Commentary

Understanding and Controlling Variation in Public Health

Marlene J. Mason, MBA, BSN; John W. Moran, MBA, MS, PhD, CMC, CQIA, CMQ/OE

Variation in work processes is a critically important concept and method for creating true and sustainable improvement in public health services and activities. This article describes the concept of variation based on W. Edwards Deming's profound knowledge and defines basic terms such as common cause and special cause variation. Control charts are explained as the primary tool for calculating variation within work processes. The article also provides an example of how variation theory can be applied to create sustainable improvement in public health.

KEY WORDS: common cause variation, control charts, special cause variation, variation in public health, work process

We must understand variation.

—W. Edwards Deming[1]

Imagine this scenario: Mary Smith arrives at the Best Health County Health Department for her family planning clinic visit. She is a single mom with 3 children younger than 5 years. She definitely wants to get an effective method of birth control and, therefore, prevailed on her neighbor to watch the children for an hour and a half while she attended this appointment. The clinic receptionist pleasantly asks Mary to have a seat as they are running behind and it will be a few minutes. As 15 and then 30 minutes go by, Mary gets more frantic. She checks with the receptionist who tells her it will just be a few more minutes. When the staff comes to get Mary for her appointment after she has waited 45 minutes, Mary is gone, and 6 weeks later, without the needed birth control, Mary is pregnant again. It is then that we often ask: "Could this situation have been prevented and if so, how?" Part of the answer lies in understanding and controlling variation. W. Edwards Deming considered the understanding and application of the theory of variation critically important to improving our services and products.

What is this thing called variation and how should we apply it in our work? *Variation* is the difference between what should be happening (ideal) and what is happening (current state). In any process that delivers a product or service to a customer, we observe variation in how the service is delivered by the people involved in the process. Dr Deming stated, "Variation there will always be, between people, in output, in service, in product. What is the variation trying to tell us?"[2]

According to the *law of variation* as defined in the *Statistical Quality Control Handbook*[3]:

- "Everything varies." In other words, no 2 things are exactly alike.
- "Groups of things from a constant system of causes tend to be predictable." We cannot predict the behavior or characteristics of any one thing. Predictions only become possible for groups of things where patterns can be observed.

Dr Deming stated that of all the problems encountered in processes about 80% to 85% are caused by common causes and about 15% to 20% are caused by special causes[4] and that both occur naturally in every process. It is critical that we address common cause variation

Author Affiliations: MarMason Consulting LLC, Kirkland, Washington (Ms Mason); and Public Health Foundation, and University of Minnesota School of Public Health, Minneapolis (Dr Moran).

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Correspondence: Marlene (Marni) Mason, MBA, BSN, 10620NE 125th Place, Kirkland, WA 98034 (marni@marmason.com).

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differently than special cause variation to improve our processes.

Common Cause and Special Cause of Variation

Common cause variation is the result of many factors inherent to the work process, acting totally at random and independently of each other with small effect on the process. Some examples of common cause variation are materials, equipment, people, environment, poor training, inappropriate methods or procedures, poor work area design, inconsistent processes, and measurement error.

Special cause variation is a nonrandom event that is evident by using a control chart to identify when data points are outside of control limits, indicating they are not part of the stable process. Special causes of variation are indicators or clues that something unpredictable is different in the process, affected by and attributable to some external factor(s). Examples of special cause variation are natural disaster, environmental disaster, mechanical failure, toxic waste in landfill, catastrophic water system failure, power failure, computer system crashes, pandemic influenza outbreak, or power spikes.

Dr Deming stated, "Confusing common causes with special causes will only make things worse."[5] When analyzing variation, there are 2 types of problems we could encounter, the first is we could mistake the cause of variation as being special in nature, when in fact it is [common or] random and caused by the system. The second problem is we identify it as a common cause of variation when in fact it is special cause and should be eliminated.

Common cause variation should be addressed by redesigning the work process not by addressing each instance of variation. If we treat a common cause of variation as a special cause, we may implement a short-term fix to a stable process, which may cause more variation throughout the system. This is often called tampering with the system!

