



Tips and Tools for Learning Improvement

# Measurement Variation vs. Improvement

## What are variation and improvement?

**Variation** is the natural up and down in the performance of a process. For example, if you walk from your house to the market, it may take you 30 minutes on average. However, each time you go, the amount of time it takes varies – 31 minutes one day, 28 minutes another, 33 minutes another, and so forth. **Figure 1** shows a time series chart with the variation of the process of walking to the market over a 12-day period. Each up and down in the graph does not represent a change in the process, but rather the variation that is normal for any process. To change the performance of the process significantly, you would need to do something differently, such as run, ride a bike, walk a different route, or drive in a car.

Changes in a process can lead to an **improvement** or decline in performance, or may not make a difference in performance. Whether an increasing or decreasing value is improvement or a decline in performance depends on the data being tracked. For example, increasing compliance with standards and decreasing morbidity would both reflect improvement. Sometimes, when collecting data over time, it can be obvious that things are improving rapidly. For example, **Figure 2** clearly shows a reduction in the percentage of men with infections following voluntary male circumcision, which is an improvement. The improvement team is achieving its goal of reducing the number of men with infections. In cases where the data points continue to move in one direction, it is easy to determine whether improvement has been made.

Figure 1. Variation example:  
Time to walk to the market daily

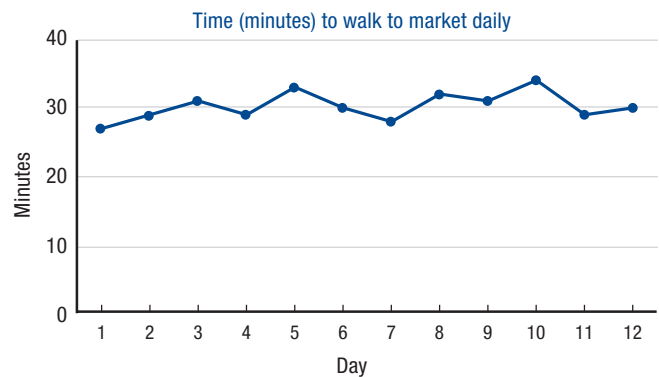
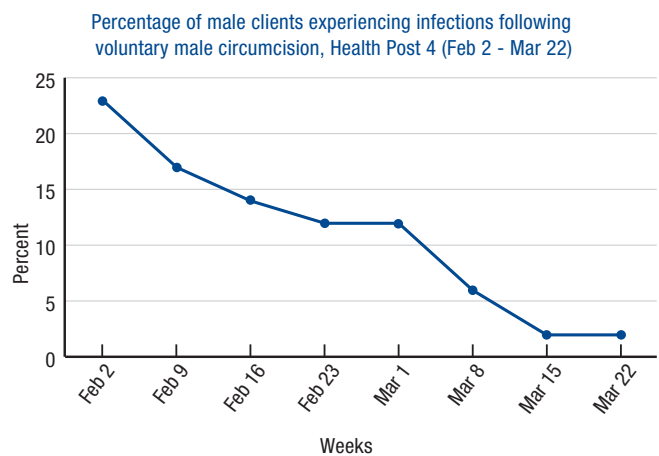


Figure 2. Example of improvement in outcome



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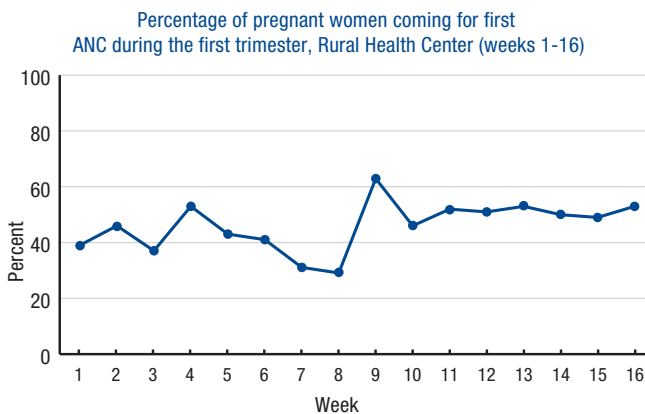
## Why is it important to understand variation?

