CHAPTER TWENTY-TWO

# MEASUREMENT AND MONITORING

## Chapter Purpose

*Aim.* To understand how to make and interpret run charts and control charts, two methods for measuring and displaying data trends over time.

*Objectives.* At the completion of this unit, you will be able to

- Describe how plotting data over time and using run charts and control charts fit into the improvement process.
- Make and interpret a run chart.
- Make and interpret one type of control chart.

The focus in this chapter is planning measurement specific to PDSA ↔ SDSA cycles to determine whether change ideas are really improvements. A goal of the Dartmouth Microsystem Improvement Curriculum is to build the capability of microsystem staff to improve quality of care and their own worklives by becoming a community of scientists. Scientists reflect on the world around them, they make hypotheses about causes and effects (what causes what), they run experiments (tests of change) to test their hypotheses, and they collect data to provide evidence to support or reject their hypotheses.

One way to look at the plan-do-study-act ↔ standardize-do-study-act (PDSA ↔ SDSA) process is to view it simply as putting the scientific method into a clinical microsystem's everyday work of finding better ways to do things. Clearly, the PDSA ↔ SDSA model represents the scientific method that we all learned in high school and college. The use of this model in health care organizations represents a way to popularize and localize the scientific method.

As you saw in our discussion of PDSA and SDSA in Chapter Fourteen, the improvement process includes gathering data related to your aim to determine whether a change is an improvement. The *plan* step involves planning data collection, the *do* step involves collecting data, and the *study* step involves evaluating the data to determine the pilot test's effect on specific aim-related measures.

Also, as you learned in our earlier discussion about the improvement ramp, the overall idea is to define your microsystem's global aim and to find a measure that can be tracked over time to determine whether all the changes you make as you ascend the ramp are helping your system to approach the target value that represents success.

In general you will want to use trend charts, such as run charts and control charts, to determine whether you are making measurable progress on reaching your aim. Once you have achieved your aim, you will want to use trend charts to monitor performance over time so you can avoid slipping back into a worse performance zone without quickly knowing it (see Figure 22.1).

As your clinical microsystem progresses to become increasingly performance driven and process minded, you will build out your data wall and graphical displays that will feature trend charts for showing changes in critical measures over time and for monitoring performance to make sure that the microsystem is maintaining consistent, high-level performance.

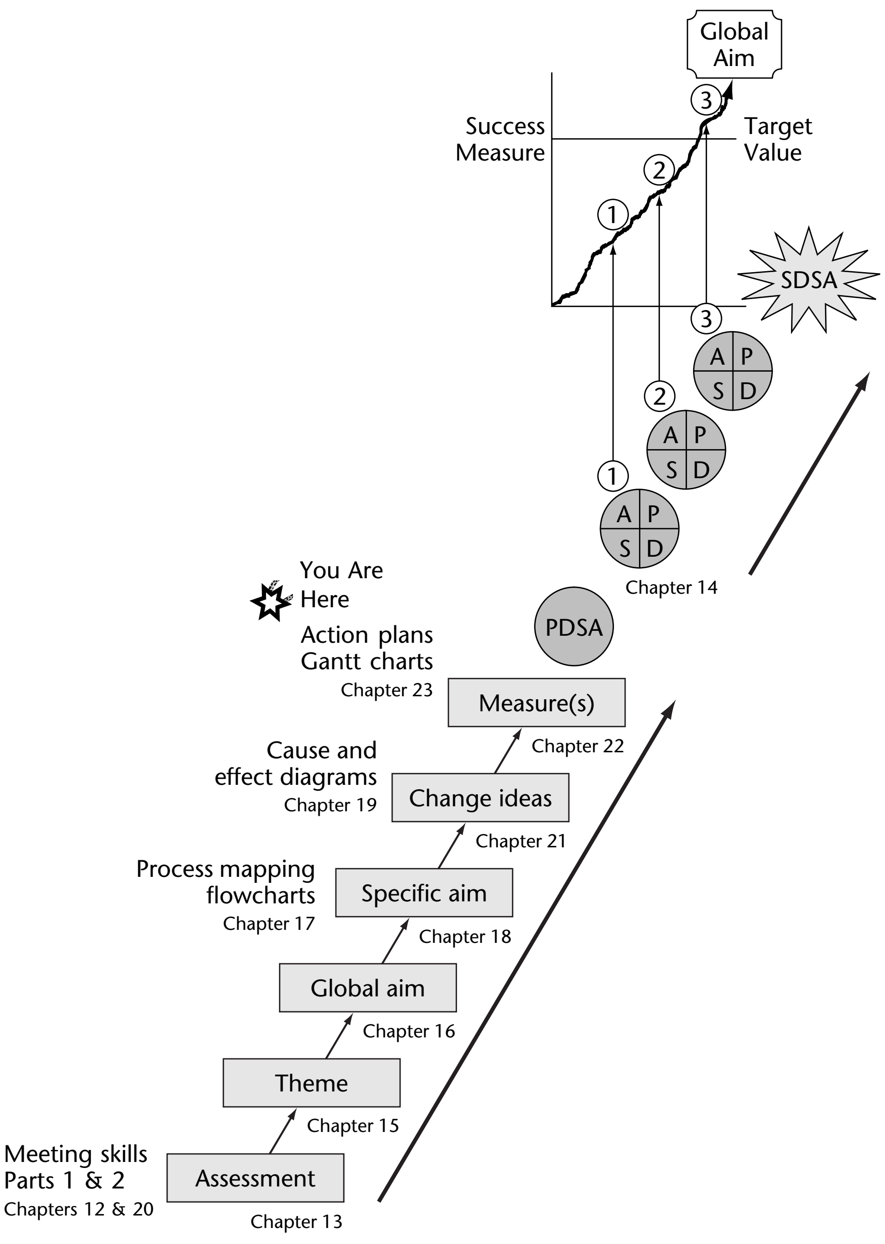
## What Are Measures, What Makes Measures Good, and How Do They Relate to Aims?

In general you can think of *measures* (or *variables*) as things to be counted so you can evaluate the amount (or the status) of a thing of interest. People in clinical microsystems use many different types of measures to evaluate such interesting and important things as quality, safety, costs, satisfaction, productivity, reliability, and so forth.