Special causes usually have an immediate negative impact on the system and are not predictable or stable. When they are detected, we usually try to put a quick fix in place to stop the negative impact and then search for the root cause. Once the root cause is detected, we can develop a longer-term permanent remedy to protect the system against future occurrences.

When we misinterpret the type of variation we are dealing with we spend money and time to fix something that does not need fixing. In this case we find ourselves taking action when doing nothing would be the best course.

Is It Common Cause or Special Cause Variation?

Getting back to the story of Mary Smith, the unpredictable wait times—consistently more than the acceptable threshold of 10 to 15 minutes-–led leadership to choose this problem for a quality improvement (QI) project. The QI Team decided to use a systematic method to address this situation, applying variation theory to help solve the problem. To do this, they first had to determine which factors were built into the clinic visit process (common cause factors) and which were not built into the process (special cause).

One of the teams' first actions was to collect data to understand the actual wait times, shown in the run chart below. They found that wait times varied with no predictability of when a shorter or longer wait would occur. In this run chart, the data point of 45 minutes is obviously far higher than the other data points and may be a special cause. All the other data points are common cause variation and any improvement to these wait times must be accomplished by redesigning the clinic visit process itself (Figure 1).

Describing and Visualizing Variation

One of the first applications of variation theory occurred when Dr Walter Shewhart of the Bell Laboratories was developing ways to make a more reliable telephone. He realized that it was important to have an understanding of the causes of variation in the Laboratories' processes.[6] To make meaningful improvements, he realized that he had to understand which variations in the way the work was done had no assignable cause (common cause) and those variations that had an assignable cause (special cause). Again, common causes are those that are built into the way the work is done and special causes are events that are not built in (or are not "common") to the work process.

Dr Shewhart developed the Control Chart[7] as a means of visualizing variation in a process and determined that data points within the control limits on the control chart indicate the presence of common cause variation. The Control Chart starts with a Run Chart and then calculates upper and lower control limits that are 3 standard deviations from the median. Data points lying outside of the control limits, in most cases, indicate special cause variation. If all the data points are within the control limits, we are dealing with a stable and predictable process and any variation observed is common cause and this process will produce that same variation over time. If a process has only common cause variation present, the process output is predictable and

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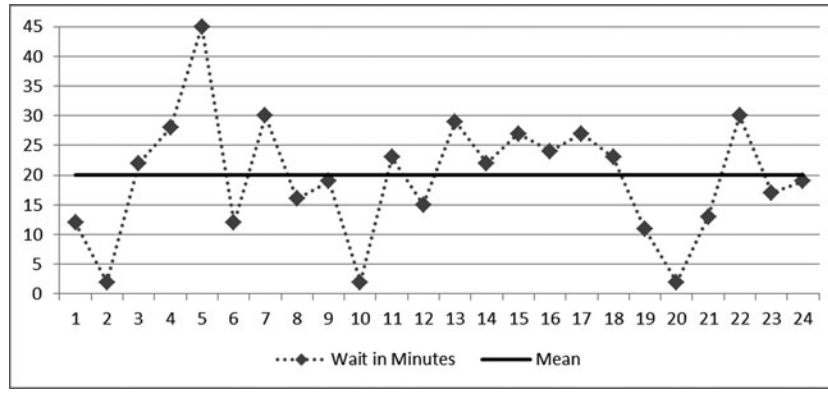
FIGURE 1 ● Run Chart of Wait Times.



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can be expected to fall within a defined range of values. If the process shows a special cause, it will not be predictable and performance will not fall within a defined range of values and the output cannot be reliably predicted.

Dr Shewhart understood that to make improvements to a stable process, we must make fundamental changes to the process itself. In other words, a redesigned process must be developed that eliminates or reduces the steps or tasks in a process that contribute to the current common causes of variation.

Application of Variation Theory

At the Best Health County Health Department where Mary Smith had her visit, the QI team investigated some of the common variation in the clinic visit process. The QI team redesigned the client flow to customize it based on which services they needed. This redesign resulted in the clinic visit wait times becoming much more predictable and within acceptable waiting times. A work flow chart describes the steps in a process using standard symbols to indicate points of tasks, decisions, data entry, and other types of work activities.

