Early Swiss Mortality Tables

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The calculation of mortality tables is reckoned nowadays as one of the primary tasks of the official vital statistics of any country. Such tables are, therefore, also constructed and published by the Swiss Federal Statistical Office. As will be seen from another paper in this publication [1], the first table calculated by the Federal Statistical Office was based on the deaths occurring in the years 1876–1880. This does not, however, mean that there are no earlier tables. The growing interest in statistical and demographical questions of all kinds which could be observed nearly everywhere in Europe in the second half of the eighteenth century, was also to be found in Switzerland. There was considerable activity in this field during that period, and, *inter alia*, several mortality tables were calculated. Of course, since the first calculation of such tables by *Graunt* and *Halley* towards the end of the seventeenth century, quite a number of mortality tables had been published by *Smart*, *Deparcieux*, *Kersseboom*, *Struyck*, *Wargentin*, *Süssmilch*, and others, so that the attempts of the Swiss writers could no longer claim to be original, the more so, as they did not go beyond distributing the observed deaths per thousand according to age. It may, nevertheless, be of interest to see what work was done in Switzerland in this direction and to compare the results with those obtained at the same time in other countries [2]. Moreover, there were in the eighteenth century a few mathematicians of Swiss origin who made valuable contributions to the theoretical problems in vital statistics in general and to the calculation of mortality tables in particular.

I

As may be remembered, Switzerland, in the second part of the eighteenth century, was merely a loose alliance of a number of small and practically independent republics. There existed no vital statistics for the whole country, but only for some towns and regions. We will first turn to Geneva which at that time was the largest [3] and most progressive town of Switzerland and the home of a number of remarkable men. In Geneva, death registers had been kept since 1549; since 1561 the age of the deceased had been recorded. About 1760,

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[1] *Walter Wegmüller*, Grundlagen der schweizerischen Volkssterbetafeln 1931/41 und 1939/44. See pp. 366–378.

[2] For further information see *Marcel Ney*, De la mortalité dans la population suisse, Bulletin de l'Association des Actuaires suisses, Fasc. 22, Berne 1927, pp. 23–24 and 80–104, as well as my book, Bevölkerungsgeschichte und Bevölkerungspolitik der Schweiz seit dem Ausgang des Mittelalters, Zurich 1947, pp. 85–87 and 292–293.

[3] Geneva numbered in the second part of the eighteenth century roughly 20 000 inhabitants.

Jean-Antoine Cramer undertook the enormous task of extracting the age composition of the deaths for the whole two hundred years since 1561, a labour he continued till his death in 1775. *Cramer* did not publish his figures himself; this was done by a physician, *Louis Odier*, first in 1791 in the "Journal de Genève", then in 1797 in the "Bibliothèque Britannique" [1]. Later on, *Odier* brought *Cramer's* figures up to 1813 [2]. Another doctor, *Abraham Joly*, compiled the same statistics for the years 1771 to 1811; his figures differ slightly from those of *Odier*. In the following decades, the interest in population questions became still more general. There appeared quite a number of articles on such problems in the "Bibliothèque Britannique" or rather "Bibliothèque Universelle", as it was called after 1816. Further mortality tables were also published by *Théophile Heyer* and *Henry-Clermond Lombard* [3], *Jacob-Marc d'Espine* [4] and *Edouard Mallett* [5].

Below, some results of various Geneva tables are given, the figures being taken from *Mallett's* "Recherches Historiques et Statistiques sur la population de Genève".

Geneva Mortality Tables

Average Expectation of Life in Years

Period	Males	Females	Both Sexes
1561–1600	*	*	21,2
1601–1700	*	*	25,7
1701–1750	29,2	35,7	32,6
1751–1800	31,9	37,0	34,5
1801–1813	35,1	41,5	38,5
1814–1833	38,5	42,7	40,7

As already mentioned, all the earlier Swiss mortality tables were calculated according to the method usually, but not quite correctly, ascribed to *Halley* and would, therefore, only be correct, if the population had been stationary.