Good measures have several important characteristics.

- Good measures can provide an answer to a critical question. For example, an emergency department might ask, "Have we reached our specific aim of doing an ECG and drawing cardiac enzymes on every appropriate patient within fifteen minutes of arrival?" and the appropriate measures would answer that question.

**FIGURE 22.1. IMPROVEMENT RAMP: MEASUREMENT.**



- Good measures are sufficiently accurate (reliable and valid) for the purpose at hand, such as having your own local, relevant evidence on your microsystem's level of performance.
- Good measures have such basic working parts as
  - A descriptive name
  - A conceptual definition describing the measure
  - An operational definition describing the method to be used to score or categorize the measure
  - Graphical (or tabular) data displays that can be used to answer the critical question

It takes good measures to determine whether your global aim and specific aims are being met.

Recall that the basic model for improvement begins with three questions (see Chapter Fourteen).

1. *Aim.* What are we trying to accomplish?
2. *Measures.* How will we know that a change is an improvement?
3. *Changes.* What changes can we make that will result in an improvement?

Look again at the improvement ramp, and you will see how all of this fits together—aims, measures, use of the scientific method in the form of PDSA to make changes to reach a targeted level of performance, and use of SDSA to maintain the needed level of performance.

## What Is a Run Chart?

A *run chart* is a graphical data display that shows trends in a measure of interest; trends reveal what is occurring over time. Run charts are the most common type of trend chart, and we all are accustomed to seeing them in newspapers, financial reports, reference books, and particularly in modern improvement work.

A run chart shows data points in time order. The value of the measure of interest is shown on the vertical dimension and the value of the measure at each point, *running* over time, is shown on the horizontal dimension. You will often see run charts used to show trends related to patients or organizations or clinical units. You might make or see run charts for many different measures, for example:

- Fasting blood sugar. Blood sugar levels for a person with diabetes might be plotted daily for a month (see Figure 22.2).

**FIGURE 22.2. RUN CHART DISPLAYING FASTING BLOOD SUGAR LEVELS.**

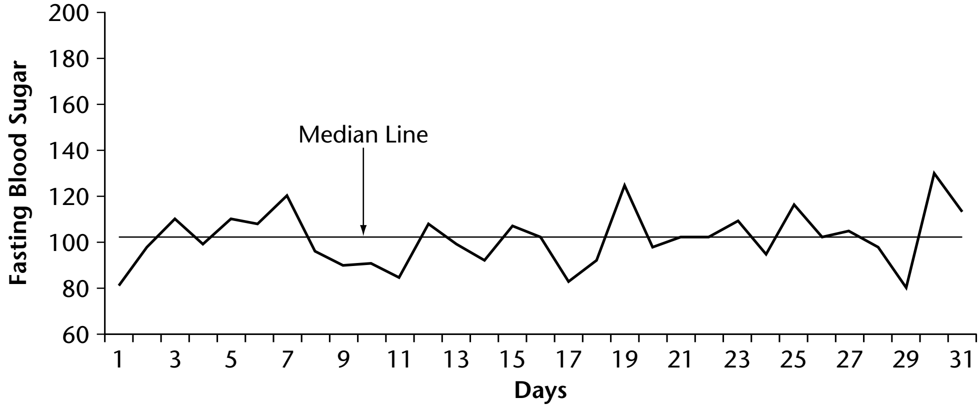
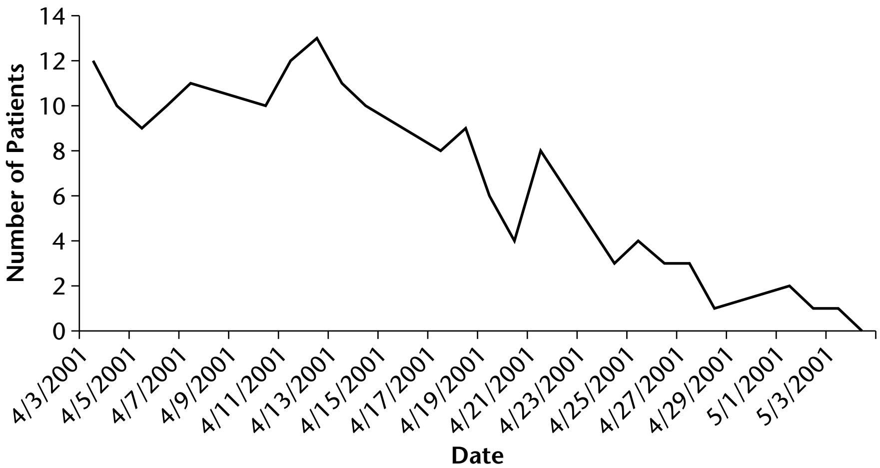
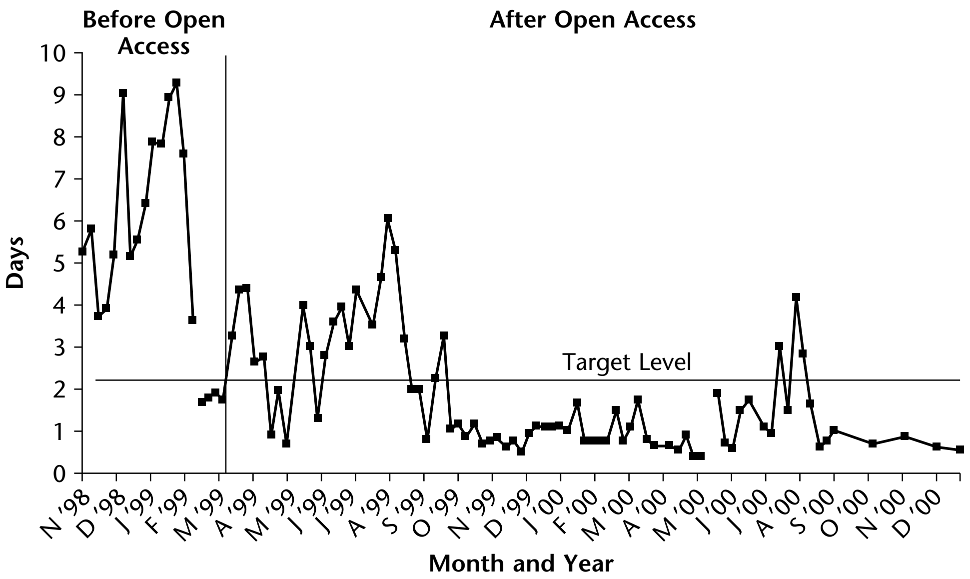



**FIGURE 22.3. RUN CHART DISPLAYING NO SHOWS.**




- No shows. The number of patients who do not arrive for an appointment at a clinic might be plotted daily for a month (see Figure 22.3).
- Appointment access. The number of days to the third next available appointment might be plotted over a two-year time period as changes are made to improve access to care (see Figure 22.4).

