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Standard Deviation Rule: Applications

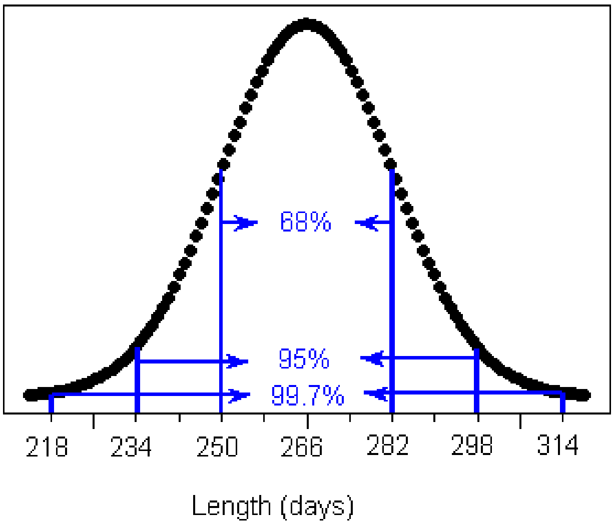
Learning Objective: Apply the standard deviation rule to the special case of distributions having the "normal" shape.

The following example illustrates how we can apply the Standard Deviation Rule to variables whose distribution is known to be approximately normal.

Example: Length of Human Pregnancy

The length of the human pregnancy is not fixed. It is known that it varies according to a distribution which is roughly normal, with a mean of 266 days, and a standard deviation of 16 days. (Source: Figures are from Moore and McCabe, *Introduction to the Practice of Statistics*).

First, lets' apply the Standard Deviation Rule to this case by drawing a picture:



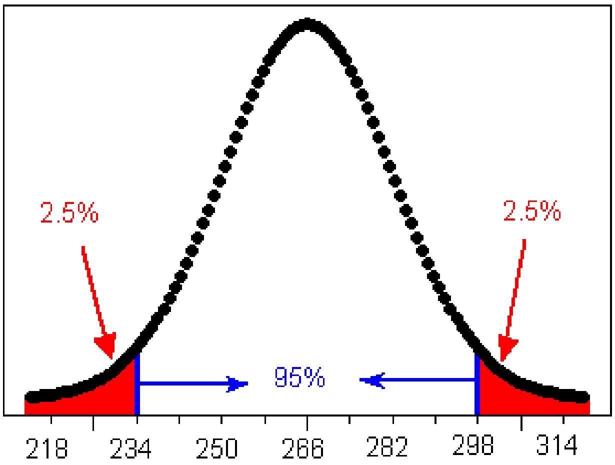
We can now use the information provided by the Standard Deviation Rule about the distribution of the length of human pregnancy, to answer some questions. For example:

Question: How long do the middle 95% of human pregnancies last?

Answer: The middle 95% of pregnancies last within 2 standard deviations of the mean, or in this case 234-298 days.

Question: What percent of pregnancies last more than 298 days?

Answer: To answer this consider the following picture:



Since 95% of the pregnancies last between 234 and 298 days, the remaining 5% of pregnancies last either less than 234 days or more than 298 days. Since the normal distribution is symmetric, these 5% of pregnancies are divided evenly between the two tails, and therefore 2.5% of pregnancies last more than 298 days.

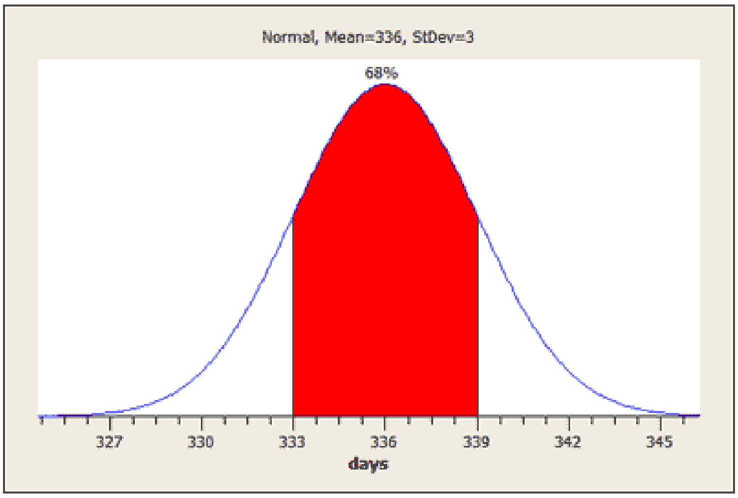
Question: How short are the shortest 2.5% of pregnancies?

Answer: Using the same reasoning as in the previous question, the shortest 2.5% of human pregnancies last less than 234 days.

Question: What percent of human pregnancies last more than 266 days?

Answer: Since 266 days is the mean, approximately 50% of pregnancies last more than 266 days.

In general, the larger the animal the longer the length of pregnancy (also called gestation period). For the horse, for example, the gestation period varies roughly according to a normal distribution with a mean of 336 days and a standard deviation of 3 days (Source: These figures are from Moore and McCabe, *Introduction to the Practice of Statistics*). Use the Standard Deviation Rule to answer the following questions. This picture of the SD rule applied to this distribution will help:



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Almost all (99.7%) horse pregnancies fall in what range of lengths?

○ Above 336 days

○ Below 336 days

○ Between 333 and 339 days

○ Between 330 and 342 days

● Between 327 and 345 days ✓

Answer

Correct:

The Standard Deviation Rule tells us that virtually all the data fall within 3 standard deviations of the mean, which in this case is exactly between 336 - 3(3) = 327, and 336 + 3(3) = 345.

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What percentage of horse pregnancies last longer than 339 days?

○ 2.5%

● 16% ✓

○ 50%

○ 68%

○ 100%

Answer
Correct:
According to the SD rule, 68% of horse pregnancies last between 336 - 3 = 333 and 336 + 3 = 339 days, which means that the remaining 32% of horse pregnancies are divided evenly between lasting less than 333 days and lasting more than 339 days. We therefore conclude that 16% of horse pregnancies last more than 339 days.

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Let's Summarize

- The standard deviation measures the spread by reporting a typical (average) distance between the data points and their average.
- It is appropriate to use the SD as a measure of spread with the mean as the measure of center.
- Since the mean and standard deviations are highly influenced by extreme observations, they should be used as numerical descriptions of the center and spread only for distributions that are roughly symmetric, and have no outliers.
- For symmetric mound-shaped distributions, the Standard Deviation Rule tells us what percentage of the observations falls within 1, 2, and 3 standard deviations of the mean, and thus provides another way to interpret the standard deviation's value for distributions of this type.

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