

# Age-aggregation bias in mortality trends

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In PNAS, Case and Deaton (1) show a figure illustrating the “marked increase in the all-cause mortality of middle-aged white non-Hispanic men and women in the United States between 1999 and 2013.” The authors state that their numbers “are not age-adjusted within the 10-y 45–54 age group” (1).

We suspected an aggregation bias and examined whether the increase in aggregate mortality rates could be due to the changing composition of this age group. Adjusting for age confirmed this suspicion. Contrary to Case and Deaton’s figure (1), we find there is not a steady increase in mortality rates for this age group. Instead there is an increasing trend from 1999 to 2005 and a constant trend thereafter. Moreover, stratifying age-adjusted mortality rates by sex shows a marked increase only for women and not men, contrary to the article’s headline.

Age-adjustment is not merely an academic exercise. Fig. 1A shows the unadjusted mortality rates over the 1999–2013 time period. During this period, however, the average age in this group increased as the baby boom generation passed through (Fig. 1B).

We calculated the change in the group mortality rate due solely to the change in the underlying age of the population. We took the 2013 mortality rates for each age and computed a weighted average rate each year using the number of individuals in each age group. Fig. 1C shows that the changing composition in age alone explains about half the change in the mortality rate of this group since 1999 and all of the change since 2005.

We then age-adjusted the mortality rates published in the Case and Deaton paper (1). Fig. 2A shows adjustment to a uniform age distribution over ages 45–54, where the mortality rate is calculated each year by dividing the number of deaths for each age between 45 and 54 by the population of that age and then taking the average. Consistent with Fig. 1C, the adjusted mortality rate increased from 1999 to 2005 and then stopped.

We find that age-adjustment is not sensitive to the age distribution used to normalize the mortality rates. Fig. 2B shows three adjustments: first, under the aforementioned uniform age distribution; second, using the distribution of ages that existed in 1999, which is skewed toward the younger end of the 45–54 group; and third, using the 2013 age distribution, which is skewed older. The general pattern does not change.

Calculating the age-adjusted rates separately for each sex reveals a crucial result (Fig. 2C). The mortality rate among women increased markedly, but the corresponding group of men nearly reversed its 1999–2005 increase over the 2005–2013 period.

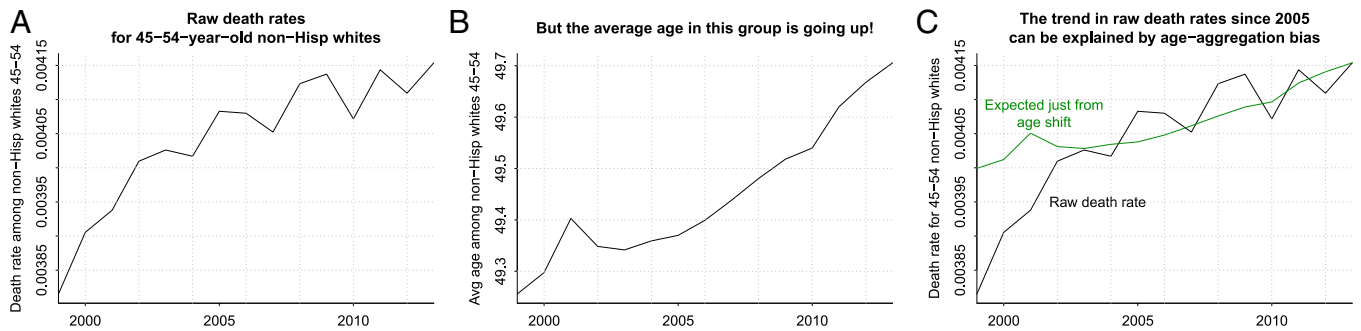
We stress that this does not change a key finding of the Case and Deaton paper (1): the comparison of non-Hispanic United States middle-aged whites to other populations. It affects claims concerning the absolute increase in mortality among United States middle-aged white non-Hispanics. We believe it is vital that future researchers understand the aggregation bias as they read Case and Deaton’s article and consider how to investigate these noteworthy findings further.

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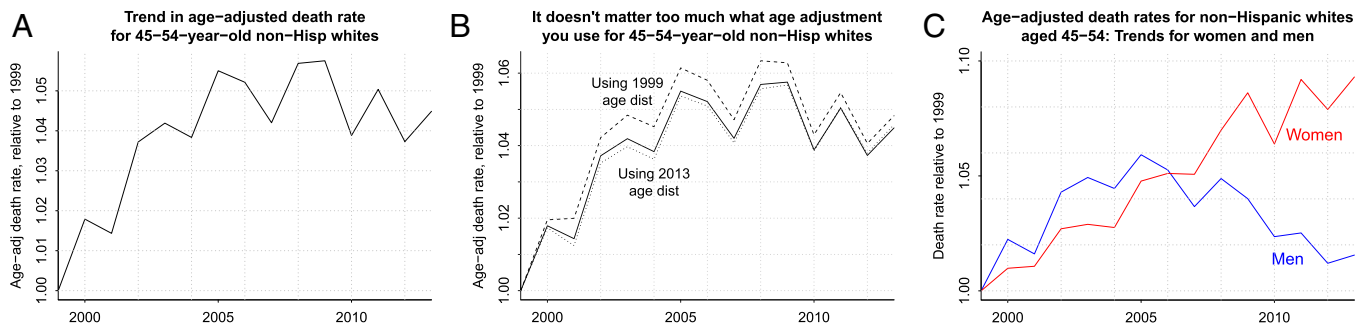
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**Fig. 1.** (A) Observed increase in raw mortality rate among 45- to 54-y-old non-Hispanic whites, unadjusted for age. (B) Increase in average age of this group as the baby boom generation moves through. (C) Raw death rate, along with trend in death rate attributable by change in age distribution alone, had age-specific mortality rates been at the 2013 level throughout.



**Fig. 2.** (A) Age adjusted death rates among 45- to 54-y-old non-Hispanic whites, showing an increase from 1999 to 2005 and a steady pattern since 2005. (B) Comparison of three different age adjustments. (C) Trends in age-adjusted death rates broken down by sex.

1 Case A, Deaton A (2015) Rising morbidity and mortality in midlife among white non-Hispanic Americans in the 21st century. *Proc Natl Acad Sci USA* 112(49): 15078–15083.