**FIGURE 22.4. RUN CHART DISPLAYING DAYS TO THIRD NEXT AVAILABLE APPOINTMENT.**




## What Are the Benefits of Using a Run Chart?

There are many advantages to using run charts:

- They are easy to make and easy to interpret.
- They provide a "picture" that reveals how the process is performing, communicating more information more clearly than a table that contains the same information.
- They can be used for several important purposes:
  - To detect problems that might otherwise go unnoticed
  - To see if your microsystem is performing at the targeted level
  - To determine if a change (or all the changes being made) is associated with movement of an aim-related measure in the right direction
  - To show how much variation there is in the process you are working to improve, which may give you a hint about the underlying system of causes influencing the process

## How Do Run Charts Fit in the Overall Improvement Process?

As represented in the improvement ramp (Figure 22.1), one place that run charts fit into the overall improvement process is to show if the changes being made are causing an aim-related outcome measure to move into the targeted zone of success. Consequently, as soon as a general aim is established it is important to find a way to measure current performance of a measure related to that aim and to track movement in this measure over time as changes are planned and executed. What you want to do is to make the most powerful changes possible in the least amount of time to attain the desired level of performance as measured by run chart (time-trended) results.

Run charts also fit into the overall improvement process when your lead improvement team is conducting individual tests of change using PDSA cycles. Each cycle may involve using run charts to see if specific changes are being made in upstream processes (doing something "this way each time") or in *downstream* results (getting certain outcomes as a result of doing it "this way each time").

## What Do Run Charts Tell You About Your Performance Level and Variation?

Run charts show the amount of the measure on the vertical axis, and they show the time when this value occurred on the horizontal axis. As the number of data points builds up, and as you start connecting the data points, you see some important things:

- First, you see whether or not the measure is "running" in the targeted or desired zone. Measures related to aims should, in general, have a specified target value that can be used to determine if performance is adequate or inadequate.
- Second, you see how much variation there is point to point and over time. In general you want to have results that stay in the targeted performance zone, or at the desired level, with only a small amount of variation. When this state of affairs is achieved, you have a reliable process that is producing consistent results that are at the desired level.

## What Are Special Cause and Common Cause Variation?

It should be noted here that as you gain knowledge about causes and effects you will also gain knowledge about sources of variation. Deming popularized the idea of two types of variation: special cause and common cause.

- *Common cause variation* occurs when the system of causes, or the web of causation, is relatively consistent and the variation in outcomes is being produced by *chance causes,* by random variation in the causal system.
- *Special cause variation* occurs when the system of causes, or the web of causation, experiences a *new* or *special* or *assignable* cause(s) that enters the causal system for either a short or extended period of time and that has an effect on outcomes beyond what can be accounted for by random variation.

All causal systems have common cause—that is, chance or random—variation. Sometimes causal systems have both common cause and special cause variation embedded in them.

Common causes typically take the form of a large number of small and ongoing sources of variation. For example, random variation in arrival times of patients to a clinic might be due to such things as weather, vehicle problems, parking issues, traffic volume, and so forth. Special causes are not part of the process all of the time. They arise from less ordinary circumstances. For example, patients arriving late to a clinic due to a strike by bus drivers are being affected by a special cause.

For another example, imagine that you are on a track team and run the 100-meter dash in twenty track meets. If you stay in about the same physical condition, then your times will vary by a few tenths of a second up or down depending on such common causes as the direction of the wind, how quickly you react to the starting gun, the condition of the track, and so forth. However, if you are injured one day, if you pull a muscle in your leg and have severe pain, your time for the 100-meter dash that day will be several seconds slower, because of the special leg problem. Once your muscle pull heals, and you are back to normal, your times will return to their prior performance zone. This is a simple example of a system that has both common cause and special cause sources of variation.

When making improvements, it is important to know if the system you are seeking to make better is subject to only common cause, or random, variation or if it is subject to both common cause and special cause variation.

- If it has special cause variation—and this variation causes extraordinarily poor results,—then you will want to identify the special cause and find a way to remove it (or design it out of) the system. For example, if access to care is poor every

February because many staff take a vacation during a school holiday, then you might wish to set up a policy that rations time off during the choicest time periods.

- If it has special cause variation and if this variation causes extraordinarily good results,—then you will want to identify the special cause and try to find a way to reproduce it (or design it into) the system. For example, if one physician's patients with newly diagnosed hypertension do much better at rapidly reducing their blood pressure and keeping it in a safe zone than the patients of all the other clinicians in the practice do, then it might be helpful to determine what process that one clinician uses to educate newly diagnosed patients with hypertension, and to encourage the other clinicians to try adapting that process to their patients. This is the practice of process benchmarking, whereby you identify the best process, the one that produces consistently superior results, and attempt to incorporate this best process's features into your own process.
- If it has common cause variation only and yet the performance level is not adequate or is too highly variable, then the best way to improve the process is to use disciplined improvement work or to make innovations in the way the process works.

The reason you need to understand common cause and special cause variation is that part of the value of trend charts—both run charts and control charts—is that they provide your microsystem with a method for determining whether or not its processes are subject only to common cause variation or if they are subject to both common and special cause variation. As you will see, the rules for interpreting run chart and control chart results give you a way of judging the likelihood that your outcomes are subject to special cause as well as common cause variation.

## How Do You Make a Run Chart?

You may find it helpful to use a data collection tool for making run charts and control charts (see Figure 22.5).

