formula represent the kernel of Beta distribution as follows

$$p(\theta/X) = \theta^{\alpha-1}.(1-\theta)^{b-1} \ldots\ldots\ldots \ldots\ldots(2-3)$$

such that $\qquad \alpha = X + \dfrac{1}{2}$, $b = n - X + \dfrac{1}{2}$

Therefore, the posterior distribution can be written as

$$P(\theta / X) = \frac{\Gamma(\alpha + b)}{\Gamma \alpha \Gamma b} \theta^{\alpha-1} . (1-\theta)^{b-1}$$

The moments of first and second of the posterior distribution are respectively:

$$E(\theta / X) = \frac{X + \dfrac{1}{2}}{n+1} \ldots\ldots\ldots\ldots(2-4)$$

$$V(\theta / X) = \frac{(X + \dfrac{1}{2})(n - X + \dfrac{1}{2})}{(n+1)^2 (n+2)} \ldots\ldots\ldots(2-5)$$

Because the prior distribution is parameter-free, the final distribution of θ parameter is calculated solely on the information obtained from the sample.

4.4.2. Finding the posterior distribution for a binomial distribution parameter using the standard informative prior distribution

By using the distribution which we obtained from equation (2-3) as prior distribution for the parameter (a_o , b_o) as follows [6]:

$$P(\theta) \sim Beta(\alpha_0, b_0)$$

$$P(\theta) \sim \theta^{\alpha_0 - 1}(1-\theta)^{b_0 - 1}$$

By using Bayes Theorem, we get the posterior probability

$$p(\theta / X) = \theta^{\alpha_0 - 1}(1-\theta)^{b_0 - 1} \theta^X (1-\theta)^{n-X}$$

$$p(\theta / X) = \theta^{\alpha_0 + X - 1}(1-\theta)^{b_0 + n - X - 1}$$

and this estimator represents the kernel of Beta distribution with parameters

$$\alpha = \alpha_0 + X , \ b = b_0 + n - X$$

That is, the posterior distribution of the defective number ratio follows the Beta distribution as follows

$$p(\theta / X) = \frac{\Gamma(\alpha_0 + b_0 + n)}{\Gamma(\alpha_0 + X)\Gamma(b_0 + n - X)}$$

The moments of first and second of this distribution are respectively

$$E(\theta / X) = \frac{\alpha_0 + X}{\alpha_0 + b_0 + n} = \hat{p}_B \ldots\ldots\ldots(2-6)$$

$$V(\theta / X) = \frac{(\alpha_0 + X)(b_0 + n - X)}{(\alpha_0 + b_0 + n)^2 (\alpha_0 + b_0 + n + 1)} = \sigma^2_{\hat{p}_B} \ldots\ldots\ldots(2-7)$$

where $n\hat{P}_B$ represents the number of abnormal children in the studied sample and the vertical axis represents the chart, while the horizontal axis represents the number of samples (sequence of samples) and the center line or it is so-called goal line, which represents the general average of the number of abnormal children and is denoted by the symbol T and is calculated according to the following formula

$$T = \overline{n\hat{p}_B} \ldots\ldots\ldots(2-8)$$

such that
$$\overline{n\hat{p}_B} = \frac{\sum_{i=1}^{m}(n\hat{p}_B)}{m}……….…..(2-9)$$

where (m) represents the number of samples drawn.

The two control boundaries of the (np-chart) is calculated according to the Bayes method as follows

$$UCL = \overline{n\hat{p}_B} + 3\overline{\sigma}_{n\hat{p}_B}……….…..(2-10)$$

$$LCL = \overline{n\hat{p}_B} - 3\overline{\sigma}_{n\hat{p}_B}……….…..(2-11)$$

such that $\overline{\sigma}_{\hat{p}_B} = \dfrac{\sum_{i=1}^{m}(n\sigma_{\hat{p}_B})}{m}$, $n\sigma_{\hat{p}_B} = \sigma_{n\hat{p}_B}$

5. Applied side

The study includes Bayes-method analysis of the control chart (np-chart), with five variables reflecting newborn measurements: weight (kg), height (cm), head circumference (cm), chest circumference (cm), and arm circumference (cm). For the year (2017), these measures were taken at random for (100) children at Ibn Al-Baladi Hospital in Baghdad. The (100) child observations were separated into (20) samples, each of which contained (5) observations (children). A total of 52 males and 48 females were observed.

