December 2022 MITE Hot Topic: P-Charts for Statistical Process Control

Author: Hilary Perrey, MHA, LSSBB, CPHQ

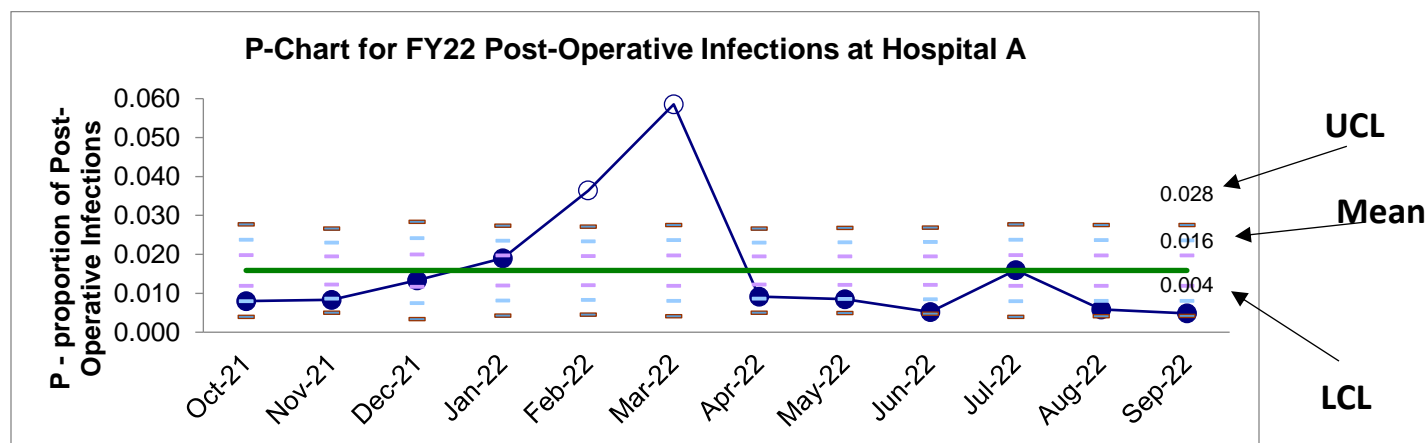MHPI, Improvement Specialist II

Learning Objectives:

1. Describe what p-charts are and how we use them in performance improvement.
2. Explain how to create p-charts.
3. Illustrate a helpful p-chart example.

What is statistical process control (SPC) and how can this be helpful in my performance improvement or quality improvement project? SPC is a standard methodology for measuring, monitoring, and controlling quality during a process using control charts (Minitab 2022)[1]. In 1924, Walter Shewhart of Bell Laboratories developed control charts, also called Shewhart charts, to describe whether a process is in statistical process control[2]. In the November 2020 edition of MITE Hot Topic, Dr. Parker described the concepts of common cause and special cause variation. SPC allows us to distinguish whether a system change represents common cause or special cause variation. The p-chart is an attribute control chart and is used to monitor the proportion of defective items where each item can be classified into one of two categories, like pass or fail (Minitab 2022)[3]. It is one of the most common SPC used in healthcare. Attribute data can be counted and plotted as discrete events. The subgroup size, or sample size, is variable and is usually >= 50 (The Memory Jogger Healthcare Edition)[4].

Examples:

- % of patients with post-operative infections
- % of patients who failed to keep medical appointments
- % of patients who fell on a unit

The p-chart below shows FY22 post-operative infections at Hospital A and was created using SigmaXL, a Microsoft Excel add-in. Please note this data was developed for the purpose of this exercise.

Why do we use p-charts here?

The p-chart is an appropriate statistical process control chart to use when analyzing post-operative infections. Post-operative infections vary monthly and this data shows the proportion of infections relative to total number of surgeries.

How do we create and interpret the p-chart?

There are several statistical tools in addition to SigmaXL which can be used to create p-charts and other control charts including R, a free statistical software program, SAS Enterprise Guide, and Minitab.

In order to create a p-chart using SigmaXL, data must be entered in columns in Microsoft Excel. The example data below was graphed to create the p-chart: month, number of post-operative infections (numerator), and the number of surgeries (denominator). By selecting these columns in SigmaXL, this will create a p-chart. The fraction of infections are calculated below as a percentage of the monthly total surgeries (# of post-operative infections/# of surgeries * 100), so you can see the monthly variation.

Month	# of Post-Operative Infections	# of Surgeries		% of Monthly Total
Oct-21	8	1,000		0.80%
Nov-21	10	1,200		0.83%
Dec-21	12	900		1.33%
Jan-22	20	1,050		1.90%
Feb-22	40	1,100		3.64%
Mar-22	60	1,025		5.85%
Apr-22	11	1,200		0.92%
May-22	10	1,175		0.85%
Jun-22	6	1,150		0.52%
Jul-22	16	1,000		1.60%
Aug-22	6	1,025		0.59%
Sep-22	5	1,033		0.48%

The dots which are graphed in the p-chart correspond to the monthly proportion of post-operative infections which are also seen as percentages in the column below. Simply, multiply the proportion on the p-chart by 100 to see what the monthly % defective is. In March 2022, the % of post-operative infections peaked at 5.85% (note: this corresponds to 0.0585 on the p-chart). The mean is 0.016 or 1.6%. The upper control limit (UCL) is 0.028 or 2.8% while the lower control limit (LCL) is 0.004 or 0.4%. Control limits are generated by the statistical package and are used to apply rules for special cause variation.

A process is considered to be out of statistical control when one or more points fall outside of the control limits. There are several other rules used to determine if your process is out of statistical control beyond this particular rule. In February and March 2022, post-operative infections are at an all-time high and are out of statistical control – the white open circle dot is used to indicate that they are out of statistical control. After initiating improvement work in March, post-operative infection rates fell between April – September 2022 with an increase in post-operative infections just above the mean in July 2022. Hospital A's improvement work was successful in reducing post-operative infections between April – September 2022 and the process stayed in statistical control.

References:

1. [Real-Time SPC | Statistical Process Control Software | Minitab](#)
2. [Walter A Shewhart, 1924, and the Hawthorne factory - PMC (nih.gov)](#)
3. [Overview for P Chart - Minitab](#)
4. The Memory Jogger II Healthcare Edition: A Pocket Guide of Tools for Continuous Improvement and Effective Planning. MemoryJogger.org
5. [p-Charts - SPC Charts Online](#)