Here are some general steps for making a run chart.

1. Select a measure that can answer a critical question.
2. Document your operational definition to explain the details of how you will collect data on the measure.
3. Make a plan (who does what, when, in following which process) to collect data on the measure at set intervals, such as hourly, daily, weekly, or monthly.
4. Collect data on the measure, and record them on a measurement worksheet.
5. Make your run chart.
   a. Plot your data points in a time-ordered sequence. Use the vertical dimension to show the value of the measure and the horizontal dimension to show variation over time.

# FIGURE 22.5. WORKSHEET FOR COLLECTING DATA TO MEASURE A KEY VARIABLE.

## MEASUREMENT OF KEY VARIABLE

**Variable:** **Unit of Measure:** **Method of Measurement:**

1. Enter your data

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
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| **Date** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Time** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Measures ($X$)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Moving range ($R$)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

2. Do these calculations

Average = $\overline{X}$ = __________ Sum of $X$'s / # of $X$'s Upper Natural Process Limit = $\overline{X}$ + (2.66 x $\overline{R}$) = __________

Moving Range = $R = (X_2 - X_1)$ Absolute #'s only Lower Natural Process Limit = $\overline{X}$ – (2.66 x $\overline{R}$) = __________

Average Range = $\overline{R}$ = __________ Sum of $R$'s / # of $R$'s Upper Control Limit for Range Limit = 3.27 x $\overline{R}$ = __________

3. Plot limits, data, averages

| **Measurements ($X$)** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
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| **Moving range ($R$)** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
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   b. Name your run chart. A good way to do this is to write the question that the run chart answers above the run chart. For example:
      - Are the fasting blood sugar levels of this patient in a safe zone?
      - Do our diabetic patients have HbA1c levels under 7?
      - How long do patients need to wait for an appointment?
6. Connect the data points to make it easy to see the pattern they represent.
7. Calculate the mean or the median to show where the distribution is centered.
8. Make sense out of the results by studying them and understanding their pattern, following the common rules for interpreting run charts.
9. Overlay the target value for the measure that you have set as a performance goal and determine whether the process being measured has or has not yet reached the desired level, or whether it is approaching the target level.

As a rule of thumb, you should seek to have about twenty-five or more data points to determine the pattern of results that your process is producing. Wheeler (1993) recommends this number as a minimum for process analysis but states that you can begin to make provisional assessments with as few as twelve data points.

## How Do You Interpret Run Chart Results?

Use these questions to interpret the pattern of results represented in your run chart.

1. Is the measure running at or above the target level?
   - If the measure is at or above the target level, what actions might you take to maintain the process? Consider using SDSA.
   - If the measure is below the target level, what actions might you take to improve or innovate? Consider using PDSA.
2. How much variation is there in the measure?
   - Do the levels of the measure's high points or low points mean that the process is unreliable?
3. Are there any special cause signals? Here are some of these signals:
   - Eight data points in a row are above or below the center line (the mean or the median value).
   - Six data points in a row are going up.
   - Six data points in a row are going down.

A word of caution about point 3. There are many different guidelines for detecting special cause patterns in process performance data plotted on run charts. The three special cause rules we have listed are often used to interpret run chart results, but they are not perfect rules. It is possible to get a pattern of points that matches one of these rules and for this signal to be a false alarm. The odds of the alarm's being false are relatively small, but the more rules that are used, the more likely it is to get a false alarm (Wheeler, 1995, chap. 1, "Shewhart's Control Charts").

## What Is a Control Chart?

Run charts and control charts are similar in that they both use time-ordered data. The difference is that control charts provide limits within which observed variation can be characterized as random and expected, and outside which you can recognize variation as extraordinary. With control charts you have more ways than run charts provide to detect special cause signals.

As mentioned earlier there are three common rules for detecting special cause signals in run charts. These same rules apply to control charts but additional rules can be used with control charts because they have an added feature, calculated upper and lower *control limits,* or upper and lower *natural process limits,* that can be used to detect special causes in your process.

We illustrate the essential difference between these two types of trend charts in Figures 22.6 and 22.7.

Figure 22.6 shows the gross anatomy of a run chart. It has a variable, *X,* whose value is measured on the vertical dimension and is shown at each point in a time-ordered sequence on the horizontal dimension. The run chart also has a center line based on either the calculated average value or the median value of the points.

Figure 22.7 shows the gross anatomy of a control chart. It has all the features of the run chart but in addition has upper and lower *calculated limits.* These calculated limits are shown, by convention, as dotted lines and are called the *upper control limit* (UCL) and *lower control limit* (LCL), respectively. Another set of terms for these calculated limits, one that Wheeler prefers (1993, 1995), is *upper natural process limit* and *lower*

