

TRANSACTIONS

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THE DIP IN MORTALITY IN THE TWENTIES OF AGE

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THE mortality tables with which we are most familiar have a maximum death rate in the first year of life, a decrease to a low point in the neighborhood of age ten and then a steady increase to the final age of the table. However, in the Society's textbook *Mortality Studies* (1932) the following appears (page 151) in reference to the 1912-1927 Japanese Experience Life Tables: "A peculiarity is that the death rate increases rapidly up to about age 20 after which it decreases to about age 32 for both males and females." The latest Japanese table is even more marked in this regard. It covers the five years April 1930 to April 1935, and appears in *The Annual Statistical Report of Post Office Life Insurance and Annuities for the Fiscal Year 1951-52* (Tokyo, Japan). Its death rate rises to a maximum at age 19 (12.60 per 1,000) and drops to a low point at age 33 (8.33 per 1,000). This is a 34% decline over an interval of 14 years of age. At age 45 the death rate has just barely exceeded that of age 19. The total length of the trough is thus 26 years. This is a most remarkable phenomenon, which may merit some investigation and amplification.

The same Japanese report includes a so-called "annuity" mortality table for each sex, showing characteristics similar to those for insurances. For men the maximum is at age 20, with a 26% drop to the low at age 31 and a trough of 21 years. For women the maximum is at age 21, with a 16% drop to age 31 and a trough of 26 years. These tables are synthetic, however, for a footnote states (page 161): "The Annuity Mortality Tables were constructed by deducting, in the case of the male, 20% of the male mortality rates, and in the case of the female, 30% of the female mortality rates, from the 5th Life Table compiled in 1936 by the then Government Bureau of Statistics." This is a general *population* table covering the years 1926-1930; hence these data are not really based on the lives of annuitants at all. They should therefore be excluded from any tabulations of true annuitant mortality.

Starting from this Japanese insured life experience, I shall briefly review other mortality tables across the world and over a century and a half

of time. Then consideration will be given to the causes of the phenomenon under review.

In no other case is the dip in mortality so extensive. The Japanese Post Office premium rates for short-term endowments reflect the dip. The monthly premiums for 50,000 face amount of endowment coverage are as shown in Table 1. The dip is most marked at age 27, but on the ten year endowment plan the premium at entry age 37 is less than that at age 17. On the 15 year plan the two are equal.

When we look at other mortality tables, we may start with the Healthy Males of England (H^M ; 1869). The Makeham graduation of this table appeared in both King's *Text Book* Part II and also Spurgeon's *Life Contingencies*. This is the table from which most of us received our first and most sensitive impressions of the nature of things actuarial. In that graduation

TABLE 1

Age	10 Year Endowment	15 Year Endowment	20 Year Endowment
7.....	425	285	215
17.....	445	300	225
27.....	435	295	220
37.....	440	300	230
47.....	460	330	265

there is no dip in the twenties of age. The process of making the table conform to the Makeham formula eliminated that feature. In the Woolhouse graduation, however, there was a maximum at age 22, a 3% drop to a low at age 25, and a 5 year trough. The corresponding ultimate table $H^{M(5)}$ had a more pronounced dip—a maximum at age 24, a 15% drop to a low at age 31, and a trough of 14 years. Not until age 38 does the death rate exceed that of age 24.

Even as far back as the Carlisle table (1816) we find a small dip—maximum at age 20, a 2% drop to age 21, and a trough of four years. Much more recently the Male English Life Table #10 of 1930-'32 has a 6 year trough and a 2% drop from age 23 to 27.

A table of European Males was presented by Dr. Peter Smolensky of Italy in the November 15, 1933 *Bulletin* of the International Congress of Actuaries. It covers together English, French, German, Austro-Hungarian and Scandinavian lives. There is a 14 year trough, beginning at age 15, and a 7% drop to a low at age 25.

Similar features occur in the Australian Mutual Provident's table for 1849-1888; in the AM 47 population table of Australia (1946-1948) and

in the New Zealand population table (1895). These were published in *Practical Lessons in Actuarial Science* by M. M. Dawson. The details which are germane to the present research appear in Table 4.

