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CORRESPONDENCE

How should we speak about years of life lost (YLL) values?

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We would like to comment on the interpretation of *years of life lost* (YLL) values [1, 2] which are a widely used metric to quantify the burden of mortality resulting from different risk factors. A discussion around the use and interpretation of YLL values arose recently in the context of the COVID-19 pandemic [3–6] but is also applicable in other contexts. Here we outline why, contrary to what the name suggests, YLL values typically do not estimate the years of life that deceased people may have been expected to continue to live had they not died from or with a specific risk factor. We provide suggestions for a language which adequately paraphrases what YLL values mean.

Unlike raw death counts, YLL estimates attribute a higher burden of mortality to the death of people who may have been expected to live longer (typically those who died at a younger age) in the counterfactual scenario that they had not died from or with a given risk factor. In its simplest and original form, YLL are computed by comparing the age at death in a subpopulation of people with the age at death of other people in the same population who lived *at least as long*. For example, if a person dies from a specific cause at the age of 82 and the population of people alive at age 82 continue to live, on average, until the age of 90, a YLL value of 8 years can be attributed to the disease. The population YLL value of the disease is then computed by averaging the calculated YLL values of all deaths attributed to that specific disease.

While straightforward to compute, YLL estimates can be difficult to interpret. It was noted by [7, 8] that performing the above operation on the general population, i.e., without examining specific risk factors, can result in a YLL estimate of more than 9 years. Our own example calculation based on the life table for Italy from 2016 (which resulted in 9.5 and 8 YLL for men and women, respectively) is linked in [4]. Likewise, any variable that is not associated with shorter or longer life spans (e.g., eye color, blood type, fingerprint pattern) can be linked to the same YLL value. In such cases, interpreting YLL values to imply how long deceased people would otherwise have been expected to continue to live (if they had not had green eyes, blood type B, whorl fingerprints etc.) would be misguided. Such a direct interpretation of YLL values may be compared to the practice of *double dipping* [9, 10] in data analysis where cases are first selected along specific properties (here: people who have just died) and are then analyzed with regards to a related variable (here: residual lifetime). In other examples, however, YLL values may well be argued to estimate the years of life that were lost due to a specific lethal incidence. For instance, if a person aged 82 is struck and killed by a lightning, a reasonable guess for the time she would otherwise have continued to live could indeed be argued to be the average remaining lifetime of other people after they had reached that age.

In the above examples, it may be easy to see how the meaning of YLL estimates does not follow automatically from their computation but must be discussed against the background of the causal structure behind lethal events. In many situations in epidemiology, however, characterizing the causal structure behind deaths is complicated, sometimes even impossible. While the existence of causal links between widely discussed risk factors and people's deaths is typically well established [6], risk factors also tend to co-occur [7], making it difficult to delimit their effects from each other. Specifically, individuals who have died from or with a given risk factor and were multimorbid may be expected to have had a heightened risk of dying prematurely from other causes had they not died from the given cause. In pursuit of retaining YLL's insinuated meaning as an estimate for how long people may otherwise have lived, [6] discusses approaches to statistically correct for multimorbidity. By contrast, [11] argues against such corrections, noting

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that it would typically not be possible to collect data on all relevant comorbidities, and highlights that uncorrected YLL values are still useful for the purpose of comparing health outcomes (between different risk factors, in different populations, across time etc.).

In our view, researchers could report both uncorrected YLL estimates and additionally report on models that (partially) correct for multimorbidity. Importantly, however, choosing not to correct YLL values for multimorbidity implies giving up on trying to provide a statistical estimate for how long people would otherwise have lived. Specifically, with positive correlations between risk factors, the number of years that could reasonably be expected to be lost is lower than what an uncorrected YLL value suggests. We do not object the use of uncorrected YLL values for the purpose of comparisons but argue that their meaning should be conveyed clearly. While a majority of research articles using YLL values do not use misleading language when paraphrasing their results, we have also found epidemiological articles where YLL values were misleadingly paraphrased to represent statistical estimates for how long someone who died with a specific risk factor may otherwise have been expected to live [3, 12, 13]. In our view, YLL estimates should instead be paraphrased to represent a "measure of premature mortality", a "measure for the impact of risk factors", a "summary statistic of ages at death attributable to a disease", a "composite indicator which considers information on mortality and life expectancy" or related descriptions that point to the abstract nature of YLL values.

When we raised this point in previous communications with other researchers, we were confronted with three types of objections to which we would like to take a stance. Some researchers responded that (1) it is trivial to note that YLL values are imperfect measures for premature morbidity, because all measures in empirical research are imperfect. However, we do not object the measure's imperfection but its bias. Just like double dipping [9] almost always leads to inflation and not deflation of effect sizes, uncorrected YLL values can be reasonably expected to be larger than the number of years that were actually lost. Some researchers argued that (2) we are being overly pedantic since the margin of error we speak of is often relatively small. Indeed, adjustments for multimorbidity in the context of COVID-19 only marginally reduced YLL values in some recent analyses [3, 6]. However, note that these adjustments were relatively crude (e.g., did not even consider symptom severity of comorbidities). We know from other analyses that incomplete adjustments for collinearity can dramatically distort research findings [14] and it is not easy to rule out that similar effects are present in YLL analyses. Finally, some researchers argued that (3) it is sufficient to precisely describe and discuss the construction of a model for informed readers to understand what resulting estimates mean. However, we would argue that a correct translation of statistical findings into everyday language is part of a research work. A discussion on how this task should be carried out is being actively pursued with regards to other statistical terms such as *significance* [15], but, to our knowledge, is still largely lacking in the context of YLL values.

To sum up, while years of life lost values are useful when comparing health outcomes, they are typically not intended to be literal estimates for the years of life that deceased people have lost due to a specific risk factor. We, as researchers, should use an adequate language when communicating our research results, in particular when scientific terms do not indicate what their literal meaning suggests, which is the case for years of life lost values.

Statements & declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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