Understanding the difference between variation and improvement is important because a slight increase or decrease between data points can be normal variation and does not necessarily signify improvement or decline in performance.

## How do you determine if a time series chart shows improvement?

Figure 3 shows an example of a time series chart that would need more analysis to determine if the process of getting pregnant women to come in for their first antenatal care (ANC) visit had improved. Looking at the chart you could interpret the data as showing that the process is getting worse between weeks 4 and 8 and then is improving in week 9. However, without further analysis you cannot be sure whether the process is declining and improving or simply shows variation in a process. There are simple rules you can use to figure out whether your time series charts show improvement.

Figure 3. Example of a time series chart with unclear performance



## Analyzing a time series chart

A run chart is a specific type of time series chart in which a set of rules are applied to analyze the data. The terms run chart and time series chart are often used interchangeably. You need 10 data points before you can apply run chart rules.

When you have at least 10 data points, you can also determine the middle or central value of the data points, called the **median**. See the text box for more information on calculating and plotting the median.

## How to calculate and plot the median.

1. List the numbers in order from smallest to largest.
2. If there is an odd number of data points in the set, take the number in the middle. For example, the median (or middle value) of the following set of 15 data points is the 8<sup>th</sup> number, or 11: 3, 4, 6, 7, 9, 10, 10, 11, 13, 14, 17, 17, 18, 20, 22
3. If the data set has an even number of data points, add the middle pair of numbers together and divide by two. For example, the median in the following set of 16 data points is the average of the 8<sup>th</sup> and 9<sup>th</sup> numbers, or 12: 3, 4, 6, 7, 9, 10, 10, 11, 13, 14, 17, 17, 18, 20, 22, 24 (median= (11+13)/2)
4. Draw a horizontal line on the time series chart to represent the median.

There are two main types of analysis (called run chart rules) that will tell you whether or not you have improvement: **trend** and **shift**.

**Trend:** Five consecutive increasing or decreasing points suggest a **trend**. A *trend is continued movement of data in a single direction, either up or down, and means that something has happened (a change) that is causing the process to perform differently, either improving or declining in performance.* You do not need the median to calculate a trend.

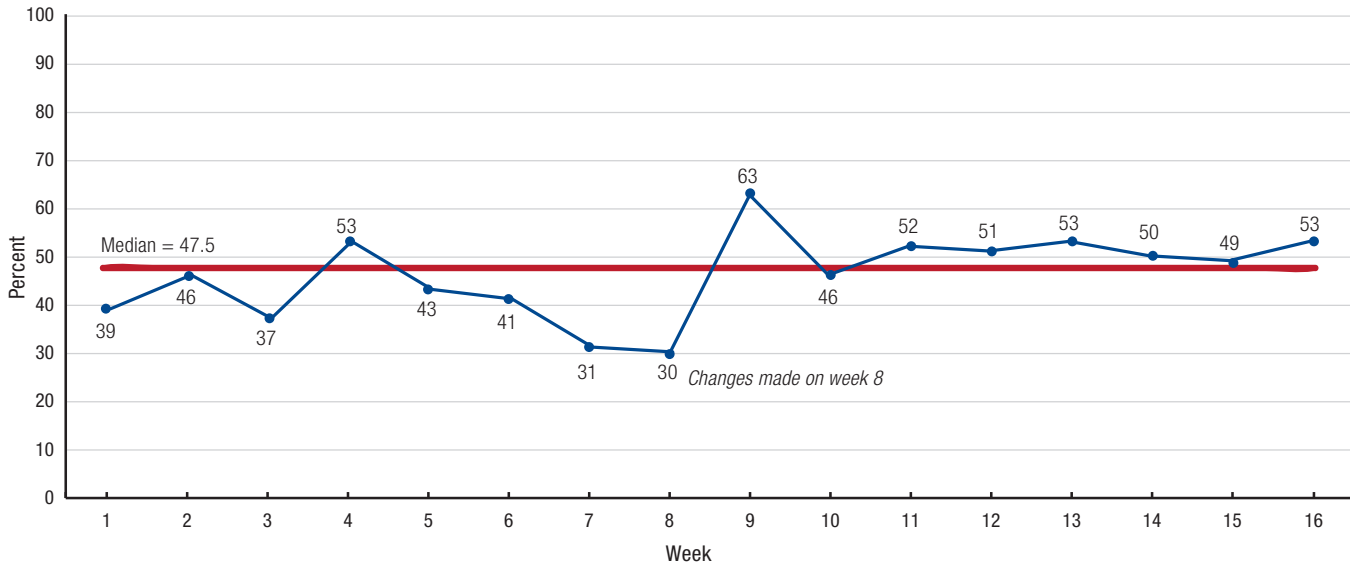
**Shift:** Six consecutive points above or below the median line suggest a **shift** in the process. A *shift is a pattern that shows that a change has caused the process to either improve or decline.* Before applying the run chart rules for shifts, it is important to calculate and plot the median. The median is the central value in a list of numbers.

