Brief Report

The attribute control charts for outbreak trends of selected states in the USA: a brief report of the insight into the pattern

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Abstract

Background: Outbreaks are global issues that threaten human life. Developed nations such as the USA have developed strict measures for control and containment of the events.

Methods: From the long-term thorough observations, a huge database can be constructed which is available for public on the internet web site of the National Outbreak Reporting System (NORS) from Centers for Disease Control and Prevention (CDC). The records were segregated and filtered, then each data set was processed as a separate outbreak for randomly selected six states (Alabama, Alaska, Arizona, Delaware, Arkansas, and Florida) in the country using statistical process control (SPC) software package. Laney attribute control charts were constructed as the number of illness per outbreak (Y-axis) against the number of outbreaks within 20 years of recorded data from 1998 to 2017.

Results: Each state showed a unique set of visually observed data on the control charts in terms of the mean, upper control limit, frequency, and the magnitude of the outbreak excursions.

Conclusions: These trending charts could be valuable not only in the process assessment and prediction, but also to develop simplified type of quantitative risk assessment based on the magnitude, frequency, and threshold of the outbreak observed in each state.

Keywords: CDC, outbreak, USA

Introduction

Outbreaks are globally critical medical issues that affect the health of the community with a great financial impact on the nation’s economy [1]. Despite advances in human health sciences, human awareness about public health, disease control and monitoring, it seems that outbreaks are unavoidable phenomena. The problem may be exaggerated in developing countries [2]. Monitoring of events could be accomplished by control charts (also known as process-behavior charts) which were basically constructed for the monitoring of the industrial process [3]. However, they could also be used for observation and control of inspection characteristics
such as surgical site infection (SSI) rates, microbiological quality of water, surfaces, and air in the healthcare industry [4-7]. Microbial quality of the consumable products is also an important quality attribute that requires close monitoring [8].

The present report demonstrates the almost continuous and recurring pattern of outbreak events with intermittent excursions in the number of illness which can be visualized easily using trending charts which show the characteristic manner of outbreak events during 20 years of thorough monitoring for the event in the selected states in the USA.

**Methods**

Outbreak data of USA was extracted from the database of the National Outbreak Reporting System (NORS). NORS is an internet-dependent web site that has been launched since 2009 following the Centers for Disease Control and Prevention (CDC). Original values were obtained from the “National Outbreak Public Data Tool” Microsoft Excel sheets after processing and filtering data [9]. The records were segregated into individual separate states, then each data set was processed and presented as control charts using statistical program Minitab® 17.1.0 [10].

The used control charts were attribute-types of the process-behavior charts. Laney modification was applied here to correct for over-dispersion or under-dispersion and avoid false alarming signals (indicated by red dots in the chart) according to the method applied in statistical process control (SPC) software package [11]. Laney attribute control charts were constructed as the number of illness per outbreak (Y-axis) against the number of outbreaks within 20 years of recorded data from 1998 to 2017. These dispersions were indicated numerically in the figures by Sigma Z values.

Each state showed a unique pattern of the outbreak which was a combination of the number of outbreaks per observation years, illness per each outbreak, average value, upper control limit (UCL), the frequency, and the magnitudes of excursions in the number of cases for each out-of-control episode. It should be noted that in the current events, only UCL is of interest and it can be considered as an outbreak threshold.

**Results**

From the trending of the results, it appears that this challenge is unavoidable and persistent whatever efforts are made by the regulatory agencies. This could be evident from data presented graphically through 20 years record of outbreaks from randomly selected states from the USA as could be seen from Figures 1 to 3. The value of control charts comes to play an important role here.