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[1] "Journal de Genève", 9 juillet 1791, and "Bibliothèque Britannique", vol. 4, 1797, Genève 1797, pp. 327–330. The main purpose of the "Bibliothèque Britannique" was to offer the public "des extraits des ouvrages Anglais périodiques et autres". The English influence in Geneva at that time was so strong that Geneva could be called "une ville britannique au cœur du continent"; *Ernst Gagliardi*, Geschichte der Schweiz, 4th ed., Zurich 1939, p. 1023.

[2] *Louis Odier*, Observations sur la probabilité de vie et la vie moyenne résultant des régistres mortuaires de Genève depuis 1761 jusqu'à la fin de 1813. "Bibliothèque Britannique", vol. 55, 1814, Geneva 1814, pp. 213–231.

[3] *Théophile Heyer* et *Henri-Clermond Lombard*, Recherches statistiques sur la mortalité de la ville de Genève, et des communes de Plainpalais et des Eaux-Vives, depuis 1816 jusqu'à 1830. "Bibliothèque Universelle", vol. 56, 1834, Geneva 1834, pp. 337–371.

[4] *Jacob-Marc d'Espine*, Notice statistique sur les lois de mortalité et de survivance au divers âges de la vie humaine, sur la vie moyenne et la vie probable, d'après les 10 203 décès qui ont eu lieu dans le canton de Genève pendant les 8 années de 1838 à 1845, Geneva 1847.

[5] *Edouard Mallett*, Recherches historiques et statistiques sur la population de Genève, son mouvement annuel et sa longévité depuis le XVIe siècle jusqu'à nos jours, Paris 1837.

Due to the gradual increase of the population, the values given are somewhat too small. But there is no doubt that the average expectation of life was very low in the sixteenth century and rose slowly from period to period. The very low average life expectation at birth was, of course, mainly due to the high infant mortality. This is even more apparent in the *probable* duration of life which was only 8,7 years in the sixteenth and 13,3 years in the seventeenth century, taking both sexes together. It was not before the nineteenth century that it surpassed the *average* expectation of life with 40,7 years in the period 1801–1813 and 45,1 years in the period 1814–1833.

The average expectation of life for other ages than at birth is not given in my sources; I have calculated it myself for the seventeenth century from the age distribution of deaths. It may be of interest to compare the results with *Halley's* famous figures [1].

Average Expectation of Life at Various Ages in Years

Age	Geneva 17th century	Halley
0 *	23,3	29
10	36,7	40
20	31,9	34
30	27,3	28
40	22,7	22
50	18,0	17
60	13,5	12
70	9,6	8
80	6,7	*

* Including still-births.

The figures do not agree badly, excepting the average expectation of life at birth which is considerably higher in *Halley's* table, surpassing even the figure given in my *first* table for the seventeenth century, where the still-born are not included. It is hardly possible to give a definite reason for this discrepancy, in view of the fact that the old birth and death lists are not very reliable.

Finally, I give the number of survivors at certain ages for Geneva in the sixteenth, seventeenth and eighteenth centuries [2] in comparison with the two life-tables compiled by *Deparcieux* and *Kersseboom* [3], at the same time adding two further Swiss life-tables calculated by *Waser* and *Muret*, which will be discussed later on.

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[1] *Harald Westergaard*, Die Lehre von der Mortalität und Morbidität, 2nd ed., Jena 1901, p. 37.

[2] The figures for the sixteenth century (1561–1600 with some years omitted) are calculated from 13 845, those for the seventeenth century from 53 783, and those for the eighteenth century from 67 994 deaths.

[3] *Westergaard*, op. cit., p. 51.

