The First Life Table
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THE FIRST LIFE TABLE

TO two Fellows of the Society, John Graunt (elected 1663) and Edmond Halley (elected 1678), the world owes the invention of that powerful vital-statistical instrument, the life table or table of mortality, but the respective shares of these men in the discovery is a matter of dispute.

In the first edition of Graunt's famous 'Natural and Political Observations mentioned in a following Index and made upon the Bills of Mortality' (p. 84 of fifth edition), which secured his admission to the Society, Graunt included a short table purporting to give the survivors of 100 quick conceptions at the end of 6, 16, 26, 36, 46, 56, 66, 76 and 86 years.

The Bills of Mortality in Graunt's time did not record ages at death, and he reached the second entry in his table, viz. 64 survivors at the age of 6, by a rough classification of the named causes of death into those which wholly affected children (thrush, convulsion, rickets, etc.), and those of which he thought about half (small pox, swine pox, etc.) affected children below the age of 6. The remaining figures are conjectural. Some statisticians hold that Graunt had discovered the principle that, under certain conditions, a survivorship table could be computed from a summation of deaths in age-groups; others believe that the table is a mere guess and not even Graunt's but a contribution to his book from his friend William Petty.[1] There is no doubt that, as an instrument of computation, the table is of little value.

No advance was made for more than thirty years. The stimulus to further progress was provided by inquiries possibly circulated at the instance of the Society itself (there is, however, no record of this), some time after 1680, designed to secure accurate records of births and deaths. It is not known whether Halley first moved in the business or whether, after the data had been collected, they were referred to him as the person most competent to use them. All that is certain is that

[1] See Willcox, *Revue de L'Institut Intern. de Statistique*, 5th Year, 1938, pp. 321-328.

by 1691 Henry Justel, the King's Librarian, who was in touch with the Society, had been brought into communication with Caspar Neumann, a scientifically-minded evangelical pastor of Breslau, who supplied the data upon which Halley worked. It is a reasonable conjecture that Justel first heard of Neumann's data from Leibnitz, although a letter of Leibnitz commending Neumann's work is dated 1692, after the time when Justel and Neumann were in communication. Some letters between Neumann and Justel were published in Zenner's *Novellen* in 1694, but give no statistical details. In 1883, J. Graetzer, a medical-statistical official of Breslau, published the results of a historical research.[1] Graetzer not only extracted from the Breslau records all the data which were, or might have been, communicated to the Society, but, at his request, Sir John Burdon Sanderson searched the archives of the Society. This search led to the discovery of two letters (both published by Graetzer, his reference is R.S. Archives, Nr. 1.73), one from Neuman to Justel, dated 9 December 1692, and another from Neumann to Halley, dated 1 March 1694. Both letters have statistical appendices. Although much is left obscure, the information supplied by Graetzer enables one to form a reasonably probable conclusion as to Halley's procedure. The best account of this is given in R. Böckh's paper, published in 1893 [2] in honour of the two hundredth anniversary of Halley's publication (*Philos. Trans.* n. 196, p. 596-610, Jan. 1693); Böckh points out that Halley set himself the task of estimating the survivors of births in calendar years, *i.e.* from a given number of births in five calendar years, how many will survive on the 1 January of each successive year. It is probable that he asked Neumann to supply that information in the letter to which Neumann's letter of 1 March 1694 is the answer, as a check on his method. Neumann misunderstood him and gave a table which, as Graetzer points out, is incorrect. Thus Neumann correctly gave as the survivors of births on 1 Jan. 1688 the difference between the births of 1687 and the number of those not surviving on 1 Jan. 1688. But the survivors he gives on 1 Jan. 1689 are too many, for

[1] *Edmond Halley und Caspar Neumann. Ein Beitrag zur Geschichte der Bevölkerungs-Statistik.* von Dr J. Graetzer. Breslau, 1883, p. 94.

[2] *Bulletin de l'Institut Intern. de Statistique*, T. VII, 1893, pp. 1-24.

he only subtracted the balance of the deaths at ages under 1, not also the deaths at ages over 1, which occurred in 1688 from the births of 1687.

What in fact Halley calculated for each age was not what would now be called the l_x column, survivors at exact age x, but what would now be called L_{x-1}, the life table population from age $x-1$ to x, hence his use of the term age current. Halley's greatest difficulty was that in his data deaths did not balance births. His data (an average of five years) were 1238 births, 1174 deaths, and his table accounts for 1238 deaths. He had, therefore, to adopt some method of increasing deaths at later ages. Graetzer suggests that Halley may have made two graphs, one having an ordinate of 1238 at the origin and an ordinate of 64 at the oldest age, the other an ordinate of 1174 at the origin and 0 at the oldest age, that he plotted the survivors for each graph based on recorded deaths and drew a curve passing through 1238 and 0 between these two graphs.

The arithmetical work of both Graetzer and Böckh justifies the opinion that Halley used the data most sagaciously. Indeed Böckh, who seems to have had a poor opinion of many of his colleagues (a habit of mind not uncommon in statistical circles), says roundly that many contemporary statisticians have made no essential advance on 'ein geistvoller Mann vor zwei Jahrhunderten.' Perhaps Halley's method slightly overstated the rate of mortality. But actually Graetzer's calculations of rates of mortality in Breslau for 1876-80 (based, of course, upon enumerated populations) do not show lower rates than those of Halley. Certainly nobody using deaths and births only, *i.e.* without an enumeration of the living, has done better than Halley. An interesting historical question is whether Halley suggested the inquiry or merely undertook it. He never returned to the subject. Abraham de Moivre, using Halley's table, made the next important advance, not on Halley's constructional work but on his method of calculating annuity values.

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