X: represents the number of abnormal children.

n: represents the size of the sample (the number of newborn children).

$\hat{p}_B$: represents the estimator of Bayes ratio for abnormal children in the sample.

$\sigma_{\hat{p}_B}$: represents the variance of posterior distribution for the ratio of abnormal children in the sample.

The normal measurements of a newborn are: weight (2.5-3.5) kg, head circumference (35-40) cm, chest girth (30-33) cm, arm circumference (11.5-13.5), length (46-54) cm.

If any of the above criteria for a child does not match the child's natural characteristics, the child is called abnormal. Abnormal newborns make up a small fraction of all births.

5.1. Bayes Application for the number of abnormal children
5.1.1. Bayesian estimation of the number of abnormal children and the variance of the posterior distribution for each sample if very little information is available

We calculate the Bayes average estimation for the number of abnormal children and the variance of the posterior distribution for each sample using equations (2-4) and (2-5), and the results are presented in Table No (1). To explain how to calculate $\hat{p}_B$ according to equation (2-4) in the sample No. (1)

$$\hat{p}_1 = \frac{x_1 + \frac{1}{2}}{n+1} = \frac{0 + \frac{1}{2}}{5+1} = \frac{0.5}{6} = 0.08333$$

Thus, we calculate $\hat{P}_B$ for the rest of the samples including sample No.(20) such that ($\hat{P}_B = 0.75$). While for $\sigma_{\hat{P}_B}^2$ is calculated according to the equation (2-5) for the sample No. (1).

$$\sigma_{\hat{p}_B}^2 = \frac{(0+0.5)(5-0+0.5)}{(5+1)^2(5+2)}$$

Using the same method, the value of $\sigma_{\hat{P}_B}^2$ is calculated for the rest of the samples including sample No. (20) such that $\sigma_{\hat{p}_B}^2 = 0.02678$

Table 1 represents the number of abnormal children in the sample, a Bayes estimate for the ratio and number of abnormal children for each sample, a Bayes estimate for variance, and the posterior distribution of each sample.

Table 1. The number of abnormal children in the sample, a Bayes estimate for the ratio and number of abnormal children for each sample, a Bayes estimate for variance, and the posterior distribution of each sample.

Samples	The number of abnormal children (X)	Bayes Estimate for the ratio the number of abnormal children for each sample $\hat{p}_B$	Bayes Estimate for the ratio the number of abnormal children for each sample $n\hat{p}_B$	Variance estimate for the posterior distribution for each sample $\sigma^2_{\hat{p}_B}$	$\sigma_{\hat{p}_B}$	$\sigma_{n\hat{p}_B}$
1	0	0.08333	0	0.01091	0.10445	0.52225
2	1	0.25	1	0.02678	0.16364	0.8182
3	3	0.58333	3	0.03472	0.18633	0.93165
4	5	0.91667	5	0.01091	0.10445	0.52225
5	3	0.58333	3	0.03472	0.18633	0.93165
6	5	0.91667	5	0.01091	0.10445	0.52225
7	0	0.08333	0	0.01091	0.10445	0.52225
8	4	0.75	4	0.02678	0.16364	0.8182
9	2	0.41667	2	0.03472	0.18633	0.93165
10	4	0.75	4	0.02678	0.16364	0.8182
11	0	0.08333	0	0.01091	0.10445	0.52225
12	1	0.25	1	0.02678	0.16364	0.8182
13	3	0.58333	3	0.03472	0.18633	0.93165
14	3	0.58333	3	0.03472	0.18633	0.93165
15	3	0.58333	3	0.03472	0.18633	0.93165
16	4	0.75	4	0.02678	0.16364	0.8182
17	4	0.75	4	0.02678	0.16364	0.8182
18	2	0.41667	2	0.03472	0.18633	0.93165
19	2	0.41667	2	0.03472	0.18633	0.93165
20	4	0.75	4	0.02678	0.16364	0.8182

While the goal line that represents the general average for the number of abnormal children is calculated according to the formula (2-9)

$$\overline{n\hat{p}_B} = \frac{53}{20} = 2.65 \qquad , \qquad \sum_{i=1}^{m} \sigma_{n\hat{p}_B} = 15.79185$$

The control boundaries are calculated according to equations (2-10) and (2-11),

UCL=2.65+3(0.7896)=5.0188≈5
LCL=2.65-3(0.7896)=0.2812≈0

Such that: $\overline{\sigma}_{\hat{p}_B} = \dfrac{\displaystyle\sum_{i=1}^{m}(n\sigma_{\hat{p}_B})}{m}$, $n\sigma_{\hat{p}_B} = \sigma_{n\hat{p}_B}$, $\overline{\sigma}_{n\hat{p}_B} = \dfrac{15.79185}{20} = 0.7896$.