In Figure 4, the median is 47.5. If we draw the median on the graph, we can see whether this example follows either of these run chart rules.

Let's analyze Figure 4. A median is not required to check for a **trend**. We start by comparing each point to the previous point. There are 4 decreasing points in a row from weeks 5 to 8 in the middle of the graph. We start counting the trend at week 5 because that is the first point to go down. Because five points are needed for a trend, the drop from weeks 5 to 8 is not a trend.

Figure 4. Example of run chart with median

Percentage of pregnant women coming for first ANC during first trimester, Rural Health Center (weeks 1-16)



The last six points on the graph are continuously above the median. Six data points above the median means that there has been a **shift** in the performance of the system. These six points do not need to be in increasing or decreasing order. You can have a shift without a trend. For the indicator “Percentage of pregnant women coming for first ANC during the first trimester”, we would be looking for the percentage to *increase* in order to show improvement. Since the 6 points in the shift are above the median, then we can say with confidence that this process has *improved*.

Run chart rules give us tools grounded in mathematics and statistics to determine whether improvement has occurred, but this should make intuitive sense as well. Look at the first seven weeks of data in **Figure 4**. There is a lot of variation, with performance ranging from a low of 31% to a high of 53%. This contrasts with weeks 11 to 16, which indicate a shift has occurred, where performance is consistently between 49% and 53%. Improvement involves both reducing variation and increasing performance.

When analyzing run charts, the size of the denominator and whether the denominator represents a sample or the whole patient population can alter the interpretation. For the sake of simplicity, the rules above assume that the denominator is large enough to interpret and is fairly consistent over time.

## Exercise 1: Calculating a median

For this exercise, you should calculate the median using the following steps.

1. Take all data points and order them in numerical order. Make sure to include any repeated numbers.
2. Count the number of data points.
3. Calculate the median.
  - a. If the number of data points is an odd number, take the middle number as the median.
  - b. If the number of data points is an even number, take the two middle values, add them together and divide them by two to get the average.

Calculate the median for the data sets below:

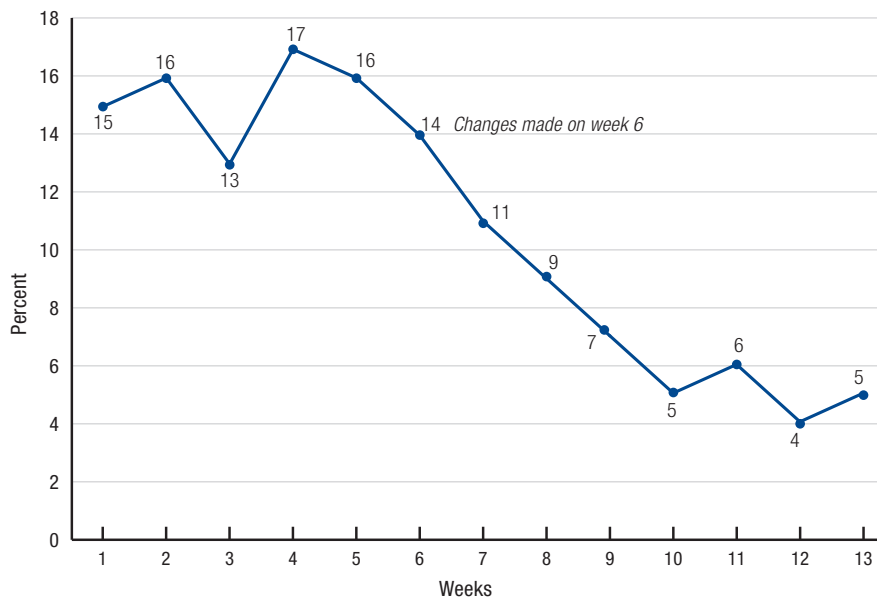
Data set	Line up the numbers in numerical order	Median
52, 41, 44, 60, 77, 41, 58		
10, 6, 15, 20, 7, 3		
4, 8, 0, 2, 4, 2, 6, 7		
11, 82, 33, 59, 25, 71		

