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Blending Census and Medicare Mortality Rates

JACQUES CARRIERE

This paper presents a new method for blending census and Medicare mortality rates for the U.S. Decennial Life Tables. Medicare data is used at ages 85 years and over because it is considered more accurate than the census data, which is inaccurate because of reporting errors among the extreme elderly. A major weakness of the current blending formula is the lack of fit of the blended rates. Therefore, a new method is proposed for determining the pattern of mortality at the older ages that addresses this weakness.

Introduction

Mortality rates based on census data are considered inaccurate at ages greater than 85 because of reporting errors among the extreme elderly. This problem does not exist with the mortality rates calculated from the Medicare data. Therefore, the mortality rates for the U.S. population life tables at the older ages are constructed with the Medicare rates rather than the census rates. These Medicare rates are blended with the census rates between the ages of 85 to 94 to ensure a smooth transition between the two sets of rates. A weakness of this blending method is the lack of fit of the blended rates. This paper will examine the current methodology and demonstrate that the blended rates do not fit the true pattern of mortality. Using techniques in the theory of graduation (London 1985) we will develop a new method that addresses the issue of fit.

The Current Blending Formula

In the paper by the National Center for Health Statistics, Armstrong, R.J., and Curtin, L.R. (1987) you will find the methodology used for constructing the U.S. Decennial Life Tables for 1979-81. This document also contains graduated mortality rates based on the Medicare data, which we will denote as q_x^m. These rates are given for the ages x=85,...,109 and they were used in lieu of the census mortality rates, q_x^c, at the ages x=95,...,109 when constructing the total population life table. The graduated mortality rates for the total population will be denoted as q_x and they are given in a National Center for Health Statistics (1985) publication with document number (PHS) 85-1150-1. The rates q_x were constructed with the rates q_x^m and q_x^c as follows

$$
\begin{aligned}
q_x &= q_x^c, && x \le 84, \\
&= q_x^c(95-x)/11 + q_x^m(x-84)/11, && x=85,\dots,94, \qquad (1)\\
&= q_x^m, && x \ge 95.
\end{aligned}
$$

Before discussing the reasonableness of this blending formula, it will be instructive to examine the pattern of mortality exhibited by the census and Medicare rates. Figure 1 is a plot of q_x^c for $x=80,\dots,94$ and of q_x^m for $x=85,\dots,99$. Notice that the two sets of rates are close but that $q_{85}^m < q_{85}^c$ and the Medicare rates are rising faster than the census rates. This implies that the blended rates q_x are also rising faster than the census rates. All the graphs in this paper were produced with the statistical computing language GAUSS.

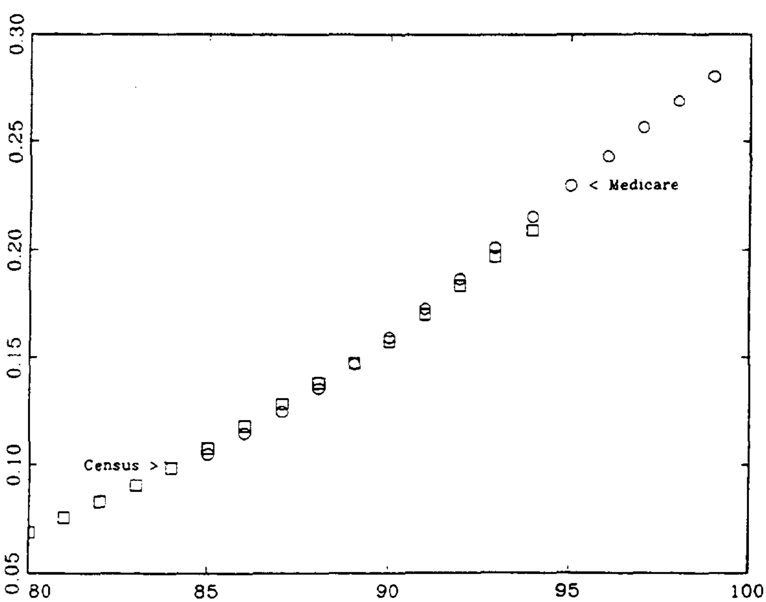

Figure 1. A Comparison of Census and Medicare Mortality Rates

A reasonble blending formula should have the property that the graduated values q_x are close to the census values q_x^c at around age 85 to ensure a smooth transition. Clearly, formula (1) exhibits this property. Note that the values of q_x at the ages 90 to 94 are increasing faster than the census values and so it seems that q_x does not follow the true pattern of mortality at the ages 90 and over. However, the Medicare rates q_x^m are in a sense better because they are based on accurate reports. With these observations in mind, we now present a new method for blending q_x^c and q_x^m.

