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The Future of Human Longevity

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Abstract

Recent scientific publications suggest that human longevity records stopped increasing. Our finding that the mortality of centenarians has not decreased noticeably in recent decades (despite a significant mortality decline in younger age groups) is consistent with this suggestion. However, there is no convincing evidence that we have reached the limit of human life span. The future of human longevity is not fixed and will depend on human efforts to extend life span.

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How long can humans live? How long will we live in the future? These are very interesting and important questions for gerontologists and also for demographers, actuaries, and the general public. In a recent paper, Vijg and Le Bourg [1] claim that there is an inevitable limit to human life span around 115 years, and humans cannot reach considerably longer life spans. Our paper is a response to this publication.

We will start by agreeing that recent demographic data support more conservative estimates for longevity records than previously thought. For example, the mortality of centenarians has not decreased noticeably in recent decades, despite a significant decline in the mortality of younger age groups (Fig. 1). Thus, the projected estimates of old-age survival should be lower indeed than formerly believed.

The second reason for being more conservative about human longevity records is related to the recent revision of mortality trajectories at older ages. Earlier studies assumed the so-called "old-age mortality deceleration," "mortality leveling-off," and "mortality plateaus" when death rates at extremely old ages do not grow as fast as at younger ages [2]. However, studies of more recent and more reliable data suggest that mortality continues to grow exponentially with age (Gompertz law), even at extremely old ages [3, 4]. This means that the chances of exceptional survival are much smaller than earlier assumed.

Nevertheless, available data do not preclude the possibility that the maximum reported age at death (MRAD) continues to increase slowly over time. Vijg and Le Bourg [1] cite a recent article in *Nature* [5] in support of their claim that the maximum reported age at death has not increased for about 25 years and is set to be around 115 years. Yet, several independent researchers challenged the conclusion of this *Nature* article, criticizing its methodological limitations. Their criticism has been published online on the academic website Publons [6] in the form of 6 postpublication peer reviews.

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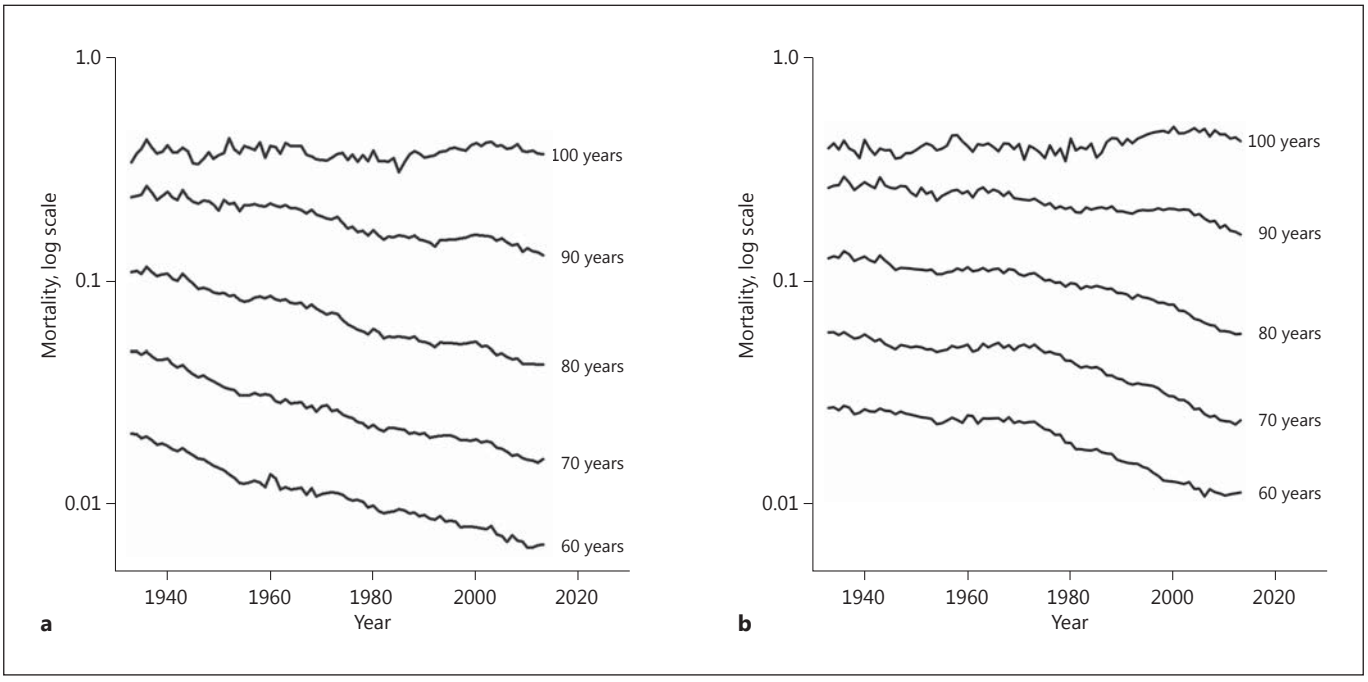

Fig. 1. Time trends of old-age mortality for US females (**a**) and males (**b**). Age-specific death rates (available in the Human Mortality Database at www.mortality.org).

Indeed, the maximum reported age at death in 2017 has exceeded 115 years thanks to the Italian supercentenarian Emma Martina Luigia Morano (November 29, 1899 – April 15, 2017), who lived 117 years and 137 days [7]. This new case is consistent with the possibility that the MRAD does continue to increase slowly over time.

Furthermore, according to the expert opinion of the eminent gerontologist Steven Austad, someone born before 2001 will reach the age of 150 years by the year 2150 [8]. Indeed, claiming the inevitable limit to human life span to be at about 115 years is equivalent to the claim of inevitable failure of all further efforts of gerontologists and other scientists in increasing human health span (and subsequently longevity). The consensus letter published in *Science* by a group of 7 gerontologists states: "... there are currently no scientifically proven antiaging medicines, but legitimate and important scientific efforts are under way to develop them" [9]. There is no reason to believe that these efforts will inevitably fail [7].

Also note that the *Nature* study [5] cited by Vijg and Le Bourg [1] assumed that MRAD follows a Poisson distribution. This distribution does not have a fixed upper limit; therefore there is no inevitable fixed limit to human longevity, if we accept a hypothesis about Poisson distribution.

Vijg and Le Bourg [1] argue that the close connection of species-specific longevity with life-history strategies explains why human life span is limited and why age-related deterioration and death is an inevitable outcome. They cite theoretical work by Fisher, Haldane, Hamilton, Medawar, Williams, and Charlesworth who provided an evolutionary explanation of aging as a result of the declining force of natural selection. However, this explanation can hardly be applied to extreme postreproductive ages (100 years and older), when the force of natural selection is already negligible and hence has no room for further decline. Life-history theory cannot provide an accurate prediction of human longevity record – why is it 122 years (Jeanne Calment 1875–1997) instead of only 100 years, for example. Also life-history theory cannot explain why exactly the same exponential pattern of mortality growth with age (Gompertz law) is observed not only at reproductive ages but also at very old postreproductive ages (up to 106 years), long after the force of natural selection becomes insignificant (when there is no space for its additional decrease) [10].

To conclude, we agree with Vijg and Le Bourg [1] that historical progress in human longevity records is very slow indeed. However, there is no convincing evidence or a theory claiming that we have already approached the

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inevitable fixed limit of human life span. Temporary periods of life-span stagnation have already been observed in the past (in the 1960s and 1970s [11]), and they were followed by further increases in life span. The future of human longevity is not fixed and depends on human efforts to increase it [7].

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