The example flow chart below, from the Greenville, South Carolina QI project shows an excerpt of how the steps in the client visit were streamlined, depending on the needs of the specific client. Each tier in the workflow indicates a different type of provider seen by the client. This stabilized the wait times for the family planning clinic in this health department (Figure 2).

Calculating Variation in Processes

In public health, we deal with individuals on a regular basis and most of our services are used by individual clients. Variation will always exist in any service provided because individuals are inherently different in what they want and demand. In addition, those that provide the services also differ in their approach and delivery of the service. Variation is a complex topic to understand but it is one we can describe and visualize for a process through measurement. We can describe how a process is operating by using the following 6 basic statistical measures:

1. Mean average value, which is the total data values divided by the total number of observations.
2. Mode—the most frequently occurring values in the set of data.
3. Median—the middle value in the data set, half of the data value lie above, half lie below the median.
4. Range—highest to the lowest observation in a set of observations.
5. Variance—a measure of the dispersion or variation of a random variable about its mean.
6. Standard deviation—how tightly all the various data points are clustered around the mean.

We want to understand variation in a process and what it is trying to tell us. The statistical measures mentioned earlier give us clues to what the variation is trying to tell us. These measures help us get an idea of how the process is centered or skewed, the range of the data, the spread of the data, how it compares to other processes, and what percentage of the data lies within a specified number of standard deviations from the mean.

These descriptive statistic measures can be enhanced by plotting the data so it can be seen visually. A histogram will show the basic shape and spread of the data. A run chart can be used to show how data are trending over time. Once we have the process under control, we can use a control and range chart to show how the process is performing over time. The control

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FIGURE 2 ● Example Flow Chart of Workflow.

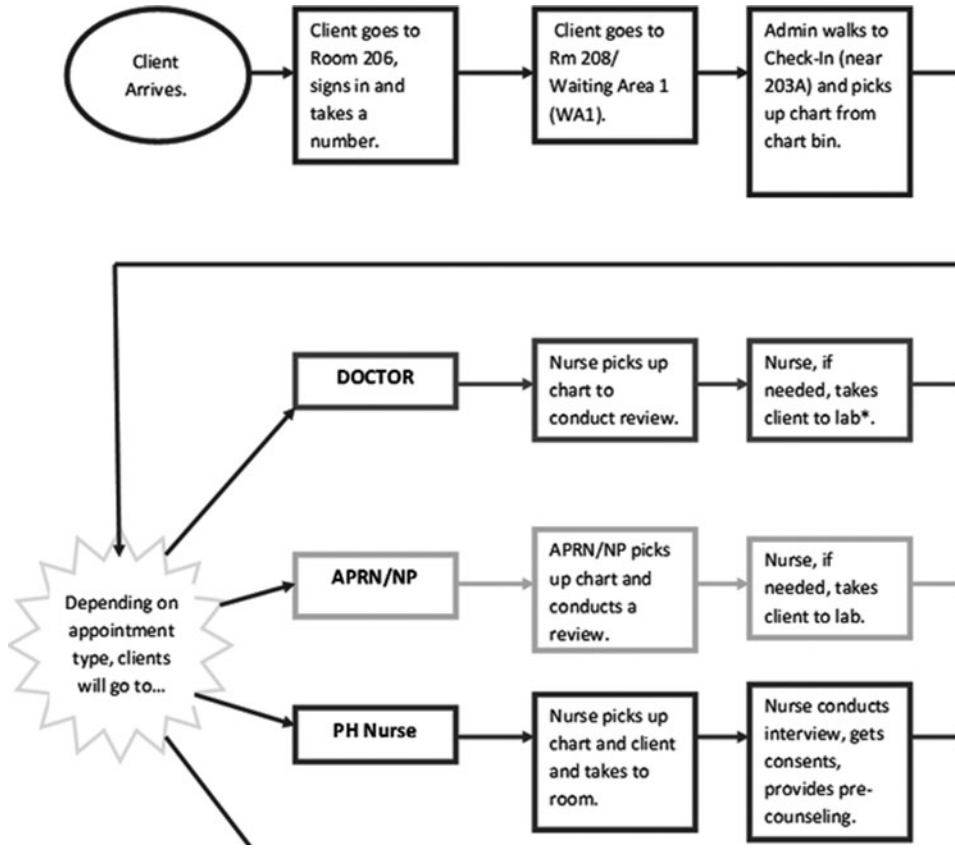

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chart shown below is from the Greenville Health Department in South Carolina and shows the impact on wait times of the improvement made in the clinic visit workflow. The wait times are consistently shorter and more stable (Figure 3).