## Exercise 2: Determining variation or improvement

For this exercise, simply look at the charts below to see whether improvement is obvious or if you need to do more analysis. There is a tendency to guess at whether improvement has happened, rather than doing analysis. How accurate are your guesses? In the next exercise, we will analyze the charts further.

### Example 1

Percentage of newborns with sepsis at 7 days of life, District Referral Hospital (Weeks 1-13)

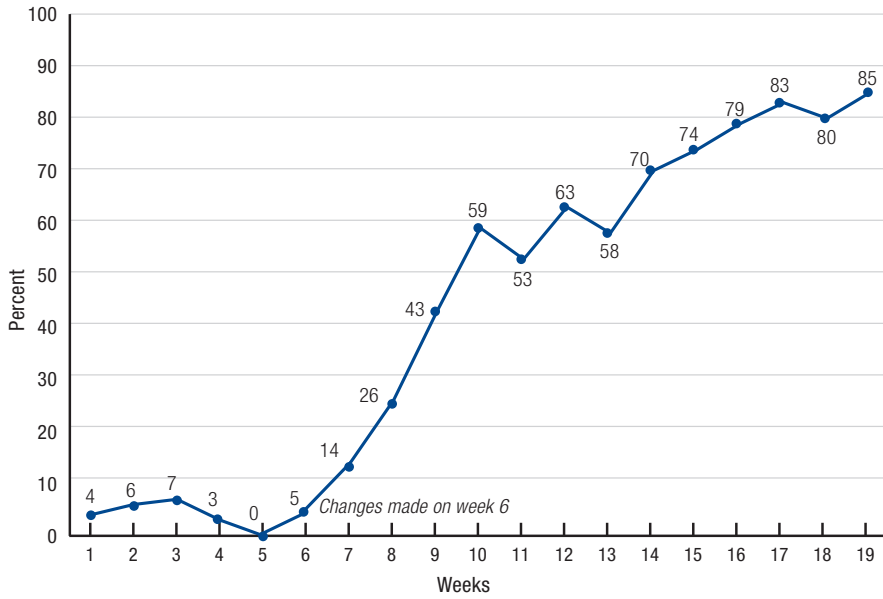


What can you tell from this graph?  
Check the right answer.

- It shows improvement
- It does not show improvement
- I can't tell. I need to do more analysis

## Example 2

Percentage of delivering women with correctly filled partograms, maternity ward (Weeks 1-19)

