Uses of the Life Table in Vital Statistics*

LOUIS I. DUBLIN, Ph.D., F.A.P.H.A., and
ALFRED J. LOTKA, D.Sc.
Third Vice-President and Statistician; and Assistant Statistician
Metropolitan Life Insurance Company, New York, N. Y.

FOR the benefit of those readers who may not be acquainted with the detailed structure of the life table, a brief description of its principal columns will first be given, using, by way of illustration the life table for white males in the United States in 1934, as computed in the Statistical Bureau of the Metropolitan Life Insurance Company. This table is reproduced as Table I.

Column 1 of this table gives the age of life from birth to age 104. The second column shows the survivors to each age of life out of 100,000, starting out at birth (age 0), and diminishing from age to age in accordance with the mortality of 1934. The figures in this column are generally denoted by the symbol l_x. The third column indicates the corresponding deaths in each year of life, the figures in this column, usually denoted by d_x, being simply the differences between two adjacent figures in the second column. The fourth column gives the death rate in each year of life, or, to be more exact, the probability at a given age of dying within 1 year, this being denoted by the symbol q_x. So, for example, the death rate at age 10 is obtained by dividing the deaths in this year of life, namely 123, by the number of persons entering this age, namely 91,625. This quotient, expressed in parts of a thousand, is 1.34.

The fifth and sixth columns are auxiliary columns employed in computing the seventh column, which gives the expectation of life at each year of age. The fifth column gives the average number of persons living in each year of life; for instance, in the first line opposite age 0, we find 97,090 which is the average of 100,000 and 94,179. The figures in this column may also be interpreted as the number of years of life lived within a given age of life; so, for instance, the figure 97,090 is the number of years lived by the survivors of the original 100,000 in passing through the first year of their life.

Column 6 is obtained by cumulating the figures in column 5 beginning at the end; for example, the figure 31 in column 6 opposite age 100 is the sum of 2+4+8+17, the figures appearing on the same line and the lines below in column 5.

Lastly, column 7, as already noted, gives the expectation of life or the average after-lifetime at each year of life. It is obtained as the quotient of the figures in column 6 and the corresponding figures in column 2, for this gives a total number of years lived by survivors of a cohort after a given age, divided by the number of persons entering that age.

A table such as this, it is seen at once, contains a great deal of detailed information and is a source from which

---

* Read before the Vital Statistics Section of the American Public Health Association at the Sixty-fifth Annual Meeting in New Orleans, La., October 23, 1936.

TABLE I

Life Table for White Males in the United States, 1934

1	2	3	4	5	6	7
	Of 100,000 Born Alive		*Rate of Mortality per 1,000*			*Complete Expectation of Life or Mean After-Lifetime; Average Number of Years Lived After Age x per Person Surviving to Exact Age x*
Age	*Number Surviving to Exact Age x*	*Number Dying Between Ages x and x+1*	*Number Dying Between Ages x and x+1 Among 1,000 Living at Age x*	*Number of Years Lived by the Cohort Between Ages x and x+1*	*Total Number of Years Lived by the Cohort from Age x on, Until All Have Died*	
x	l_x	d_x	$1{,}000q_x$	L_x	T_x	$\mathring{e}_x$
0	100,000	5,821	58.21	97,090	6,023,954	60.24
1	94,179	840	8.92	93,759	5,926,864	62.93
2	93,339	413	4.43	93,133	5,833,105	62.49
3	92,926	287	3.09	92,783	5,739,972	61.77
4	92,639	226	2.44	92,526	5,647,189	60.96
5	92,413	191	2.07	92,318	5,554,663	60.11
6	92,222	172	1.87	92,136	5,462,345	59.23
7	92,050	158	1.72	91,971	5,370,209	58.34
8	91,892	139	1.51	91,823	5,278,238	57.44
9	91,753	128	1.39	91,689	5,186,415	56.53
10	91,625	123	1.34	91,564	5,094,726	55.60
11	91,502	124	1.35	91,440	5,003,162	54.68
12	91,378	129	1.41	91,314	4,911,722	53.75
13	91,249	139	1.52	91,180	4,820,408	52.83
14	91,110	150	1.65	91,035	4,729,228	51.91
15	90,960	165	1.81	90,878	4,638,193	50.99
16	90,795	181	1.99	90,705	4,547,315	50.08
17	90,614	196	2.16	90,516	4,456,610	49.18
18	90,418	212	2.34	90,312	4,366,094	48.29
19	90,206	226	2.51	90,093	4,275,782	47.40
20	89,980	239	2.66	89,861	4,185,689	46.52
21	89,741	251	2.80	89,616	4,095,828	45.64
22	89,490	260	2.91	89,360	4,006,212	44.77
23	89,230	268	3.00	89,096	3,916,852	43.90
24	88,962	273	3.07	88,826	3,827,756	43 03
25	88,689	278	3.14	88,550	3,738,930	42.16
26	88,411	283	3.20	88,270	3,650,380	41.29
27	88,128	289	3.28	87,984	3,562,110	40.42
28	87,839	297	3.38	87,691	3,474,126	39.55
29	87,542	307	3.51	87,389	3,386,435	38.68
30	87,235	318	3.65	87,076	3,299,046	37.82
31	86,917	332	3.82	86,751	3,211,970	36.95
32	86,585	347	4.01	86,412	3,125,219	36.09
33	86,238	365	4.23	86,056	3,038,807	35.24
34	85,873	383	4.46	85,682	2,952,751	34.38
35	85,490	403	4.71	85,289	2,867,069	33.54

