RESEARCH LETTER

Case fatality: rate, ratio or risk?

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CONFLICTS OF INTEREST

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To the editor:

> When I use a word," Humpty Dumpty said, in a rather scornful tone, "it means just what I choose it to mean – neither more nor less."
> Lewis Carroll, *Alice Through the Looking Glass*

Terms such as 'rate', 'ratio' and 'risk' are part of normal usage but have technical meanings when used in an epidemiological context. However their accepted meaning is not static in either usage. This can lead to linguistic disagreements, which may be settled by reference to an authoritative dictionary. For epidemiological usage we consult the Dictionary of Epidemiology.[1] Here we find a long discussion of the epidemiological use of the term 'rate' (p207). Included in this discussion are the following statements: "All rates are ratios" and "Some rates are proportions". 'Risk' is defined in the Dictionary as "the probability that an event will occur" (p217). Given that a probability is a proportion, these definitions do not help with the distinctions between rate, ratio and proportion (risk) if a rate could also be a proportion. Furthermore, in defining a ratio, the Dictionary explains that both a rate and a proportion are "types of ratios" (p208).

Nonetheless, a possible consensus is emerging on the technical use of rate, ratio and risk. Following the work of Elandt-Johnson[2] and Vandenbroucke,[3] many modern epidemiological or biostatistical texts[4,5] define a rate as varying with time, having a dimension of time^{-1}. Although agreement on this is not universal,[6] rate defined as varying with time appears to be the most common usage. A ratio is a comparison of two like quantities. It has no dimensions and can take any value, while a ratio of 1 indicates equality between the two quantities compared. Risk is a probability, usually associated

with an adverse outcome in both normal and technical usage. Like a ratio, risk has no dimensions, but unlike a ratio, risk is confined to values between 0 and 1.

The probability of death among cases diagnosed with a disease is often used as a measure of disease severity. This quantity is usually estimated within a specified period of time by direct follow-up of cases and ascertainment of their death or recovery. Alternatively the quantity could be estimated in a population within a specified time period by dividing the number of deaths associated with the disease by the number of cases of that disease. In principle, the persons included in the numerator should be a subset of the persons in the denominator. This conditional probability of mortality among classified cases can be termed the 'case fatality risk'. It is not a rate, since time is not part of the denominator. Recognising this, many authors have preferred the term 'case fatality ratio'. However neither is this quantity strictly a ratio because it is not the comparison of like quantities. Case fatality estimates a conditional probability and should thus be considered a risk.

In the epidemiological literature the acronym CFR can denote case fatality rate, case fatality ratio or case fatality risk. Consistent with a living language, however, there is an evolution in usage. On 22 February 2013, searches of text strings in titles/abstracts in PubMed resulted in the following numbers of hits: 'case fatality rate'=3030; 'case fatality ratio'=332; and 'case fatality risk'=20. While case fatality rate has been used traditionally, case fatality ratio only started to appear in the 1970s and the papers reporting case fatality risk were all published in the last 22 years.

Although different usages of CFR are unlikely to result in any misunderstanding, we believe it would be preferable if the technical usage of terms that are also used in non-technical language were standardised. While it seems only a linguistic distinction between rate, ratio and risk for the CFR, it is important for other epidemiological measures since one does not analyse risk and rate by the same methods.

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