SPC Case Studies — Answers


**Purpose:** The following examples illustrate the basic principles, breadth of application, and versatility of control charts as a data analysis tool.

**CASE I: Flash sterilization rate**

**Issues:**

- The infection control (IC) committee at a 180-bed hospital notices an increase in the infection rate for surgical patients. A nurse on the committee suggests that a possible contributor to this increase is the use of flash sterilization (FS) in the operating theatres.

- Traditionally, FS was used only in emergency situations—for example, when an instrument was dropped during surgery—but recently it seems to have become a more routine procedure. Some committee members express the opinion that a new group of orthopaedic surgeons, who recently joined the hospital staff, might be a contributing factor—that is, **special cause variation**. This suggestion creates some defensiveness and unease within the committee.

- Rather than debating opinions, the committee decides to take a closer look at this hypothesis by analysing some data on the FS rate (number of FS per 100 surgeries) to see how it has varied over time. The committee’s analyst prepares a **u chart** (based on the Poisson distribution, fig. 1) to determine the hospital’s baseline rate and the rate after the arrival of the new surgeons.

**Description:**

- **Q1:** *What is the mean FS rate at baseline? Is the process in control? Why?* During the baseline period the mean FS rate was around 33 per 100 surgeries (the centre line on the baseline control chart) and the process appeared to be in control.

- **Q2:** *Is there a change in mean FS rate on arrival of new surgeons? Give examples.* Arrival of new surgeons indicated an increase (special cause variation) to a mean FS rate of about 50 per 100 surgeries. For example, the third point data (week 13) is beyond baseline UCL mean, as are weeks 17, 18, 19, and 21.

- **Q3:** *What additional tests signal statistical evidence of significant shift in process performance?* Additionally, several clusters of two out of three points are more than 2SD beyond the mean, several clusters of four out five points are beyond 1SD, and all of the new points are above the baseline period mean. All these signals are statistical evidence of a significant and sustained shift in process performance. The IC committee can now look further into this matter with confidence that it is not merely an unsupported opinion.

- **Discussion Question 4:** *Does this analysis lead to the conclusion that the new surgeons are to blame for the increase?* It must be noted that this analysis does not lead to the conclusion that the new surgeons are to blame for the increase. Rather, the data simply indicate that it is highly likely that something about the process of handling surgical instruments has fundamentally changed, coincident with the arrival of the new surgeons. Further investigation is warranted.
CASE II: Laboratory turnaround time (TAT)

Issues:
- Several clinicians in the A&E department have been complaining that the turnaround time (TAT) for complete blood counts has been “out of control and constantly getting worse”.
- The laboratory manager decides to investigate this assertion with data rather than just opinions.
- The data are stratified by shift and type of request (urgent versus routine) to ensure that the analysis is conducted by reasonably homogeneous processes.

Description:
- Since TAT data often follow normal distributions, X-bar and S types of control charts are appropriate here (fig 2).
- Each day the mean and SD TAT were calculated for three randomly selected orders for complete blood counts.
- The top chart (X-bar) shows the mean TAT for the three orders each day, while the bottom chart (S) shows the SD for the same three orders; during the day shift the mean time to get results for a routine complete blood count is about 45 min. with a mean SD of about 21 min.

Discussion Question I: Are the Clinicians’ complaints justified? If the clinicians’ complaints were true, out of control points and an overall increasing trend would be observed. Instead, it appears that the process is performing consistently and in a state of statistical control. Although this conclusion may not agree with the clinicians’ views, common cause variation does not necessarily mean the results are acceptable, but only that the process is stable and predictable. An in control process can therefore be predictably bad.

Discussion Question II: What should the team do next? In this case the process is stable and predictable but not acceptable to the clinicians. Since the process exhibits only common cause variation, it is appropriate to consider improvement strategies to lower the mean TAT and reduce the variation (lower the centre line and bring the control limits closer together). This would produce a new and more acceptable level of performance. The next steps for the team are therefore to test an improvement idea, compare the new process with these baseline measurements, and decide whether the process has improved, stayed the same, or worsened.
CASE III: Surgical Site Infections

Issues:

- An interdisciplinary team has been meeting to try to reduce the postoperative surgical site infection (SSI) rate for certain surgical procedures.
- A \textit{g type} of control chart (based on the \textit{geometric} distribution) for one type of surgery is shown in fig. 3.

Description:

- Instead of aggregating SSIs in order to calculate an infection rate over a week or month, the \textit{g} chart is based on a plot of the number of surgeries between occurrences of infection.
- This chart allows the statistical significance of each occurrence of an infection to be evaluated\textsuperscript{1} rather than having to wait to the end of a week or a month before the data can be analysed.
- This ability to evaluate data immediately greatly enhances the potential timeliness of the analysis. The \textit{g} chart is also particularly useful for verifying improvements (such as reduced SSIs) and for processes with low rates.
- An initial intervention suggested by the team is to test a change in the postoperative wound cleaning protocol.
- \textbf{Discussion Question I: Does this change have impact on reducing infection rate?} As shown in fig. 3, however, this change does not appear to have had any impact on reducing the infection rate. Although this intervention did not result in an improvement, the control chart was useful to help prevent the team from investing further time and resources in training staff and implementing an ineffective change throughout the hospital.