Because the prior distribution is devoid of primary information, Bayes estimation of the number of abnormal children in the sample is only based on the rich information obtained from the hospital, as shown in Table 1. As a result, the chart graph will be as in Figure 1.
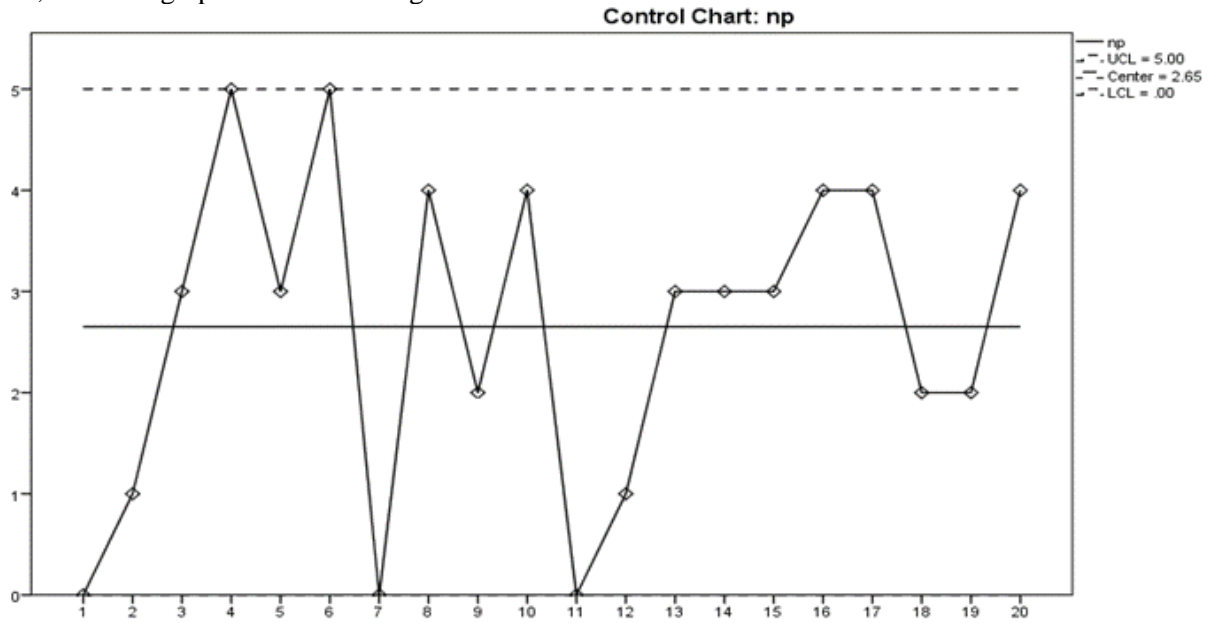

Figure 1. Chart for the Bayes defective number

When drawing the control chart for the defective number using Bayes method, it is found that all the points (samples) drawn that represent the number of abnormal children are located within the boundaries of the quality control chart as in Figure 1.

5.1.2. Bayes estimation of the number of abnormal children and the variance of the posterior distribution for each sample in the event that rich prior information is available

A Bayes estimation for the number of abnormal children and the variance of the posterior distribution for each sample is obtained using equations (2-6) and (2-7). When the number of abnormal children in the sample is initially set at 1. Table (2) shows the results.

a. Using Equation (2-6)

$$a_0 = x + \frac{1}{2} = 0 + \frac{1}{2} = 0.5 \qquad b_0 = 5 - 0 + 0.5 = 5.5$$

$$E(p/X) = \frac{0.5+1}{0.5+5.5+5} = \frac{1.5}{11} = 0.1364$$

Thus, the value of $\hat{p}_B$ is calculated for the rest of the samples including sample No. (20) such that

$\hat{p}_B = 0.5$

b. Using equation (2-7)

$$V(P/X) = \frac{(0.5+1)(5.5+5-1)}{(0.5+5.5+5)^2(0.5+5.5+5+1)} = 0.0098$$

Using the same method, the value of $\sigma^2_{\hat{p}_B}$ is calculated for the rest of the samples including sample with no. of (20) such that $\sigma^2_{\hat{p}_B} = 0.02083$.