**FIGURE 22.6. GROSS ANATOMY OF A RUN CHART.**

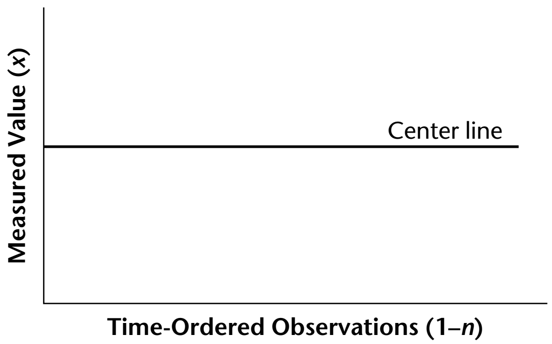


**FIGURE 22.7. GROSS ANATOMY OF A CONTROL CHART.**

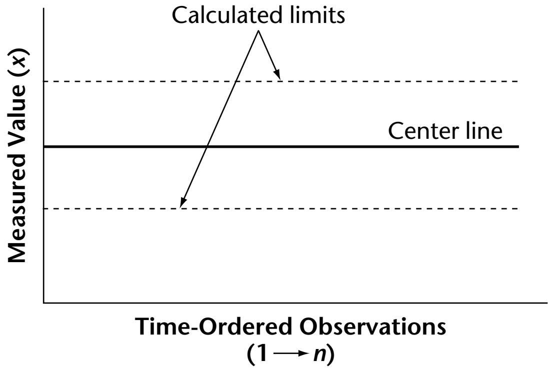
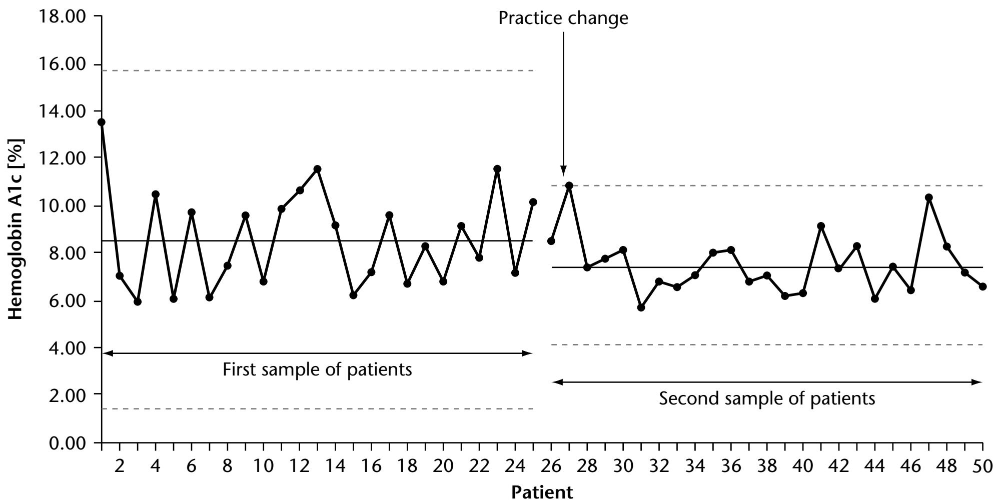



**FIGURE 22.8. CONTROL CHART FOR INDIVIDUALS WITH DIABETES IN A GENERAL MEDICINE PRACTICE.**




*natural process limit.* Wheeler prefers this terminology because it is a better reflection of the principle of special cause and common cause variation, described earlier.

In general you can interpret the results of a run chart by looking for data points above the upper limit or below the lower limit. If a data point falls *outside* these calculated upper or lower limits, it is a special cause signal, because the likelihood that a point will fall outside these limits due to a common cause is very low (less than 1 out of 100).

Figure 22.8 provides a real-life example of a control chart, one that a physician colleague of ours (Mark Splaine) used to measure progress in managing blood sugar levels in his patients with diabetes. This figure shows that after Splaine made changes in his practice, the average level of blood sugar control improved and the variation over time was reduced.

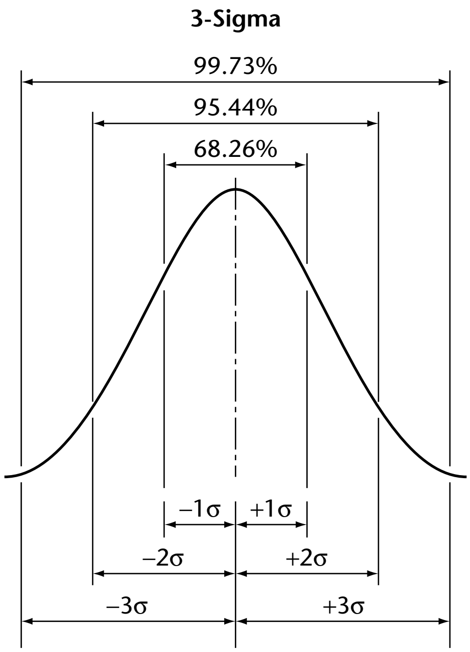
## What Is the Theory Behind Control Charts?

The term *control* chart is short for *statistical process control* (SPC) chart. What control charts reveal is whether observed variation in a process is consistent with random variation due to innumerable common causes. When variation occurs within control limits, the process is said to be in *statistical control,* free from special cause effects or assignable cause variation. The process is subject only to chance factors or random cause variation.

As mentioned earlier, calculated upper and lower control limits (or, more correctly labeled, statistical process control limits) are added to a run chart to make it into a control chart. Control limits are calculated on the basis of statistical theory describing distribution of values within any population of data.

Figure 22.9 shows a typical normal distribution (called *normal* because it applies to so much of the data that we all typically encounter). It is also known as a Gaussian

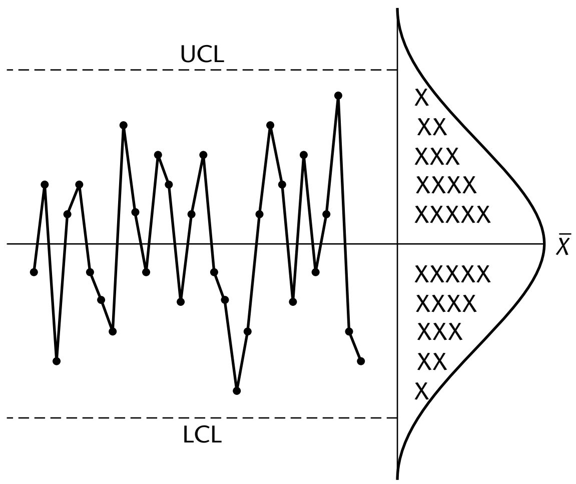
**FIGURE 22.9. NORMAL DISTRIBUTION, AKA THE BELL CURVE.**



(after Gauss, the person who first described it) or bell (for the obvious reason) curve. The normal distribution is formed by showing graphically the spread of results from observing a variety of samples (a sample might be, for example, a group of patients) drawn from a universe of possible samples. What the normal distribution shows is that samples tend to have average values that center on the true average value but that most samples are either above or below the true average value by a little bit, by a medium amount, or by a large amount. The likelihood that a sample's value will be close to the true average value is greater than the likelihood that it will be far away. The mathematics for normal distributions uses the concept of *standard deviations* of values from the true center value of the distribution. The way this works is that about 68 percent of sample values will fall within 1 standard deviation (1 SD, or 1 sigma) and that about 95 percent of sample values will fall within 2 SD, or 2 sigma, and that more than 99 percent will fall within 3 SD, or 3 sigma.