A New Blending Formula

Before presenting our blending formula, it will be instructive to investigate the relationship between the rates q_x^c and q_x^m. It is well established (Wetterstrand 1981) that Gompertz's law describes the pattern of mortality very well at the adult ages. Gompertz's law dictates that the force of mortality is an exponential function or equivalently that the function

$$y_x = \log_e\Big(-\log_e(1-q_x)\Big) \qquad (2)$$

is a linear function in x. It is well known that the linear correlation coefficient is equal to 1 if and only if $y_x = ax + b$ for some $a>0$. We found that the linear correlation between the census values y_x^c and the ages $x=85,\ldots,94$ was .99937 while the linear correlation between the Medicare values y_x^m and the ages $x=85,\ldots,94$ was .99979. Therefore, their is strong evidence that both the census and Medicare mortality rates follow Gompertz's law at the ages $x=85,\ldots,94$. If Gompertz's law holds for both sets of rates, then it can be shown that there exists α and β such that $y_x^c = \alpha\, y_x^m + \beta$. This relationship is clearly evident in Figure 2 where y_x^c is plotted as a function of y_x^m at the ages $x=85,\ldots,94$. We found that the linear correlation between the census values y_x^c and the Medicare values y_x^m was .99967.

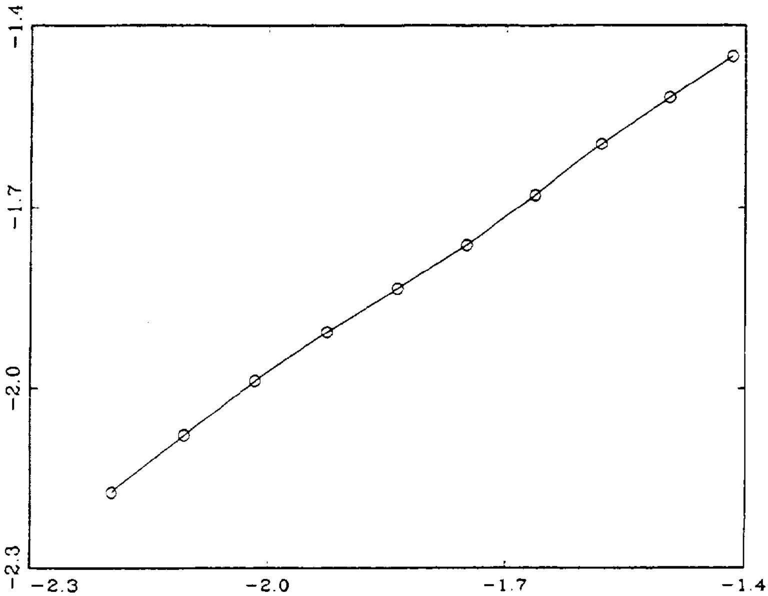

Figure 2. A Plot of y_x^c versus y_x^m

Based on the prior arguments, we suggest that q_x be calculated as follows:

$$
\begin{aligned}
q_x &= q_x^c, && x \le 84, \\
&= 1-\exp\Big(-\exp(\alpha\, y_x^m + \beta)\Big), && x \ge 85, \qquad (3)
\end{aligned}
$$

where α and β are the values that minimize the fit measure

$$\sum_{x=85}^{94} (95-x)(y_x^c - \alpha\, y_x^m - \beta)^2. \tag{4}$$

Using standard weighted least-square formulas, we found that $\alpha = .91192$ and $\beta = -.15716$. Note that if $y_x^c = \alpha\, y_x^m + \beta$ in (3), then $q_x = q_x^c$. Moreover, if $q_x^m \to 1$ then $q_x \to 1$. Also note that the fit measure in (4) assures that q_x will be close to q_x^c at the transition ages of 85 and 86 because of the weight put on these values. This fit measure also assures that q_x is increasing at about the same rate as q_x^c between the ages of 85 and 94. These properties are all evident in Figure 3 where q_x at $x=80,\ldots,104$ is calculated with the old formula given in (1) and the new formula given in (3).

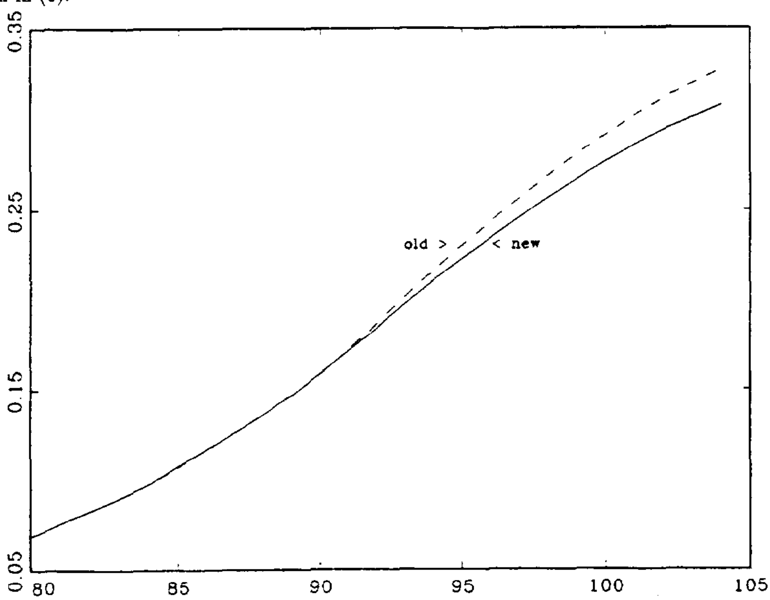

Figure 3. A Plot of the Blended Rates Calculated with the Old and New Formulas

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