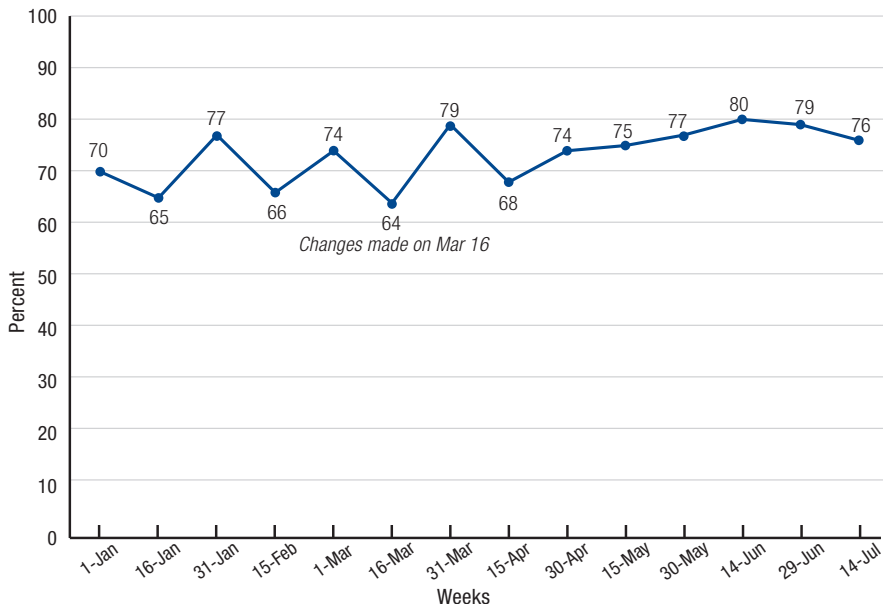


**What can you tell from this graph?  
Check the right answer.**

- It shows improvement
- It does not show improvement
- I can't tell. I need to do more analysis

## Example 3

Percentage of TB-HIV co-infected patients on ART, Clinic A (Jan 1 - Jul 14)

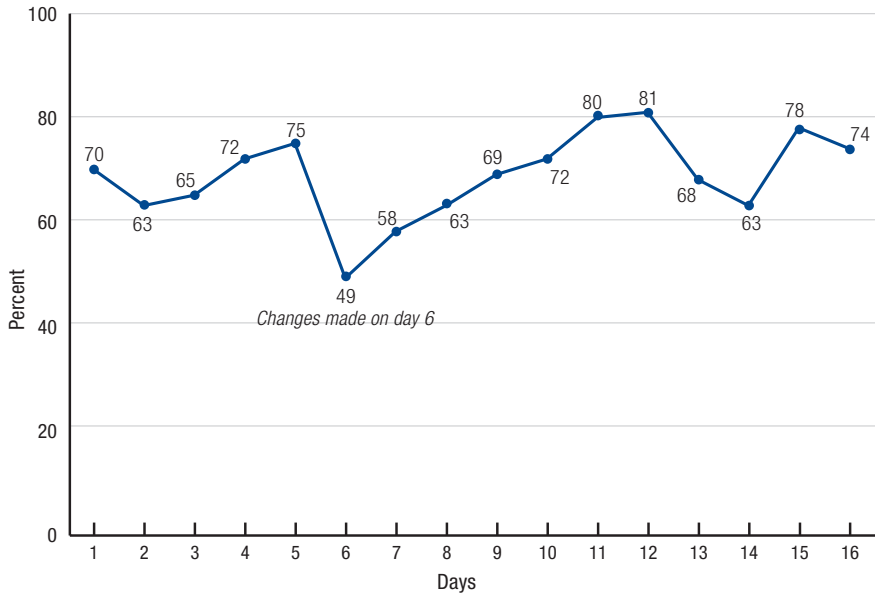


**What can you tell from this graph?  
Check the right answer.**

- It shows improvement
- It does not show improvement
- I can't tell. I need to do more analysis

## Example 4

Percentage of vulnerable children sleeping under bednets in Rural Community #3 (Days 1-16)



**What can you tell from this graph?  
Check the right answer.**

- It shows improvement
- It does not show improvement
- I can't tell. I need to do more analysis

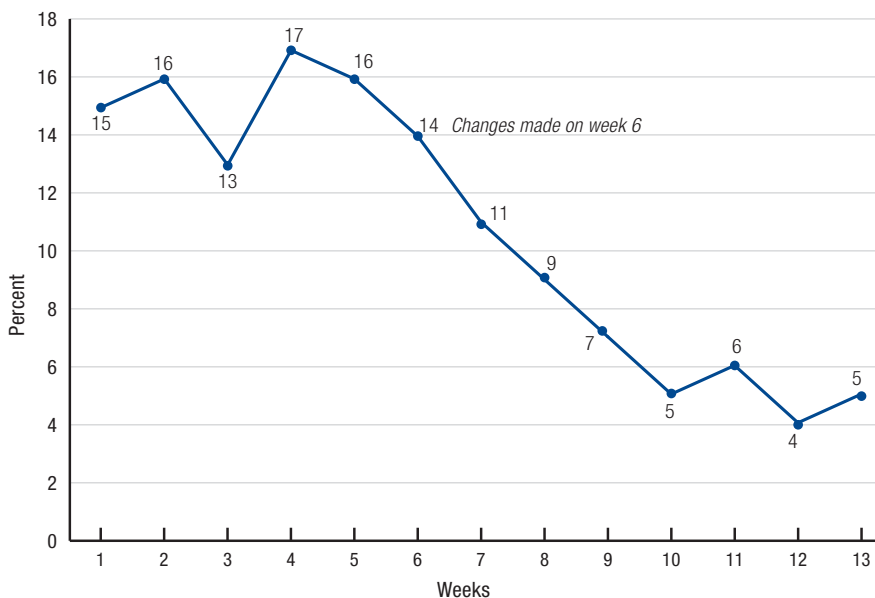
## Exercise 3: Practicing run chart rules

