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Standard deviations and standard errors, what do they do?

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In statistics, the terms standard deviation (SD) and standard error (SE) are often confused [1]. Novices are not the only ones who make these mistakes [2] as errors in their use is seen in journal articles [3]. Many people are unsure which to present and when [4], with some journals feeling the need to state a policy on the subject [5]. The two terms denote different parameters that have specific functions, so they are not interchangeable. This paper will define and discuss the properties and functions of the SD and SE. Statistics analysis has two roles; the description of the data being examined and inference to the larger population. This is essentially the difference between an SD and an SE. The SD is a descriptive statistic, and the SE is an inferential statistic.

The SD plays an important role in statistics, as it is contained in many calculations, but, primarily, it is a summary measure of the variability of a set of data around the data's mean score. Pearson first used the term in 1894, but Altman [6] said it is a poor name as there is nothing 'standard' about it. The SD describes how tightly, or loosely the individual observations in a given data set are dispersed around the centre of the data, the mean [7] Streiner [4] described the SD as an index of how closely each data point in a data set is to the mean. A good way to think of the SD is as the average distance of each data point from the mean [6][8]. It is a popular choice because it reports the spread of data in the original units of measurement. Additionally, it complements the mean [8], and in combination the mean and SD give all the information needed about the distribution [4]. Provided the data is normally distributed, approximately 68% of observations will lie within one SD of the mean and approximately

95% lie within two SDs of the mean. In a previous paper [9] VAS scores with a mean(SD) of 4.1(1.2) were reported. So, 68% of the Vas scores will lie between 2.9 and 5.3, and 95% of the scores will lie between 1.7 and 6.6.

Most investigations use a sample to make inferences to the wider population. Inference is the process of drawing conclusions on a population by using observations from a sample of the population [10]. So investigators use the data provided by the sample to estimate the population mean and SD [4]. IThis is might seem a difficult concept to grasp, especially as time and resources usually only allow an investigation to be done once. It is also likely that different samples will give a different estimate of the population mean [1] However, Student [11] noted that any experiment is an individual experiment in a population of experiments. If a series of samples are drawn each one will have a mean, and those means will form a distribution [12]. This distribution will have its own mean and SD.

The population mean is unknown, but the mean of the sample is the best estimate the population mean. The population SD is harder to calculate because there is only one set of data. However, calculating the SE will give an estimate of the population SD. The data from the sample is the only piece of information about the population available, so any estimate may well deviate by an unknown amount [12]. Therefore, when the reporting the SE an inference about the population SD is made. Any such inference will be subject to error. The SE reflects the variability in estimating the population mean [2]. As the population of means forms a distribution, one SE either side of the mean will give an interval within which there is a 68% chance the population mean will lie. Thus, it effectively, gives a 68% confidence interval, and like a 95% CI it is best used to describe differences [13].

The SD and the SE are linked, so much so that the SD is part of the SE calculation as shown in equation 1, where *n* is the number of subjects in the sample.

$$SE = \frac{SD}{\sqrt{n}} \quad (1)$$

However, it is important to note that the two calculations perform different functions. The SD describes the dispersion of the data around the mean, while the SE infers the accuracy of the estimated population mean providing limits within which it will be. Authors don't always get it right in research papers [3], but if one is reported, the reader can calculate the other. Equation 1 shows the calculation for the SE, if the SD and the sample size are given. If only the SE is given, the SD can be calculated using equation 2. Make the best use of the information you read.

$$SD = SE \times \sqrt{n} \quad (2)$$

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