The same publication includes two *Makehamized* tables with the dip preserved. These are the French 1895 tables AF and RF. In each the trough begins at age 21, with a low point at 25. But in the annuity table (RF) the drop in mortality is 10% and there is a 12 year trough. The insured life table (AF) has a 9% drop and a 9 year trough. There are probably proportionately more women included in the annuity table than among the insured lives. Thus it is surprising to find the trough both deeper and longer for annuitants. In many instances the trough occurs for male lives only. In the English Life Table #10, for example, there is no such dip for female lives.

The Japanese tables covering 1912-1927, however, have even more extreme characteristics for women than for men. The J^{AM} table has a 23 year trough starting at age 19 and a 30% dip to a low at age 31. The J^{AF} table has a 32 year trough extending from age 18 to 50 and a 28% dip to a low at age 34. These are by amounts of insurance, but the tables by policies have much the same features (J^{PM} and $J^{\text{PM}(3)}$, for example).

The Substandard Industrial Mortality table covers colored (Negro) lives of the Metropolitan Life Insurance Company insured in the years 1896-1905. It is published in the 9th edition of Willey's *Principles and Practice* as revised by Fackler. The trough begins at age 21, has a 7% drop to age 27 and extends for 12 years to age 33. A similar characteristic appears in the Canadian Men table (1918) in both select and ultimate mortality. It is also found in the 1946-1949 Select Basic Table (*TSA II*, 506) in each of the first nine years of "selection" and in J. S. Elston's Joint 1939-44⁽¹⁵⁾ table (*TASA XLVIII*, 242). I am informed that a similar dip occurs in another recent table, J. D. Parsonage's 1949-1951 experience compiled through the Canadian Association of Actuaries. So far the most extreme characteristics have been found for the Japanese, another colored race (yellow) and of subtropical habitat. My search among mortality tables in this matter has not been exhaustive. There are no doubt (a) other tables with these features and (b) others yet from which a real dip and trough have been artificially removed by the mechanics of graduation.

In the aggregate German insured life tables of 1926, edited by Dr. Alfred Manes, there are only 18 deaths at ages below 17. But at later ages there are plenty of data. The bottom of the trough is at ages 20 and 21 and the respective ends at ages 10 and 28 with a total drop of 5%.

For illumination upon the present research the most valuable report is

that of the Swedish industrial life insurance company De Förenade (1933: Stockholm). This 283-page publication (in English) includes three ultimate tables for each sex, covering the experience years 1907-14, 1914-21 and 1921-28. The trough data are shown in Table 2.

The percentage drop in death rate from top to bottom of the trough is markedly less for women than for men. But there seems to be no other consistent characteristic of these data, when one column is compared with another. Incidentally, select tables are given (10 year select period) which show these same features.

This Swedish report, however, is of particular interest because the deaths are divided into nine categories, and the death rates by age and sex

TABLE 2
DE FÖRENADE (SWEDISH)

DATA OF TROUGH	1907-14		1914-21		1921-28	
	Male	Female	Male	Female	Male	Female
Age at Maximum Death Rate.....	23	23	23	23	23	23
Age of Low Point.....	32	34	34	34	33	32
Difference (Years).....	9	11	11	11	10	9
Length of Trough.....	18	20	23	19	21	15
% of Maximum Drop to Minimum.....	21%	14%	32%	12%	27%	8%
Age at End of Trough.....	41	43	46	42	44	38

are shown for each of these. The total death rate at any age is the sum of the nine death rates in the respective groupings of causes of death. These tabulations throw considerable light upon the causation of the dip and trough in mortality in the twenties of age.

The nine categories of cause of death appear on page 26 of the Swedish report (1933), and, in short title, are approximately as follows, when set forth in three groups:

1. Violence
2. Tuberculosis
3. Mental & nervous disorders
4. Digestive disorders
5. Circulatory & syphilis
6. Cancer & goitre
7. Septic infections
8. Other acute infections
9. Other miscellaneous diseases

These are here arranged in three groups because that corresponds to the incidence of mortality. Let us take as example the death rates for *males* in the years 1921-1928, as in Table 3.

