

**Making Sense of Biostatistics: Standard Score (z)**

**By Melissa Pressman**

The z-score, or standard score, indicates how many standard deviations an observation is above or below the mean, or, more simply, how far away from the mean a score falls. The z-score is used to calculate the probability of a score occurring within the standard normal distribution and provides a way to statistically compare two scores from different normal distributions.<sup>1</sup>

This dimensionless value is calculated by subtracting the sample population mean from individual values and then dividing the difference by the population standard deviation:

The standard score of a raw score x is:

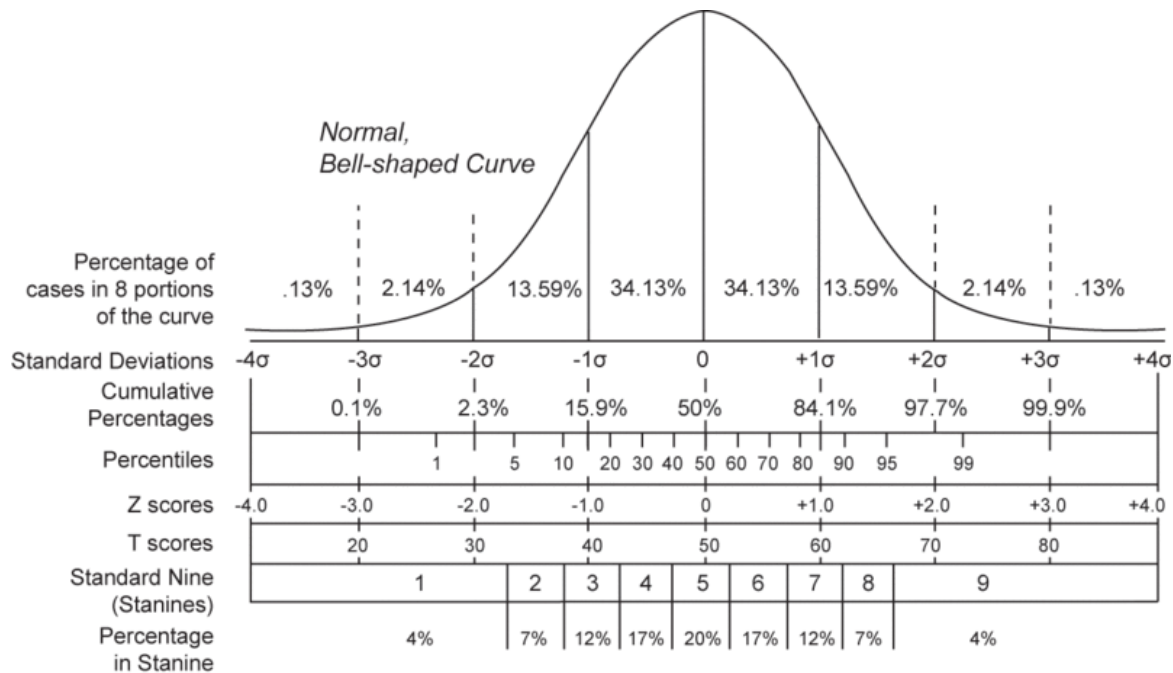
$$z = \frac{x - \mu}{\sigma}$$

where:

- $\mu$  is the mean of the population and
- $\sigma$  is the standard deviation of the population

A z-score of 0 means the score is the same as the mean. A negative or positive value indicates that the z-score is below or above the mean, and by how many standard deviations.

The chart below shows how z-scores relate to other statistical values involved with a normal distribution:<sup>2</sup>



The z-score is also used in the z-test. This is a standardized test, similar to the Student's t-test, for where the entire population size, not just the sample size, is known. In addition, the z-score may be used in calculating prediction intervals.

### Examples

Madeline receives a 50 on her biology midterm and a 50 on her math midterm. Did she perform the same on both tests?

A: On the biology midterm, Madeline's score is 10 points above the mean. On her math midterm, her score is 10 points below the mean.

Both tests have the same standard deviation (10).

Madeline's z-score in biology:  $(50-40)/10 = 1$

Madeline's z-score in math:  $(50-60)/10 = -1$

Madeline's score is 1 SD above the mean in biology and 1 SD below the mean in math, so Madeline performed better on the biology exam.

B: Both the biology and math midterm have the same mean (40), but different standard deviations (10 for biology, 20 for math).

To compare Madeline's performance, we need to evaluate not just how far she is from the class mean but also the variability of the exam scores.

Madeline's z-score in biology:  $(50-40)/10 = 1$

Madeline's z-score in math:  $(50-40)/20 = 0.5$

Madeline's score is 1 SD above the mean in biology and 0.5 SD above the mean in math, so Madeline performed better on the biology exam.

(Examples are adapted from reference 3)

### References

1. <https://statistics.laerd.com/statistical-guides/standard-score.php>
2. Ward, A. W., Murray-Ward, M. (1999). *Assessment in the Classroom*. Belmont, CA: Wadsworth. ISBN 0534527043
3. [www.uic.edu/classes/psych/psych343f/lecture06.ppt](http://www.uic.edu/classes/psych/psych343f/lecture06.ppt)

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