Upper and lower control limits are generally calculated so that values that fall outside 3 SD are displayed as falling outside the control limit. Those data points that fall outside 3 SD, or 3 sigma, are very unlikely to happen by chance. The normal distribution tells us that the vast majority of data points (99.73 percent) will fall within the upper and lower range (within 3 SD) and thus it is likely that the process is experiencing special causes when a point falls outside these calculated statistical process control limits. Figure 22.10 illustrates this concept by juxtaposing a control chart and the normal distribution. The reason for setting your limits

**FIGURE 22.10. CONTROL CHART IN RELATION TO NORMAL DISTRIBUTION.**



at 3 standard deviations rather than 2, as is customary in much scientific writing, is based on Walter Shewhart's observation that it is generally more effective, from a practical, economic point of view, to restrict investigation for special causes to situations in which the data are quite different from what one would expect, not just somewhat different (Shewhart, 1931/1980, 1939/1986).

## What Are the Benefits of Using a Control Chart Instead of a Run Chart?

The primary benefit of using a control chart is that it provides another guideline for identifying special cause signals. When you see a run chart, you will often see a point that looks extremely high or extremely low relative to the other points. You might be tempted to say that something special is happening. But absent calculated control limits, it is not possible to know from the chart itself whether this apparently very high or very low point is likely to be due to chance variation or likely to signal a special cause event or pattern.

## What Are the Different Kinds of Control Charts?

Because there are different types of measures (that is, different kinds of variables), there are different types of control charts. What they all have in common is the mathematics of probability theory. The basic idea is that your choice of control chart depends on the type of measure that you are using.

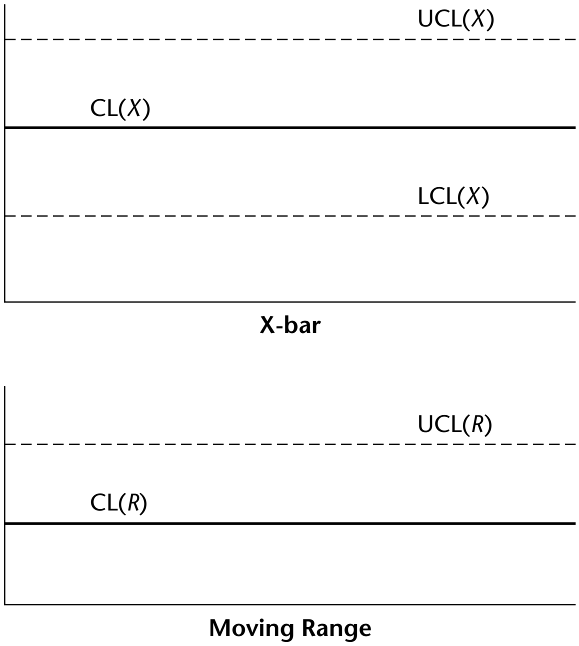
Measures can be made using various methods for counting or classifying data. Here are two common types of measures:

- *Variables* data are measures of such things as times, blood glucose levels, dollars, or other types of counts or measures that can conceivably take any value (that are *continuous*). A good control chart for variables data is the XmR chart.
- *Attributes* data are measures of such conditions as infected/not infected, defective/not defective, error/no error, and other types of classifications that indicate whether a characteristic is present or absent in each case examined. Attributes data for a series of cases are often summarized as a proportion: for example, the proportion infected or the proportion defective or the proportion with error. A good control chart for attributes data is the P-chart.

## What Is an XmR Control Chart?

Because the most common types of measures involve variables data we will discuss the XmR control chart in this chapter.

**FIGURE 22.11. GROSS ANATOMY OF AN XMR CHART.**



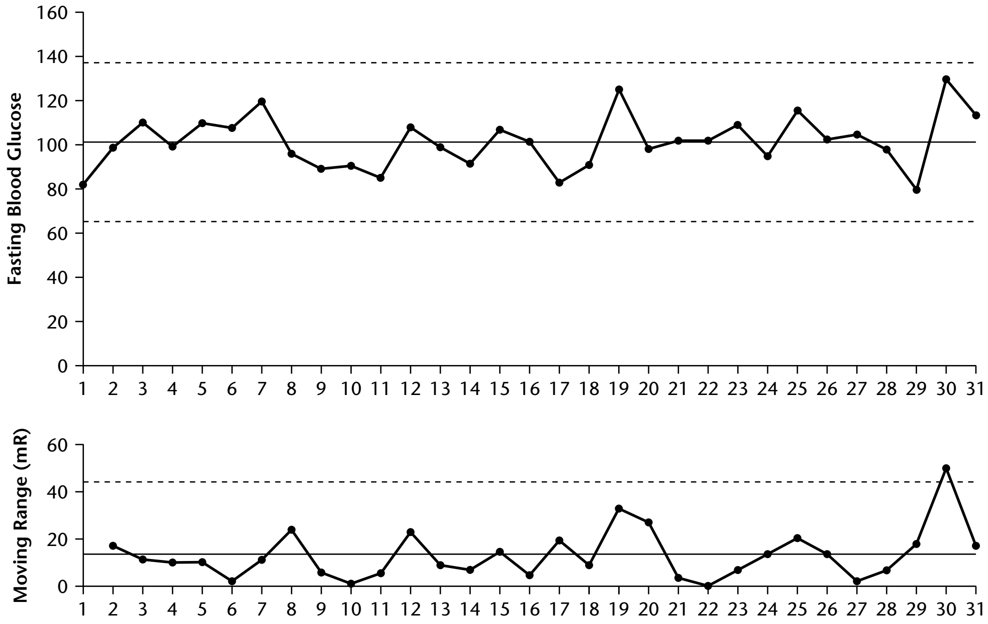

The XmR chart is both versatile and relatively easy to make. The calculated control limits use simple formulas that require only basic arithmetic (adding, subtracting, multiplying, and dividing) and nothing more. An excellent book that introduces both control chart thinking and the use of the XmR chart is *Understanding Variation,* by Donald Wheeler (1993); it is a good book for novices to read to gain insight and practical knowledge on the topic of control charts.

Figure 22.11 shows the basic anatomy of an XmR control chart. It is made by using a pair of trend charts. The upper chart (the *X*-bar display) shows each value and its average over time. The lower chart (the moving range display) shows the amount of difference between successive points and their average difference, each from its predecessor, over time. An example of an actual XmR chart for fasting blood glucose levels in an individual patient is shown in Figure 22.12.