![Laney Attribute Control Chart of Illnesses (Alabama)](image1)

**Figure 1.** Trending chart of outbreak record in Alabama and Alaska States within 20 years.

![Laney Attribute Control Chart of Illnesses (Arizona)](image2)

**Figure 2.** Trending chart of outbreak record in Arizona and Arkansas States within 20 years.
Alabama State showed two major trends: first, a low-frequency before the greatest outbreak (208th with 741 illnesses) and second, a greater rate after the greatest outbreak. Only one excursion was observed at 12th episode involving 140 persons at the initial phase, but after the major event, several out-of-control occasions could be detected. On the other hand, Alaska showed very few out-of-control points, but the initial (2nd of 191 individuals) and middle (121st of 2500 individuals) excursions were much greater in magnitude if compared with Alabama. Detailed events could be seen in chronological order in Figure 1.

Arizona State showed a greater number of outbreaks compared with the previous states. Accordingly, a higher frequency of excursions, with variable magnitudes, was observed throughout the whole period. In contrast, Arkansas State showed a much lower rate of outbreaks. Accordingly, a lower frequency of excursions was observed, especially in the second half of the curve in Figure 2.

![Figure 3. Trending chart of outbreak record in Delaware and Florida States within 20 years.](image)

Interestingly, Delaware State showed a very low number of the out-of-control outbreaks. This is may be due to not only a low number of the events, but also due to relatively small variations between the successive outbreaks. Based on Figure 3, Florida State showed the greatest number of assignable cause incidents in the present examined report due to the highest frequency of the outbreaks during the 20 years of the study.

**Discussion**

The USA suffered from horrific catastrophic outbreaks such as Flu of 1918 that struck the country and caused massive national and global deaths and causalities [12]. Criticalities of outbreak situations have forced the regulatory institutions such as US Food and Drug Administration (FDA) to set rules to be implemented in emergencies [13]. The consequences of the outbreaks have made the authorities in the USA setting strong rules for control and monitoring of the outbreak events in the country [14]. Thus, data analysis could provide beneficial values only in the presence of comprehensive, accurate and timely records which are considered crucial in the advanced wealthy nations. SPC in such instances delivers useful guiding information for the current situation, outcome prediction, a suitable corrective and preventive (CAPA) action such as in the present report. Although the number of outbreaks that were mediated from food sources was descending for 20 years, sudden inflection was reported in the number of overall outbreak cases after the year 2008 in the USA. This spiking was primarily originated from the person-to-person mode of transmission, in addition to other less influential causes which may be known (such as water, environmental and/or animal contact) or undetermined [9].
Control charts provide an important mean to visualize the pattern of the outbreak for each state, its footprint, and the alert level for the excursions in the number of sick individuals per a single event of outbreak. This observation is a part of greater monitoring research to cover the country and predispose an approach to implement a simplified method for risk assessment development to assess the outbreaks quantitatively. Like this study with variation, trending charts have been used previously in other researchers’ studies for the detection of the nosocomial infection outbreaks [15]. Importantly, the application of the commercial statistical software has facilitated on-time monitoring of the inspected characteristic using process-behavior charts. The average and UCL are the outbreak quantitative parameters during the inspection period of the study. In addition to the magnitude, frequency and type of the alarming signals could be elucidated from the constructed chart and progressively updated with data to reveal the process change or drift either to an improvement or deterioration.

From the current study, it can be concluded that the huge outbreaks remain a serious national and even international problem that threaten human health and life with great financial, time, manpower, and effort lost due to a non-productivity period of citizens coupled with resources wasted to combat the outbreaks. This health challenging issue annoys the developed nations and devastates most of the poor countries which suffer from the lack of rigorous monitoring and control in the presence of carelessness, ignorance, and perception of the problem. Outbreaks are incidents that are impossible to avoid. Nevertheless, they can be maintained under a process of continuous monitoring and control to contain them if there are suitable, rapid, and effective countermeasures for the etiological agents available on demand. Further study is required in this case to stratify outbreak records according to geographical, demographical, ecological, etiological, and the primary mode of transmission.

**Conflict of interest**

The authors declare that they have no conflict of interest.

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**References**