For the graphs below, determine if there is improvement or not using the run chart rules. Keep in mind the following tips:

- You need 10 data points before you can apply run chart rules.
- 5 consecutive points up or down in one direction indicate a trend. This may show improvement or decline in performance, depending on the indicator.
- After calculating the median, if there are 6 or more consecutive points above or below the median you have a shift.

### Example 1

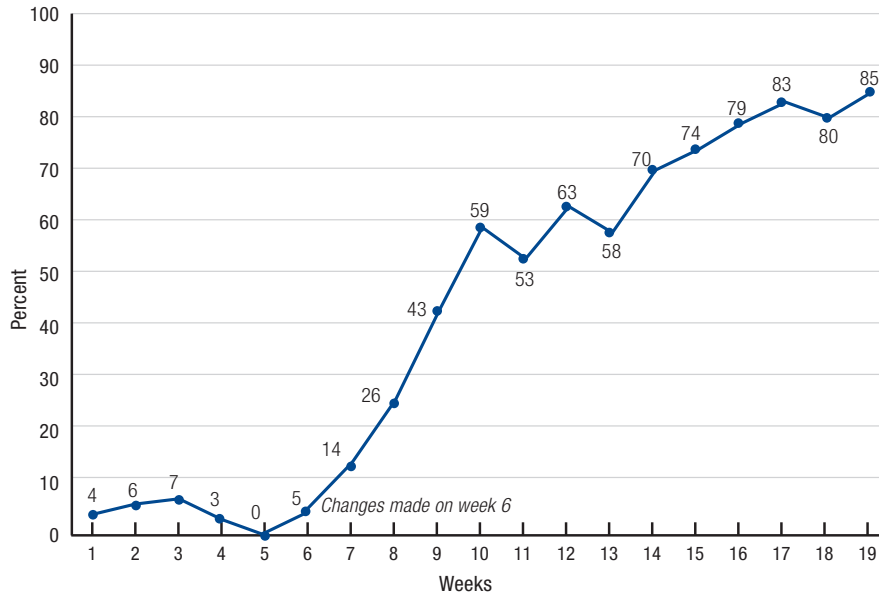
Percentage of newborns with sepsis at 7 days of life, District Referral Hospital (Weeks 1-13)



Analysis question	Circle or write in the answer	
At least 10 data points?	Yes	No
Do at least 5 points continue up or down in the same direction?	Yes	No
Is there a trend?	Yes	No
What is the median? (write in and draw on graph)		
Are there 6 or more points above or below the median?	Yes	No
Is there a shift?	Yes	No
Does this graph show improvement?	Yes	No

## Example 2

Percentage of delivering women with correctly filled partograms, maternity ward (Weeks 1-19)



**Circle or write in the answer**

**Analysis question**

- At least 10 data points? Yes  No

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- Do at least 5 points continue up or down in the same direction? Yes  No

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- Is there a trend? Yes  No

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- What is the median?  
(write in and draw on graph) \_\_\_\_\_
- Are there 6 or more points above or below the median? Yes  No