Table 2. The expect and variance of the posterior distribution when the initial value of the number of abnormal children in the sample = 1

Samples	The number of abnormal children (X)	Bayes Estimate for the ratio the number of abnormal children for each sample $\hat{p}_B$	Bayes Estimate for the ratio the number of abnormal children for each sample $n\hat{p}_B$	Variance estimate for the posterior distribution for each sample $\sigma^2_{\hat{p}_B}$	$\sigma_{\hat{p}_B}$	$\sigma_{n\hat{p}_B}$
1	0	0.1364	1	0.0098	0.0989	0.4949
2	1	0.2273	1	0.01463	0.12095	0.60475
3	3	0.4091	2	0.02014	0.14192	0.7096
4	5	0.59091	3	0.02014	0.14192	0.7096
5	3	0.4091	2	0.02014	0.14192	0.7096
6	5	0.59091	3	0.02014	0.14192	0.7096
7	0	0.1364	1	0.0098	0.0989	0.4949
8	4	0.5	3	0.02083	0.14433	0.72165
9	2	0.3182	2	0.01808	0.13446	0.6723
10	4	0.5	3	0.02083	0.14433	0.72165
11	0	0.1364	1	0.0098	0.0989	0.4949
12	1	0.2273	1	0.01463	0.12095	0.60475
13	3	0.4091	2	0.02014	0.14192	0.7096
14	3	0.4091	2	0.02014	0.14192	0.7096
15	3	0.4091	2	0.02014	0.14192	0.7096
16	4	0.5	3	0.02083	0.14433	0.72165
17	4	0.5	3	0.02083	0.14433	0.72165
18	2	0.3182	2	0.01808	0.13446	0.6723
19	2	0.3182	2	0.01808	0.13446	0.6723
20	4	0.5	3	0.02083	0.14433	0.72165

While the goal line that represents the general average for the number of abnormal children is calculated according to the formula (2-9)

$$\overline{n\hat{p}_B} = \frac{53}{20} = 2.1 \qquad , \qquad \sum_{i=1}^{m} \sigma_{n\hat{p}_B} = 13.3621$$

The control boundaries are calculated according to equations (2-10) and (2-11)

UCL=2.1+3(0.66811)=4.10433≈4

LCL=2.1-3(0.66811)=0.1≈0

Such that: $\overline{\sigma}_{\hat{p}_B} = \dfrac{\sum\limits_{i=1}^{m}(n\sigma_{\hat{p}_B})}{m}$, $n\sigma_{\hat{p}_B} = \sigma_{n\hat{p}_B}$, $\overline{\sigma}_{n\hat{p}_B} = \dfrac{13.3621}{20} = 0.66811$.
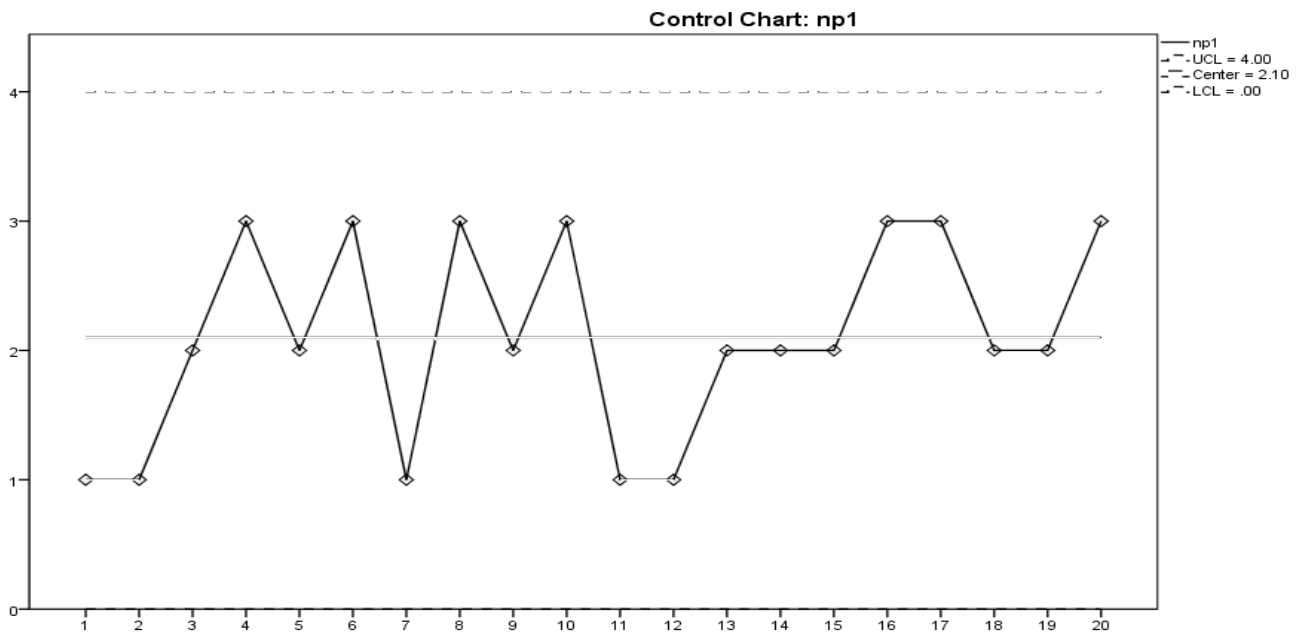