## How Do You Make an XmR Control Chart?

You can use the data collection worksheet (Figure 22.5) to turn your run chart into an XmR control chart. Instructions are summarized on the worksheet and discussed in more detail here:

**FIGURE 22.12. XMR CHART SHOWING FASTING BLOOD SUGAR VARIANCE IN ONE PATIENT OVER ONE MONTH.**




1. Specify the name of your measure (variable, for example, systolic blood pressure), the unit of measure (for example, mm) and the method of measurement.
2. Enter your data:
   a. The first two rows provide space for entering the data and the time of data collection and can be used when helpful.
   b. Row 3 provides space for entering the value of each measurement that you take.
3. Do these calculations:
   a. Moving range. Row 4 provides space to enter the moving range. This is done by calculating the absolute value of the difference between each two time-ordered points: that is, the difference between Points 1 and 2, then the difference between Points 2 and 3, then the difference between Points 3 and 4, and so forth.
   b. Average = *X* bar. The sum of the measures in Row 3 divided by the number of measures listed in Row 3 (the sum of the *X*'s divided by the total number of *X*'s).

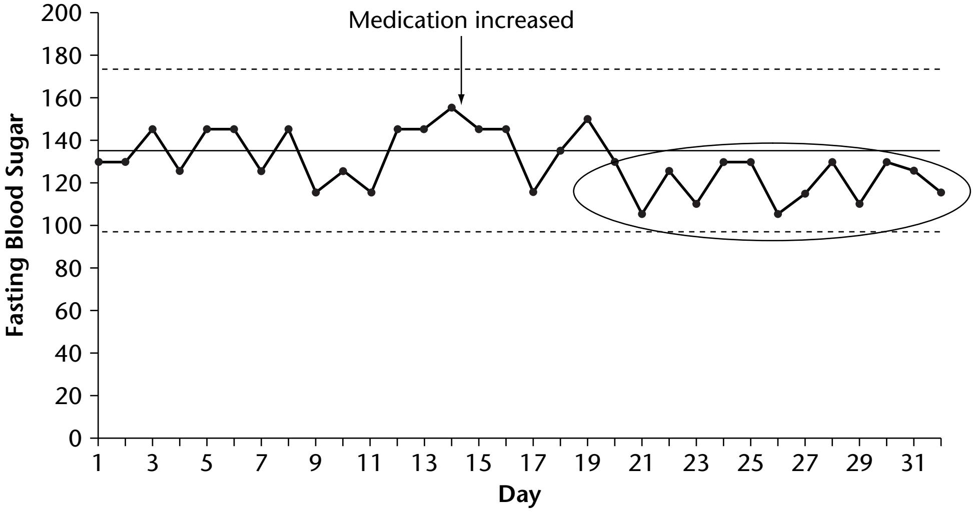
   c. Average range = $R$ bar. The sum of the measures in Row 4 divided by the number of moving ranges in Row 4 (the sum of the $R$'s divided by the total number of $R$'s).
   d. Upper natural process control limit (UCL) = $X$ bar + (2.66 × $R$ bar).
   e. Lower natural process control limit (LCL) = $X$ bar – (2.66 × $R$ bar).
   f. Upper control limit for moving range = $UCL_R$.
4. Plot your data for the upper chart showing the time trend for your measures (values of $X$), keeping in mind that the upper and lower control limits must fit onto the chart:
   a. Plot the data for each point in time order (all the $X$'s), and connect the dots.
   b. Draw the center line, using the average value of all the $X$'s ($X$ bar).
   c. Draw in the upper control limit for $X$, using a dotted line.
   d. Draw in the lower control limit for $X$, using a dotted line.
5. Plot your data for the lower chart, showing the time trend for the moving range between your measures (values of $R$):
   a. Plot the data for each point in time order (all the $R$'s), and connect the dots, keeping in mind that the upper control limit must fit onto the chart.
   b. Draw in the center line using the average value of all the $R$'s ($R$ bar).
   c. Draw in the upper control limit for $R$ ($UCL_R$), using a dotted line; there is no lower control limit for the moving range because absolute values are used to show point-to-point variation.
6. Interpret the results by studying them and understanding the patterns; use the common rules for interpreting control charts.
7. Overlay the target value (on the upper chart) for the measure that you have set as a performance goal and determine whether your system has or has not yet reached the desired level or whether you are approaching the target level.

## How Do You Interpret Control Chart Results?

As we mentioned earlier, you can interpret your control chart results using the same approach used for run charts except that now you have another way to identify possible special cause signals in your data. You will know you have a likely special cause signal when one or more points fall outside the upper or lower control limits.

Figures 22.13, 22.14, and 22.15 illustrate special cause signals occurring in control charts.