TABLE I (Cont.)

Life Table for White Males in the United States, 1934

1	2	3	4	5	6	7
	Of 100,000 Born Alive		*Rate of Mortality per 1,000*			*Complete Expectation of Life or Mean After-Lifetime; Average Number of Years Lived After Age x per Person Surviving to Exact Age x*
Age	*Number Surviving to Exact Age x*	*Number Dying Between Ages x and x+1*	*Number Dying Between Ages x and x+1 Among 1,000 Living at Age x*	*Number of Years Lived by the Cohort Between Ages x and x+1*	*Total Number of Years Lived by the Cohort from Age x on, Until All Have Died*	
x	l_x	d_x	$1{,}000q_x$	L_x	T_x	e_x
36	85,087	424	4.98	84,875	2,781,780	32.69
37	84,663	445	5.26	84,441	2,696,905	31.85
38	84,218	467	5.55	83,985	2,612,464	31.02
39	83,751	492	5.87	83,505	2,528,479	30.19
40	83,259	518	6.22	83,000	2,444,974	29.37
41	82,741	548	6.62	82,467	2,361,974	28.55
42	82,193	581	7.07	81,903	2,279,507	27.73
43	81,612	620	7.60	81,302	2,197,604	26.93
44	80,992	663	8.19	80,661	2,116,302	26.13
45	80,329	709	8.83	79,975	2,035,641	25.34
46	79,620	759	9.53	79,241	1,955,666	24.56
47	78,861	809	10.26	78,457	1,876,425	23.79
48	78,052	861	11.03	77,622	1,797,968	23.04
49	77,191	914	11.84	76,734	1,720,346	22.29
50	76,277	968	12.69	75,793	1,643,612	21.55
51	75,309	1,022	13.57	74,798	1,567,819	20.82
52	74,287	1,077	14.50	73,749	1,493,021	20 10
53	73,210	1,133	15.47	72,644	1,419,272	19.39
54	72,077	1,191	16.53	71,482	1,346,628	18.68
55	70,886	1,255	17.70	70,259	1,275,146	17.99
56	69,631	1,326	19.04	68,968	1,204,887	17.30
57	68,305	1,406	20.59	67,602	1,135,919	16.63
58	66,899	1,496	22.36	66,151	1,068,317	15.97
59	65,403	1,591	24.33	64,608	1,002,166	15 32
60	63,812	1,688	26.46	62,968	937,558	14.69
61	62,124	1,783	28.70	61,233	874,590	14.08
62	60,341	1,872	31.02	59,405	813,357	13.48
63	58,469	1,952	33.39	57,493	753,952	12.89
64	56,517	2,028	35.89	55,503	696,459	12.32
65	54,489	2,103	38.60	53,438	640,956	11.76
66	52,386	2,181	41.64	51,296	587,518	11.21
67	50,205	2,264	45.09	49,073	536,222	10.68
68	47,941	2,350	49.02	46,766	487,149	10.16
69	45,591	2,435	53.41	44,374	440,383	9.66

TABLE I (Cont.)