Various Mortality Tables

Number of Survivors (Both Sexes)

Age	Geneva 16th century	Geneva 17th century	Geneva 18th century	Deparcieux	Kersseboom	Waser	Muret
0	1000	1000	1000	*	1000	1000	1000
5	556	590	668	689	689	607	701
10	481	524	611	640	639	566	653
15	435	487	586	616	611	547	631
25	351	412	526	563	551	514	587
35	271	345	466	504	468	465	540
45	189	268	396	452	400	393	476
55	130	199	316	382	319	315	388
65	66	122	210	287	225	192	251

The considerable improvement of the figures for Geneva from the sixteenth to the eighteenth century is apparent. But even the values for the eighteenth century are less favourable than those calculated by *Deparcieux* and *Kersseboom*, although their tables refer rather to the seventeenth and early eighteenth than to the whole of the eighteenth century. This difference is mainly due to the fact that both *Deparcieux* and *Kersseboom* used more correct methods than the calculation from the age composition of deaths alone, and that their tables are based on material concerning the members of two tontines *(Deparcieux)* and annuitants *(Kersseboom)*, i. e. refer to the well-to-do classes of their countries and not to whole populations.

Two further mortality tables from which I have already given some figures were constructed by *Johann Heinrich Waser* and *Jean-Louis Muret*. *Waser*, a Zurich clergyman, with a keen interest in statistical questions, amassed a large and varied statistical material, a great part of which he could not publish himself owing to his untimely death [1]. His mortality table was discovered by *Stüssi* amongst his unpublished manuscripts in the Archives of the Canton of Zurich [2]. The table refers to the population of the Canton of Zurich and to the eighteenth century, but neither the exact sources on which *Waser* based his table, nor the method by which he calculated it, are known. It is, therefore, difficult to judge the value of *Waser's* figures. I will merely add that the average expectation of life according to *Waser's* table is 31,5 years, i. e. somewhat longer than according to the Geneva tables for the eighteenth century.

More interesting than *Waser's* figures seems to me the work done by *Muret*, a protestant minister of Vevey. In his fairly well-known "Mémoire sur l'état

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[1] *Waser* was decapitated in 1780 at the age of 38 for high treason and the theft of important state papers. About Waser see *E. Anderegg*, Johann Heinrich Waser, sein Leben und sein Werk. Zurich 1932.

[2] *H. Stüssi*, Die erste schweizerische Mortalitätstafel. "Zeitschrift für schweizerische Statistik" 1877, p. 217.

de la population dans le Pays de Vaud"[1], *Muret* tried to show that the population of the Pays de Vaud which at that time was held in subjection by Berne, was continually decreasing, a fact *Muret* attributed to emigration, alcoholism and the general addiction of the population to luxury and laziness[2]. To prove his contention, *Muret* painstakingly collected a large statistical material from the parish birth, marriage and death registers of his native canton. As *Malthus* in his famous chapter on Switzerland already pointed out, "the facts which M. *Muret* has collected are all valuable, though his inferences cannot always be considered in the same light"[3]. We have here, however, not to examine *Muret's* views on the population development, but his mortality table. It refers to about 40 parishes of the Pays de Vaud and the years 1751–1760. As can be seen from the extract given above, *Muret's* results are more favourable than those for Geneva. The average expectation of life is calculated by *Muret* as 35,0 years for males, 39,4 years for females and 37,5 years for both sexes together. There is hardly any doubt that the mortality of the rural population of the Pays de Vaud was in fact sensibly lower than that of the urban population of Geneva, the more so as the birth rate of the Pays de Vaud was for that time comparatively low.

Apart from this, *Mure* has also tried to calculate a marriage table for women, and separate mortality tables for married and single women. He found that married women live longer than single ones, a fact which was, however, already known at the time of his writing.

Some further mortality tables were compiled in the nineteenth century by *Kocher*, the "Schweizerische Lebensversicherungs- und Rentenanstalt", *Gisi*, and *Kinkelin*[4]. Of these tables, *Gisi's* may justly claim to be the first table for the whole Swiss population[5]. It is correctly calculated from the results of the census of 1860 and death figures for fifteen cantons, referring in the main to the years 1850–1865. That not all cantons are included, matters less than other defects of the material. The average expectation of life was found by *Gisi* to be 41,6 years for males and 42,7 years for females, whilst the first official mortality table for the period 1876–1880 gave an average expectation of life of 40,6 and 43,2 years respectively. *Gisi's* figures are, therefore, probably a little too high (especially for males), although there was hardly any great improvement in mortality in the years lying between the two tables.