Figure 2. Bayes chart for the defective number when the initial value for the abnormal children in the sample =1

When drawing the control chart for the defective number using Bayes method, it is found that all the points (samples) drawn that represent the number of abnormal children are located within the boundaries of the quality control chart as in Figure 2.

Bayes estimation for the number of abnormal children and the variance of the posterior distribution for each sample is obtained using equations (2-6) and (2-7). When the number of abnormal children in the sample is initially set at 2. Table 3 shows the results.

a. Using Equation (2-6)

$$a_0 = x + \frac{1}{2} = 0 + \frac{1}{2} = 0.5 \quad b_0 = 5 - 0 + 0.5 = 5.5$$

$$E(p/X) = \frac{0.5 + 2}{0.5 + 5.5 + 5} = \frac{2.5}{11} = 0.22727$$

Thus, the value of $\hat{p}_B$ is calculated for the rest of the samples including sample No. (20) such that $(\hat{p}_B = 0.59091)$

b. Using equation (2-7)

$$V(P/X) = \frac{(0.5 + 2)(5.5 + 5 - 2)}{(0.5 + 5.5 + 5)^2 (0.5 + 5.5 + 5 + 1)} = 0.01463$$

Using the same method, the value of $\sigma_{\hat{p}_B}^2$ is calculated for the rest of the samples including sample No. (20) such that $\sigma_{\hat{p}_B}^2 = 0.02014$.

Table 3. The expect and variance of the posterior distribution when the initial value of the number of abnormal children in the sample = 2

Samples	The number of abnormal children (X)	Bayes Estimate for the ratio the number of abnormal children for each sample $\hat{p}_B$	Bayes Estimate for the ratio the number of abnormal children for each sample $n\hat{p}_B$	Variance estimate for the posterior distribution for each sample $\sigma^2_{\hat{p}_B}$	$\sigma_{\hat{p}_B}$	$\sigma_{n\hat{p}_B}$
1	0	0.22727	1	0.01463	0.12097	0.60488
2	1	0.31818	2	0.01808	0.1345	0.6723
3	3	0.5	3	0.02083	0.14433	0.72163
4	5	0.68182	3	0.01808	0.13454	0.67268
5	3	0.5	3	0.02083	0.14433	0.72163
6	5	0.68182	3	0.01808	0.13454	0.67268
7	0	0.22727	1	0.01463	0.12097	0.60488
8	4	0.59091	3	0.02014	0.14193	0.70967
9	2	0.40909	2	0.02014	0.14193	0.70967
10	4	0.59091	3	0.02014	0.14193	0.70967
11	0	0.22727	1	0.01463	0.12097	0.60488
12	1	0.31818	2	0.01808	0.1345	0.6723
13	3	0.5	3	0.02083	0.14433	0.72163
14	3	0.5	3	0.02083	0.14433	0.72163
15	3	0.5	3	0.02083	0.14433	0.72163
16	4	0.59091	3	0..02014	0.14193	0.70967
17	4	0.59091	3	0.02014	0.14193	0.70967
18	2	0.40909	2	0.02014	0.14193	0.70967
19	2	0.40909	2	0.02014	0.14193	0.70967
20	4	0.59091	3	0.02014	0.14193	0.70967

