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Historical Evolution of Old-Age Mortality and New Approaches to Mortality Forecasting

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Abstract

Knowledge of future mortality levels and trends is important for actuarial practice but poses a challenge to actuaries and demographers. The Lee-Carter method, currently used for mortality forecasting, is based on the assumption that the historical evolution of mortality at all age groups is driven by one factor only. This approach cannot capture an additive manner of mortality decline observed before the 1960s. To overcome the limitation of the one-factor model of mortality and to determine the true number of factors underlying mortality changes over time, we suggest a new approach to mortality analysis and forecasting based on the method of latent variable analysis. The basic assumption of this approach is that most variation in mortality rates over time is a manifestation of a small number of latent variables, variation in which gives rise to the observed mortality patterns. To extract major components of mortality variation, we apply factor analysis to mortality changes in developed countries over the period of 1900–2014.

Factor analysis of time series of age-specific death rates in 12 developed countries (data taken from the Human Mortality Database) identified two factors capable of explaining almost 94 to 99 percent of the variance in the temporal changes of adult death rates at ages 25 to 85 years. Analysis of these two factors reveals that the first factor is a “young-age” or background factor with high factor loadings at ages 30 to 45 years. The second factor can be called an “old-age” or senescent factor because of high factor loadings at ages 65 to 85 years. It was found that the senescent factor was relatively stable in the past but now is rapidly declining for both men and women. The decline of the senescent factor is faster for men, although in most countries, it started almost 30 years later.

Factor analysis of time series of age-specific death rates conducted for the oldest-old ages (65 to 100 years) found two factors explaining variation of mortality at extremely old ages in the United States. The first factor is comparable to the senescent factor found for adult mortality. The second factor, however, is specific to extreme old ages (96 to 100 years) and shows peaks in 1960 and 2000. Although mortality below 90 to 95 years shows a steady decline with time driven by the senescent factor, mortality of centenarians does not decline and remains relatively stable.

The approach suggested in this paper has several advantages. First, it is able to determine the total number of independent factors affecting mortality changes over time. Second, this approach allows researchers to determine the time interval in which underlying factors remain stable or undergo rapid changes. Most methods of mortality projections are not able to identify the best base period for mortality projections, attempting to use the longest-possible time period instead. We observe that the senescent factor of mortality continues to decline, and this decline does not demonstrate any indications of slowing down. At the same

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