Description Con’d:

- After more brainstorming and review of the literature, the team decided to try experimenting with the \textit{shave preparation technique} for preparing the surgical site before surgery.
- Working initially with a few willing surgeons and nurses, they developed a new shave preparation protocol and used it for several months.

\textbf{Discussion Question II: Did the change result in an improvement, or not? Why?} The control chart in fig. 3 indicates that this change resulted in an improvement with the SSI rate reducing from approximately 2.1\% to 0.9\%. (For this type of chart the mean SSI rate is the reciprocal of the centre line: $1/47 = 2.1\%$ compared with $1/111 = 0.9\%$.) Note that on this type of chart data plotted above the UCL indicate an improvement, as an increase in the number of surgeries between SSIs equates to a decrease in the SSI rate.
CASE IV: Appointment Access Satisfaction

Issues:

- A GP practice is working hard on improving appointment access and has decided to track several performance measures each month.

Description:

- A small survey has been developed to gauge patients’ satisfaction with several aspects of appointment access (delay, telephone satisfaction, in office waiting times, able to see provider of choice, etc.).
- The percentage of patients who respond “very good” or “excellent” to the question of how satisfied they were with the delay to get an appointment with their primary care provider is plotted on a $p$ control chart (based on the binomial distribution) shown in fig. 4.
- After exploring ideas that had been successful for other practices, the staff implemented several changes at the same time: reducing the number of appointment types, simplifying the telephone scripts, and offering appointments with the practice nurse in lieu of the doctor for certain minor conditions.

Discussion Question I: Was there an improvement in appointment access satisfaction after changes were implemented? Do we know to what extent each change contributed to the improvement? Can this chart be used to monitor sustainability of improvements? As shown in the control chart, there was a notable improvement in appointment access satisfaction soon after these changes were implemented. Since the changes were not tried one at a time, however, we do not know the extent to which each change contributed to the improvement; further testing could be conducted to determine this, similar in approach to traditional screening experiments. This chart can also be used to monitor the sustainability of improvements by detecting any future special cause variation of a decrease in appointment access satisfaction.
CASE V: Infectious Waste Monitoring

Issue:
- If several staff were asked to identify the criteria for determining what constitutes infectious waste in a hospital, a wide variety of responses would probably be obtained.

Description:
- Faced with this lack of standardization, most hospitals spend more time and money disposing of infectious waste than is necessary. For example, recent studies in the US found that less than 6% of a hospital’s waste can be considered infectious or hazardous.
- It has also been estimated that an average-size hospital spends the equivalent of a new CAT scanner every year disposing of improperly classified infectious waste such as soft drink cans, paper, milk cartons, and disposable gowns. Armed with this knowledge, a team decides to address this issue.
- Since the team had no idea how much infectious waste they produced each day, they first established a baseline.
- As shown on the left side of fig. 5 (an $XmR$ chart based on the normal distribution), the mean daily amount of infectious waste during the baseline period was a little over 7 lb (3.2 kg).

Discussion Question I: Is an improvement strategy appropriate? Why? (Clue – left side fig. 5). The process was stable and exhibited only common cause variation, so an intervention improvement strategy is appropriate. If the process is not changed, the amount of infectious waste in future weeks might be expected to vary between 6 lb (2.8 kg) and 8.2 lb (3.7 kg) per day.

To reduce the mean amount of infectious waste produced daily, the team first established a clear operational definition of infectious waste and then conducted an educational campaign to make everyone more aware of what was and was not infectious waste. They next developed posters, designed tent cards for the cafeteria tables, made announcements at departmental meetings, and assembled displays of inappropriate items found in the infectious waste containers.

Discussion Question II: What are the results of this educational effort? (Clue – right side fig. 5). The results of this educational effort are shown on the right side of fig. 5. The process has shifted to a new and more acceptable level of performance. Since the process has clearly changed, new control limits have been calculated for the data after the improvement. The new mean daily production of infectious waste is a little more than 4 lb (1.8 kg) per day. The control chart provided the team with a useful tool for testing the impact of these efforts. In this case, the shift in the process was very noticeable and in the correct direction.

Discussion Question III: Would you conclude that all changes implemented led to desired results? What is the new challenge for this team? It is interesting, however, that, although the mean amount of waste was reduced, these same improvements inadvertently also caused the day-to-day variation to increase (note the wider control). Not all changes lead to the desired results. A challenge for the team now is to reduce the variation back to at least its original level.