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## Contesting the evidence for limited human lifespan

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## No evidence for limited human lifespan

Dong et al. [1] claimed that longitudinal mortality data indicate that human lifespan has a “limit” of around 115 years. We believe these authors’ analyses—and, hence, their conclusions—are critically flawed. In this brief commentary, we outline four arguments to motivate our opinion.

First, their main result (shown in their Fig. 2a) involved splitting the dataset at the year 1995, for which the only justification given was that a visual inspection of the data appeared to show the maximum age at death had reached a “plateau” around that time. It is well-known from statistical theory that the same data set cannot be used for both hypothesis-generating and hypothesis-testing purposes, as this typically leads to severe overfitting and thus inaccurate results.

Second, whereas Dong et al. reported a sample size of 534, they included only the oldest person who died in any given year in the regressions in their Fig. 2a, which therefore used sample sizes of just 21 (1968–1994) and 12 (1995–2006). It is not possible to draw any firm conclusions from such small samples; the uncertainty around the estimates simply is too large. Furthermore, these individuals are outliers among outliers; standard linear regression techniques are inappropriate under these circumstances. Instead, Dong et al. should have used extreme value theory, a set of mathematical techniques specifically designed for analyzing extreme events. This type of analysis involves the use of Poisson processes, and related stochastic processes, to model extreme value distributions [2]. It dates back nearly a century [3].

Third, Dong et al.’s conclusions are not supported even within the (very suboptimal) linear regression framework. Dong et al. failed to compare the fit of their models to alternatives. Our re-analysis (full details and code for reproduction available at <https://osf.io/rxpkp/>) shows that there is no reason to favor the spline model the authors fit to the data in their Fig. 2c: Depending on the relative fit index used, a basic linear model where the age at death increases

steadily each year fits just as well as ( $\Delta AIC = 1.1$ ), or slightly better than ( $\Delta BIC = 7.5$ ), a natural spline model that appears to “plateau” after the mid-1990s.

Finally, and perhaps most importantly, the purported post-1995 decline in maximum longevity appears to be entirely dependent on the exceptional case of Jeanne Calment. The slopes of the two split regression lines in Fig. 2a are significantly different (year-by-split interaction  $p = .02$ ), but if Calment’s age is reset to the modal age of 114 years, the lines are no longer significantly different ( $p = .09$ ). That is, without that single outlying data point, there would be no reason to consider 1995 as a change point in the series of life expectancies. In addition, had Calment, for instance, died in 2004 instead of 1997 (at the same age of 122), Dong. et al.’s “decline” would in fact be reversed (see Fig. 1). Even disregarding the serious problem of a wide-ranging claim hinging on one observation, it is curious that the case of this remarkable woman, who lived to the age of 122, is such a crucial part of the argument that maximal human lifespan has “plateaued” at 115.

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### Author contributions

NJLB performed the regression analyses and prepared Figure 1. CJA provided theoretical input on extreme value theory. SJR conducted the analyses using splines. All authors contributed equally to the drafting of the manuscript, and approved the final version for submission.

### Competing financial interests

The authors declare that they have no competing financial interests. This work was not supported by public or private grants of any kind.

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Figure 1. Regression lines predicting age at death from the oldest death in each given year, split between 1994 and 1995. Upper panel: As reported by Dong et al. (Figure 2a). Lower panel: With Jeanne Calment's dates of birth/death changed from 1882–2004 from 1875–1997.