

**Session 1: Increased Longevity and the Challenge of
Determining q_x at Extreme Ages, Part 1**

Bending and Ending the Mortality Table

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Before the general availability of high-speed computers, actuaries often used the Gompertz or Makeham theories to design mortality tables. The theories seemed to fit the known facts about the underlying mortality curve at most ages important to insurance and annuity products and provided a convenient method of graduating the tables. In addition, joint and survivor annuity tables were easily derived from single-life tables developed using these theories. The Gompertz formula assumes an exponential increase in mortality rates, and the Makeham formula is close to an exponential increase at the older ages.

Many studies of mortality by age have established that an exponential increase is reasonable from the 50s through the 70s, but the increase decelerates at the older ages. Accordingly, the true pattern of mortality probably has the following characteristics:

An exponential increase in the mortality rates from the 50s to the 70s;

A deceleration of the rate of increase from the 70s to the 90s;

A sharp reduction, or elimination, of the rate of increase at the oldest ages.

Tables developed in the last quarter century tend to reflect the above characteristics, but terminate with an ultimate rate of 1.00 at an arbitrarily selected age to end the mortality table. Actuaries who design the tables usually take one of two approaches to end the mortality table. One is to simply put in a rate of 1.00 at the ultimate age without changing the rates before that age. A second approach is to smooth into the rate of 1.00 from an earlier age.

This paper examines the patterns of mortality at the older ages produced in prior studies going back to the American Experience and other prominent tables of the 18th and 19th centuries. The paper presents an analysis of how the different methods of ending the mortality have been used and includes an analysis of the financial effect of using alternative methods on pension plans and post-retirement medical plans in the United States.