“Violence” includes accident, homicide and suicide. These causes, when treated together with tuberculosis, have a maximum at age 23 and a low point near age 35. It may be observed that at age 23 about three-fourths of all the deaths are due to this group of deaths, at age 33 about half, and at age 43 about one-third. It is the incidence of death in this first group which is most closely associated with the trough and dip which are here under review. The third group, including the cardiovascular-renal system and cancer, may be regarded as “degenerative.” Until age 40 is past these are not relatively very important. The second group of causes includes all

TABLE 3
DE FÖRENADE DEATH RATES PER 1000
MALES: 1921-1928

Ages	Violence & Tbc. (1, 2)	Nervous, Digestive & Some Infections (3, 4, 7, 9)	Heart, Cancer, etc. (5, 6, 8)	Total
15.	1.35	.67	.34
20.	2.96	.69	.45
25.	3.36	.72	.59
30.	2.21	.76	.71
35.	1.78	.86	.94
40.	1.79	1.02	1.37
45.	1.98	1.32	2.13
23.	3.61	.69	.54	4.84
33.	1.88	.82	.83	3.53
43.	1.88	1.19	1.77	4.84
53.	2.49	2.32	4.69	9.50
63.	3.36	5.93	13.76	23.05

others. They are not comparatively very significant, and from age 33 to 63 cover roughly one-fourth of the deaths.

Before seeing the data in this Swedish report, of which Table 3 is typical, we had thought that accident and tuberculosis were the explanation of the trough and dip. In fact, the Australian report AM 47 mentions accident as such a cause in some brief introductory remarks. The advantage of the Swedish data is that they “substitute demonstrations for impressions” and give a concrete measure of the matters under consideration. There are a number of limitations, however, and one must avoid overgeneralization. We all know many facts which would prevent any generalization to all lands and all times: (1) Tuberculosis in the U.S.A. has taken a nose-dive especially in the last quarter-century, exactly the period which has followed after the latest data in the Swedish publication.

(2) The automobile and other forms of machinery in the U.S.A. have increased enormously in exactly this same period. (3) In the more advanced countries machinery has substituted for much manual labor, especially in the last 25 years. (4) The conquest of most infectious disorders and the use of antibiotics have done wonders recently in some advanced countries.

The distribution of deaths by cause at the young ages in any country and period of time is largely dependent upon the facts under these last four headings: tuberculosis, machinery, manual labor and antibiotics. We have to be careful not to try to prove too much, like the case of the cracked pot—the man showed in court that (1) he never borrowed the pot, (2) when he did borrow it, it was cracked, and (3) when he returned it, it was not cracked.

We may conclude these comments, however, as follows:

a) The dip and trough in mortality rates in the twenties of age have been found in many countries and over a period of at least 150 years.

b) The H^M table and the $H^{M(5)}$ show clearly how easily the graduation procedures can wipe out entirely this characteristic, or they can leave it in. Which to do is a matter of judgment.

c) A dozen mortality tables, which retain these features, are referred to in parallel columns in the appended Table 4. There are doubtless many others not yet brought into focus in this connection. There are likely still others in which this essential characteristic has been eliminated artificially by grading methods, especially by Makeham's formulas.

In supplement, I may mention the hypothesis that (a) violence and (b) cancer may to some extent act as substitutes for tuberculosis, as the latter continues to disappear from the scene. Ninety percent of the death rate from this cause has gone since 1900 in the U.S.A., and the decline continues every year at a rapid rate. Deaths from accident, suicide and homicide are contained in the one word "violence." In many respects cancer and tuberculosis seem antithetical, so that the one comes in as the other goes out. Between 1945 and 1950, mortality in the U.S.A. from cancer of the lungs increased 44% while that from tuberculosis of lungs decreased by 42%. The later age-incidence of cancer than that of tuberculosis accords with the greater longevity today as contrasted with the 1850's. In those days tuberculosis was responsible for more deaths than any other cause. As yet, however, I do not believe we have enough knowledge to be dogmatic in these matters.