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[1] Yverdon 1766.

[2] Similar views to those of *Muret*, but without statistical foundation, were also advanced by a physician, *Samuel-André Tissot*, in a book entitled "Avis au peuple sur sa santé" (Lausanne 1761). *Tissot* is extensively quoted by *Süssmilch* in his "Göttliche Ordnung" (2nd ed., Berlin 1761–1762, vol. 2, pp. 537–548.

[3] *Thomas Robert Malthus*, An Essay on the Principle of Population, 5th ed., 3 vol., London 1817, vol. 1, p. 480.

[4] *Ney*, op. cit. pp. 24–25 and 99–104.

[5] *Wilhelm Gisi*, Eine schweizerische Sterblichkeitstafel, "Zeitschrift für schweizerische Statistik" 1867, pp. 190–203.

After the calculation of mortality tables for the whole Swiss population had been taken up by the Federal Statistical Office, there was no reason for private statisticians to continue this work. It may, however, be mentioned that several *local* tables were published, for instance by Dr. *W. Grütter* for Berne [1], by Dr. *H. Stohler* for Basle [2], and finally by the Statistical Office of Zurich for Zurich [3]. I will, however, not dwell on these newer tables.

II

As mentioned above, the calculation of mortality tables by distributing the deaths per thousand according to age only gives correct results if the population is stationary. If the population grows, the results are too low. In his "Recherches générales sur la mortalité et la multiplication du genre humain" [4], the famous Basle mathematician *Leonhard Euler* showed how correct figures can be arrived at from death lists alone on the assumption that there is a geometrical increase of the population due to a regular surplus of births over deaths, migrations being negligible. If, for instance, the yearly surplus of births is one percent, the number of births will approximately double in seventy years, or, in other words, the persons who die at the age of seventy, will belong to a generation which was only half as numerous as that born at the time of their death. Similarly, persons dying at the age of 40 form part of a generation which is only about two thirds of the one born in the same year. It can easily be calculated with what factor the number of deaths at each age must be multiplied in order to make all the figures comparable and thus eliminate the influence of the increase of the population. About the middle of last century, *Euler's* method of adjusting the death lists was used for the calculation of various mortality tables in England, Germany and other countries [5].

Euler also supplied *Süssmilch* with a table that showed the doubling period of populations under various conditions, a point in which *Süssmilch* was particularly interested [5].

Another Swiss mathematician who contributed to the theory of mortality tables is *Daniel Bernoulli*. There are several members of the *Bernoulli* family who deserve an honourable place in the history of statistics. The weighty contribution which *Jakob Bernoulli* made to the calculus of probability by his "Ars

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[1] *W. Grütter*, Überlebensordnung für die Stadt Bern nach den Resultaten der eidgenössischen Volkszählung vom 1. Dezember 1920 und den Mortalitätsbeobachtungen der Jahre 1919 bis 1922. Bulletin de l'Association des Actuaires suisses, Fasc. 19, Berne 1924.

[2] *H. Stohler*, Basler Sterbetafel nach dem Bevölkerungsstand der Jahre 1918–1924. "Zeitschrift für schweizerische Statistik und Volkswirtschaft" 1926, pp. 109–121.

[3] Zürcher Sterbetafeln 1896–05 bis 1926–1933, and Zürcher Sterbetafeln 1926–1933 bis 1936–1945, "Zürcher Statistische Nachrichten" 1938, pp. 1–42, and 1947, pp. 133–188.

[4] Histoire de l'Académie Royale des Sciences et Belles-lettres 1760.

[5] *Westergaard*, op. cit., pp. 96 and 98.