While the goal line that represents the general average for the number of abnormal children is calculated according to the formula (2-9)

$$\overline{n\hat{p}_B} = \frac{49}{20} = 2.45 \quad , \quad \sum_{i=1}^{m} \sigma_{n\hat{p}_B} = 17.31765$$

The control boundaries are calculated according to equations (2-10) and (2-11)

UCL=2.45+3(0.86588)=5.04764≈5

LCL=2.45-3(0.86588)= - 0.1476≈0

such that $\overline{\sigma}_{\hat{p}_B} = \dfrac{\sum_{i=1}^{m}(n\sigma_{\hat{p}_B})}{m}$, $n\sigma_{\hat{p}_B} = \sigma_{n\hat{p}_B}$, $\overline{\sigma}_{n\hat{p}_B} = \dfrac{17.31765}{20} = 0.86588$
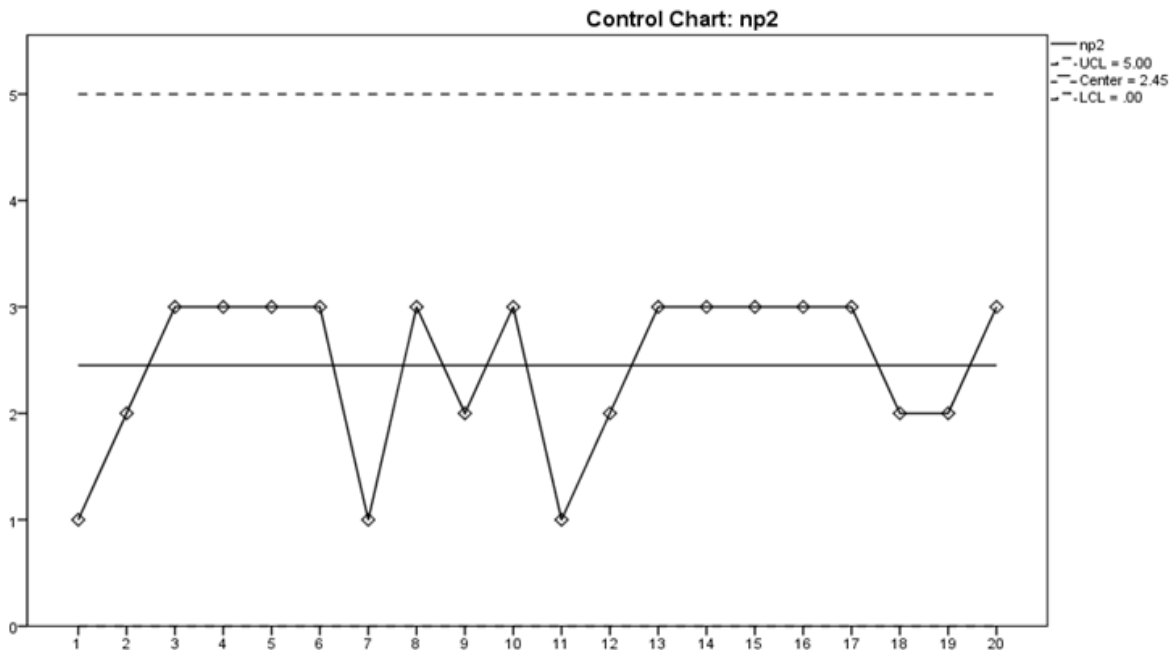

Figure 3. Bayes chart for the defective number when the initial value for the abnormal children in the sample =2

When drawing the control chart for the defective number using Bayes method, it is found that all the points (samples) drawn that represent the number of abnormal children are located within the boundaries of the quality control chart as in Figure 3.

6. Conclusions

1. The ability to create control panels using the Bayes technique rather than the traditional way, because it allows us to use both primary information (which we receive from previous experience or experiences) and data information in estimating the final distribution parameter.
2. Predicting the final distribution, which represents the average of the final distribution for any number of observations, is essential for creating a Bayes chart and making decisions about the progress of the process.
3. When the control chart is applied to the defective number in Bayes method, it is discovered that all of the points (samples) drawn that represent the number of abnormal children are located within the boundaries of the quality control chart, as shown in Figures 1, 2, and 3.

7. Recommendations

1. We recommend using the Bayes method (np-Chart) in all aspects of life.
2. We recommend using the Bayes method to improve the immunity of the control charts.
3. We recommend broadening the use of Bayes control.

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