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- Is there a shift? Yes  No

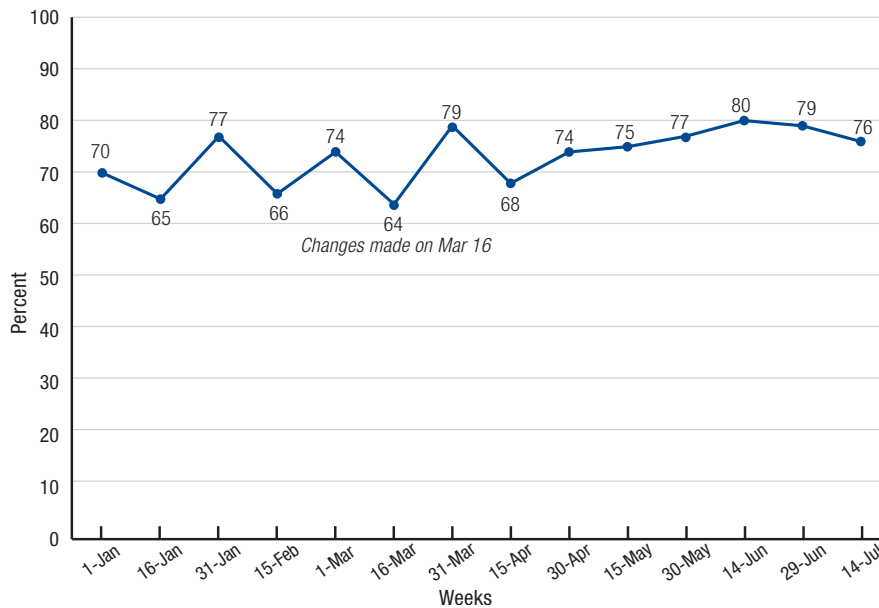
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- Does this graph show improvement? Yes  No

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## Example 3

Percentage of TB-HIV co-infected patients on ART, Clinic A (Jan 1 - Jul 14)



**Circle or write in the answer**

**Analysis question**

- At least 10 data points? Yes  No

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- Do at least 5 points continue up or down in the same direction? Yes  No

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- Is there a trend? Yes  No

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- What is the median?  
(write in and draw on graph) \_\_\_\_\_
- Are there 6 or more points above or below the median? Yes  No

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- Is there a shift? Yes  No

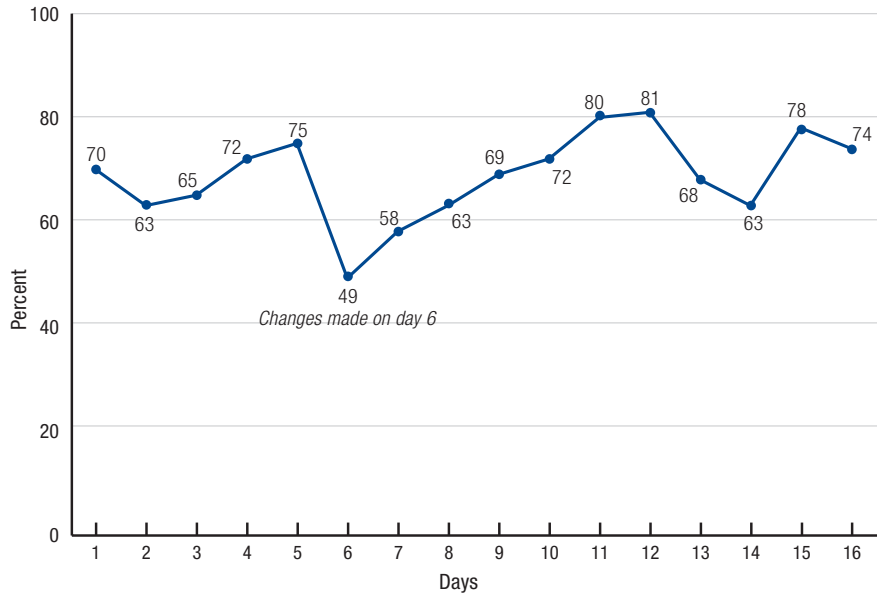
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- Does this graph show improvement? Yes  No

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## Example 4

Percentage of vulnerable children sleeping under bednets in Rural Community #3 (Days 1-16)



Analysis question	Circle or write in the answer	
At least 10 data points?	Yes	No
Do at least 5 points continue up or down in the same direction?	Yes	No
Is there a trend?	Yes	No
What is the median? (write in and draw on graph)		
Are there 6 or more points above or below the median?	Yes	No
Is there a shift?	Yes	No
Does this graph show improvement?	Yes	No