[6] *Süssmilch*, op. cit., vol. 1, p. 280.

conjectandi" [1] is generally known; less known is *Christoph Bernoulli's* "Handbuch der Populationistik oder der Völker- und Menschenkunde" [2]. Although this work hardly belongs to the very first rank of statistical literature, it may justly claim a right not to be forgotten altogether. It gives a good picture of the state of demographical knowledge at its time, and is written, as *Westergaard* says, "with a real critical sense" [3] and, I may add, not without a certain original way of looking at things. As to *Daniel Bernoulli*, economists are acquainted with the impulse he gave to the theory of marginal utility by his treatment of the Petersburg Problem. The paper I wish to mention here, however, is his "Essai d'une nouvelle analyse de la mortalité causée par la petite vérole et les avantages de l'inoculation pour la prévenir" [4]. The question *Bernoulli* sets himself in this fine piece of mathematical analysis, is to what extent mortality could be reduced if there were no deaths by small-pox. The figures he uses in his solution of this problem are more or less arbitrarily chosen, as for instance the assumption that every eighth person is attacked by small-pox yearly and that one out of eight of the attacked ones dies. Of interest is the method applied, i. e. the use of infinitely small units of time whereby the problem can be reduced to a simple differential equation. *Bernoulli's* work was later on continued by *Emmanuel-Etienne Duvillard*, who originated from Geneva [5]. *Duvillard* found that out of a hundred persons at the age of 30 only 3 had not had small-pox, and that two thirds of all new-born children would be liable to an attack. If small-pox could be prevented, a new-born child would increase its average expectation of life by 3,5 years. As *Westergaard* points out, *Duvillard's* real work became very little known; what was extensively used and criticized was his mortality table, which, using French figures, he based on the age distribution of deaths under the assumption of a stationary population [6].

Finally, I should like to mention *Johann Heinrich Lambert*, of Mulhouse in Alsace. As Professor *Linder* has recently pointed out, Mulhouse in the eighteenth century was allied to the protestant cantons of Switzerland and its citizens were held to be Swiss [7], so that *Lambert's* inclusion in this short survey of Swiss statistical activity in the eighteenth century may be justified.

Lambert's contributions to vital statistics are found in the third volume of his "Beyträge zum Gebrauche der Mathematik und deren Anwendung" [8].

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[1] Basle 1713.

[2] Ulm 1841.

[3] *Harald Westergaard*, Contributions to the History of Statistics, London 1932, p. 170.

[4] Histoire de l'Académie royale des sciences, année 1760, Paris 1766.

[5] *Emmanuel-Etienne Duvillard*, Analyse et tableaux de l'influence de la petite vérole sur la mortalité à chaque âge et de celle qu'un préservatif tel que la vaccine peut avoir sur la population et la longévité. Paris 1806.

[6] *Westergaard*, Contributions, pp. 93–95.

[7] *Arthur Linder*, Methoden zur Berechnung von Volkssterbetafeln, Berne 1934, p. 18, and *Daniel Bernoulli* and *J. H. Lambert* on Mortality Statistics. "Journal of the Royal Statistical Society", vol. 99, 1936, London 1936, pp. 138–141.

[8] Berlin 1772.

Amongst other subjects [1], *Lambert* similar to *Daniel Bernoulli* and *Duvillard* dealt with the influence of small-pox on mortality [2]. Of particular interest, however, is his attempt to establish a "Law of Mortality", i. e. to express the relation between age and the mortality rates in a mathematical formula. From the mortality table constructed by him [3], he developed the equation

$$y = 10\,000 \left(\frac{96-x}{96}\right)^2 - 6\,176 \left(e^{-\frac{x}{31\,682}} - e^{-\frac{x}{243\,114}}\right),$$

where y is the number of survivors at the age of x. Herewith *Lambert* preceded the work done in this direction by *Gompertz*, *Edmonds*, *Littrow*, *Moser*, *Makeham* and others in the nineteenth century.

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[1] One finds, for instance, in *Lambert's* work the first attempt to build up a theory of error.

[2] *Lambert*, op. cit. vol. 3, pp. 568–599.

[3] *Lambert*, op. cit. vol. 3, pp. 478–513.