Regular measurement and plotting of operational process data help us understand when we should leave the process alone or when to make adjustments when things get out of control. These measurements will also help us understand how the process has changed, the magnitude of the change, and the improvements achieved when an adjustment is made.

● Preparing for Unintended Variation

Too often we feel at the mercy of unintended variation in a system and wish we could have had the foresight to see the special cause in advance and prepare for it. The Process Decision Program Chart is a tool that can help systematically identify what might go wrong in a system under study.[8] This tool helps anticipate problems in advance so contingency plans can be developed and ready for implementation when a problem occurs. This is a useful tool for a management team to use to review a major system and try to figure out what can go wrong over a specific time period.

A few questions for a management team to use in analyzing a system as to what components might fail are:

- If we wanted this to fail, how could we accomplish that?
- What assumptions are we making that could turn out to be wrong?
- What has been our experience in similar situations in the past?
- Does this depend on actions, conditions, or events? Are these controllable or uncontrollable?

The team can rate each item as to its probability of happening from low to high. The highly rated items should be classified as to those you have control over, those you could influence, and those that you have no control over. Contingency plans can be developed for

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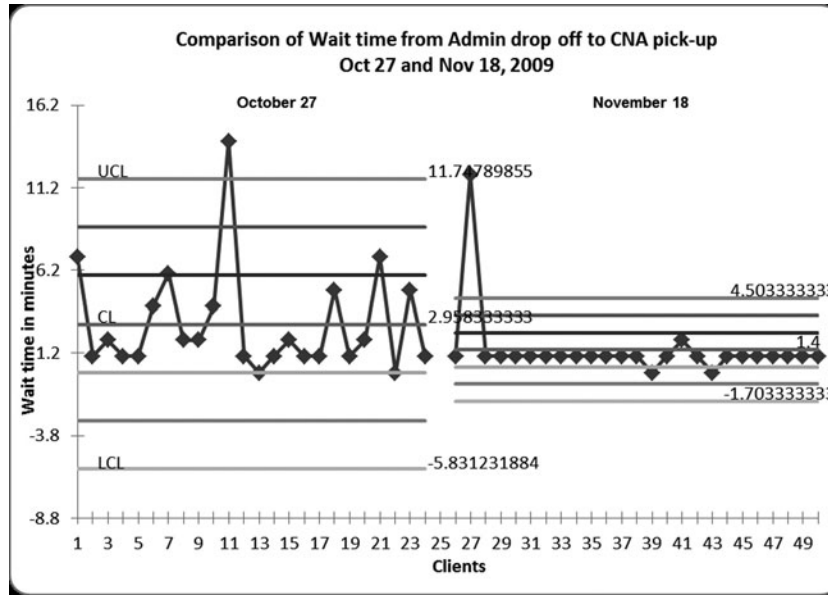
FIGURE 3 ● Control Chart.



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those you have control and influence over and reactive plans can be developed for those you have no control over. Variation will still be present but you will be prepared to deal with the special causes in a more logical manner and not a reactive one.

Summary

Dr Deming describes the benefits of a stable process as one where a process has an identity and its performance is predictable; therefore, there is a rational basis for planning. Costs and quality are predictable. Productivity is at a maximum and costs are at a minimum for the process. The effect of changes in the process can be measured faster and more reliably.[9] The key to understanding any process is to develop process indicators, measure them on a regular basis, plot the data, develop a control chart, and control limits, and react if things get out of control. In addition, use the Process Decision Program Chart on a regular basis to plan for unintended variation. By appropriately applying the theory of variation to public health practice, we will make our processes more efficient and effective and increase our ability to prevent illness and protect the public.

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