**FIGURE 22.13. SPECIAL CAUSE SIGNAL: EIGHT CONSECUTIVE POINTS ON SAME SIDE OF CENTER LINE.**




**(Limits based on readings prior to medication change.)**

**FIGURE 22.14. SPECIAL CAUSE SIGNAL: SIX CONSECUTIVE POINTS TRENDING IN THE SAME DIRECTION (UPWARD IN THIS CASE).**

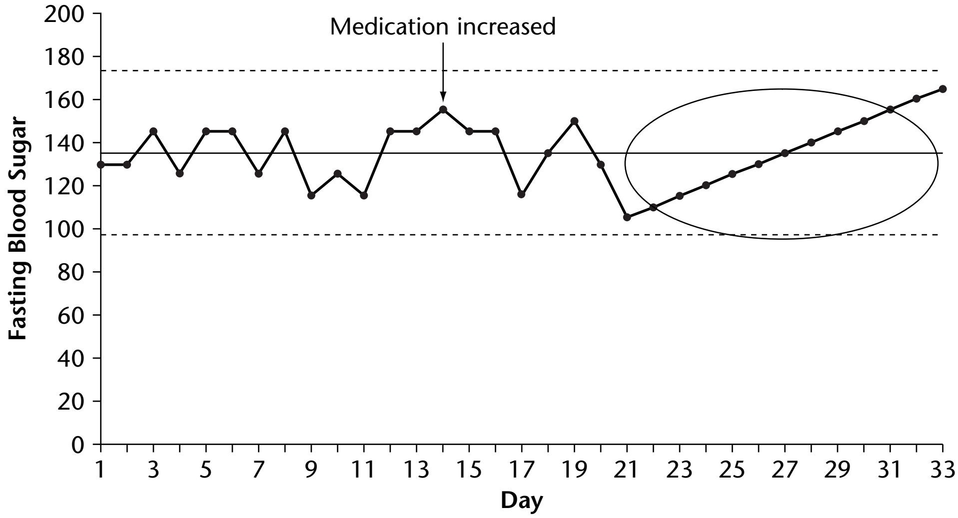
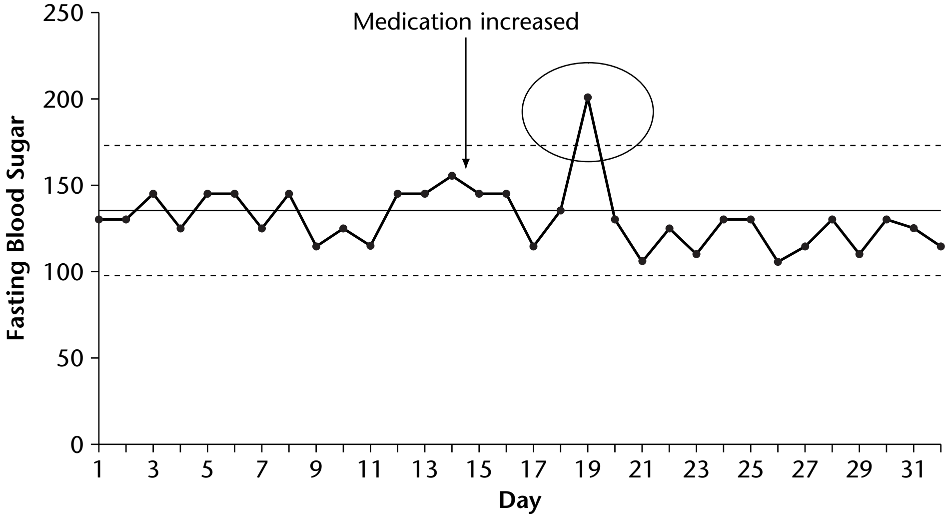


**FIGURE 22.15. SPECIAL CAUSE SIGNAL: A POINT OUTSIDE A CONTROL LIMIT.**




## When Do You Recalculate Control Chart Values?

As you start using control charts and run charts in your microsystem—and as you measure processes and make changes that lead to improvement—you will also need to know when to recalculate the values (the average value and the upper and lower control limits) on your control charts.

For example, once you have ascended the improvement ramp and your microsystem has achieved a new level of performance, you should consider recalculating the center line and the control limits, using the new pattern of data that your process is producing. To do this, you will accumulate twelve to twenty-five new observations, made after the level of performance changed, and use this new series of data points to calculate the center line and the control limits. You may wish to make provisional calculations based on twelve points and then make further calculations—ones that you expect to be "fixed" for a time—after reaching twenty-five data points.

In general it is smart to consider recalculating your control chart's average value and control limits when you see any substantial change in the process (in a positive or a negative direction) signaled by a consistent shift in the data (such as consistently running eight or more points above or below the center line).

## What Are Some Tips for Using Run Charts and Control Charts?

- *Take intelligent action.* Remember that the purpose of measuring and monitoring is to gain information that helps you answer critical questions and then to take intelligent action. The more you use your data to answer good questions and to guide action, the more successful you will be at improving processes and in taking some of the *chaos* out of your microsystem's worklife.
- *Make a data wall.* Display a data wall that has run charts and control charts, and use it to discuss everyone's work.
- *Hold daily huddles.* Hold your daily huddles by your data wall so you can make use of that information to monitor your work and to stay close to improvements being tested.
- *Have a data captain.* Ask one of the numbers-oriented staff in your microsystem to serve as the data captain for a period of time and to take responsibility for making and posting trend charts. Alternatively, develop a *data squad* so that several members of the microsystem share this responsibility.
- *Stay close to the data.* When you are running tests of change, draw the run charts (or control charts) on large flipchart pages, and post new values as close to real time as possible (such as hourly, at the end of each shift, or at the end of the workday).
- *Take advantage of technology.* Use electronic spread sheets with control chart *macros* embedded in them to make it easy to enter data and to have your control charts "automatically" produced by the software. This is easy to do in standard spreadsheet programs, such as Microsoft Excel. Alternatively, use special statistical packages that have control charts and run charts included as options.
- *Compile trend reports.* Develop routine reports (daily, monthly, quarterly, and yearly) that make use of the power of showing trends in data over time and are based on run-chart and control-chart methods.

## Case Studies

### Intermediate Cardiac Care Unit (ICCU)

The measurements the ICCU lead improvement team tracked during the system's PDSA cycles included the following:

- Number of patients discharged before noon
- Portion of newly admitted patients who receive a bed assignment within thirty minutes of staff notifying the ICCU

- Patient satisfaction with the discharge and admission processes
- Staff ratings of interdisciplinary communication and ease of discharge and admission processes

### Plastic Surgery Section

Several measures were used during the lead improvement team's PDSA cycles to evaluate the impact of shared medical appointments. Patient satisfaction was measured through qualitative and quantitative measures. An important measure was whether or not the patients felt all their questions were answered. This patient-reported measure showed the greatest gain from the shared medical appointment process for patients considering breast reduction.

The primary success measure was access to care. The initial access backlog measure changed over time after shared medical appointments were launched. The baseline value for the third next available appointment was ninety-nine days and it improved to thirty days over a one-year period.

## Review Questions

1. How do control charts differ from run charts?
2. What is the importance of having a data wall for visually displaying measures?
3. How can you establish responsibility for data collection and analysis?

## Between Sessions Work

1. Create a run or control chart specific to your PDSA cycle.
2. Display the chart on a data wall for all staff to see real-time progress.
3. Build measurement into every microsystem member's activities.

## References

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