Mention of accident leads me to recall to mind the intercompany report of 1934 on the *Accidental Death Benefit* among insured lives in the United States and Canada. There were two mortality tables presented for death from accident: (1) In the 1918-25 table the death rate decreases from .679

TABLE 4
SYNOPSIS OF MORTALITY TABLES—MALE LIVES (ALL CAUSES OF DEATH)
(Arrangement Chronological)

	Range	Carlisle 1816	HM Wool- house 1869	HM (S) Wool- house 1869	Australian Mut. Prov. 1849-88	New Zealand 1895	French AF 1895	French RF 1895	Metro- politan Substand. 1896-1905	English #10 (M) 1930-32	Europe 1933	Jap. P.O. 1930- 1935	Australia AM 47 1946-48
Age of Max. Death Rate.....	(15-24)	20	22	24	19	23	21	21	21	23	15	19	22
Age of Low Point..	(21-33)	21	25	31	21	26	25	25	27	27	25	33	25½
Difference (Years)	(1-14)	1	3	7	2	3	4	4	6	4	10	14	3½
Length of Trough.	(4-26)	4	5	14	6	5	9	12	12	6	14	26	7
% of Drop Maxi- mum to Mini- mum.....	(2-34)	2	3	15	3	2	9	10	7	2	7	34	7
Age at End of Trough.....	(24-45)	24	27	38	25	28	30	33	33	29	29	45	29

at age 15 to .469 at age 32, a drop of 32%. Not until age 46 does it rise as high as at age 15. The trough covers 31 years. (2) In the 1926-33 table the similar figures are .882 at age 15, a minimum of .438 at age 30, a drop of 50%. Not until age 51 does the rate rise as high as at 15. The trough covers 36 years in this more recent of the two tables.

In the 1926 intercompany report on *Disability Experience* there are similar data for certain of the rates of disability:

a) Class (1) rate in 4th to 6th years (aggregate) at age 15 is 1.59, at 30 is 1.44 and at age 40 has passed that of age 15. (The drop from age 15 to 30 is 10%.)

b) Class (2) rate is 3.32 at age 15, 2.38 at age 30 and then upward. (The drop from age 15 to 30 is 28%.)

c) Class (3) rate is 4.70 at age 15, 4.05 at age 30 and at age 40 has barely exceeded that of age 15. (The drop is 14%.)

A synopsis of part of the above data appears in Table 4. It covers the mortality tables for all causes combined (*i.e.*, excluding tables dealing with accident only). There are twelve such tables, all graduated. The list is incomplete. Only one of these is for annuitants (the RF of 1895). The only table from the tropics or subtropics is that of Japan. It shows the most extreme characteristics and it is (a) on yellow lives and (b) one of the most recent of the experiences here reviewed. Measured by the length of the trough, the $H^{M(5)}$ and the table for Europe are the next most extreme. The $H^{M(5)}$ is also second most extreme when measured by the percentage drop in death rates. In every instance, except the two most extreme tables, the age of low point lies between 21 and 27. Also with those two exceptions, the percentage drop from top to bottom of the trough lies between 2% and 10%. With the same exceptions, the age at the end of the trough ranges between 24 and 33.

In those mortality tables where there is no dip in the death rates in the twenties of age, there is usually such a dip and trough in the first differences of the death rates. This appears clearly in the Annuity Mortality, 1950 Table (TSA II, June, 77). For males the trough extends 17 years, from 14 to 31, with lows at ages 20-21. For females the trough extends 12 years, from 14 to 26, with a low at age 19. So far as I have observed, the dip and trough, either in death rates or in their first differences, is a characteristic of all mortality tables, ancient and modern.

This paper will serve as a warning to students who may be tempted to graduate out a dip which shows up in the crude data in the construction of a mortality table.