Life Table for White Males in the United States, 1934

1	2	3	4	5	6	7
	Of 100,000 Born Alive		Rate of Mortality per 1,000			Complete Expectation of Life or Mean After-Lifetime; Average Number of Years Lived After Age x per Person Surviving to Exact Age x
Age	Number Surviving to Exact Age x	Number Dying Between Ages x and x+1	Number Dying Between Ages x and x+1 Among 1,000 Living at Age x	Number of Years Lived by the Cohort Between Ages x and x+1	Total Number of Years Lived by the Cohort from Age x on, Until All Have Died	
x	l_x	d_x	$1{,}000q_x$	L_x	T_x	$\mathring{e}_x$
70	43,156	2,511	58.19	41,901	396,009	9.18
71	40,645	2,573	63.30	39,359	354,108	8.71
72	38,072	2,616	68.70	36,764	314,749	8.27
73	35,456	2,636	74.34	34,138	277,985	7.84
74	32,820	2,634	80.27	31,503	243,847	7.43
75	30,186	2,613	86.55	28,880	212,344	7.03
76	27,573	2,571	93.25	26,288	183,464	6.65
77	25,002	2,511	100.42	23,747	157,176	6.29
78	22,491	2,432	108.15	21,275	133,429	5.93
79	20,059	2,337	116.51	18,891	112,154	5.59
80	17,722	2,226	125.63	16,609	93,263	5.26
81	15,496	2,101	135.59	14,446	76,654	4.95
82	13,395	1,962	146.49	12,414	62,208	4.64
83	11,433	1,811	158.42	10,528	49,794	4.35
84	9,622	1,649	171.36	8,798	39,266	4.08
85	7,973	1,477	185.28	7,235	30,468	3.82
86	6,496	1,300	200.15	5,846	23,233	3.58
87	5,196	1,122	215.95	4,635	17,387	3.35
88	4,074	948	232.64	3,600	12,752	3.13
89	3,126	782	250.21	2,735	9,152	2.93
90	2,344	630	268.65	2,029	6,417	2.74
91	1,714	494	287.95	1,467	4,388	2.56
92	1,220	376	308.10	1,032	2,921	2.39
93	844	278	329.13	705	1,889	2.23
94	566	199	351.22	467	1,184	2.09
95	367	137	374.62	299	717	1.94
96	230	92	399.54	184	418	1.81
97	138	59	426.23	109	234	1.68
98	79	36	454.89	61	125	1.56
99	43	21	485.63	33	64	1.44
100	22	11	518.53	17	31	1.33
101	11	6	553.68	8	14	1.23
102	5	3	591.16	4	6	1.13
103	2	1	631.06	2	2	1.03
104	1	1	673.49	..	..	.94

many problems in population study must be answered.* Incidentally, it should be remarked that life tables, as generally constructed, represent a fixed mortality of a particular calendar year or period. Such a table tells us what *would* be the number of survivors to age 10, 20, etc., *if the mortality at each age remained constant as of the calendar year or period for which it is constructed.*

APPLICATIONS OF THE LIFE TABLE

It is significant that two seemingly opposed designations have been applied to the same thing; "Mortality Table" or the "Life Table." Quite in accord with this dual character of the life table, its applications may be broadly classed in two categories—applications relating primarily to mortality and death rates, and applications relating primarily to survivals. In the field of life insurance we find a corresponding duality of interests related to these two aspects of the life table: insurance for the benefit of others in the event of death of the insured; and insurance in the form of endowments or annuities for the benefit of the insured himself in the case of his survival.

Application to problems of mortality —On this occasion we are concerned with applications to general demographic problems. In the first category, applications relating more particularly to mortality, we have, first of all, the direct use of the life table as a gauge or measure of the mortality in a given population or group of persons. The crude death rate, for well known reasons, is not a good measure, because it is quite seriously affected by differences in age composition. Standardized death rates, on the other hand, have the disadvantage that they depend on an arbitrarily selected standard population. The life table is free from this arbitrary feature, and, of course, with its several columns, exhibiting, for a "cohort" or "generation" traced from birth through life, the number of survivors, the number of deaths, the death rate, and the expectation of life at each age, such a table gives much more detailed information than a general death rate, whether crude or standardized.

There is, however, necessarily a relation between the picture presented by the life table and the corresponding general death rate. This is exhibited in Figure I in which there have been plotted, as abscissae, the values of the standardized death rates for white males in each of the states of the Union as of 1929–1931, against the corresponding values of the expectation of life at birth, as ordinates. It will be seen that the scatter of points thus shown clusters very closely about a straight line. In point of fact, the coefficient of correlation is almost unity, its exact value being $r = -.992 \pm .002$. This suggests that the expectation of life could be gauged *approximately* for any one of these states, if the standardized death rate and the regression equation were given. This equation in the present example takes the form

$$e_0 = 78.337 - .0174\,d$$

where d is the standardized death rate per 100,000. In Table II the values of the expectation of life thus computed for each state from the regression equation is shown, together with the difference between the value thus computed and that obtained by the more accurate process of computing the life table. It will be seen that in all but two instances the error is less than one year, and in all but seven it is less than one half year. Incidentally, it is of in-

* The details of the computation of a life table are rather highly technical. For a detailed description of two alternative methods that have been employed for this purpose the reader may be referred to *Length of Life—A Study of the Life Table*, by Louis I. Dublin and Alfred J. Lotka, Ronald Press, 1936, p. 307, Chapter XIV.

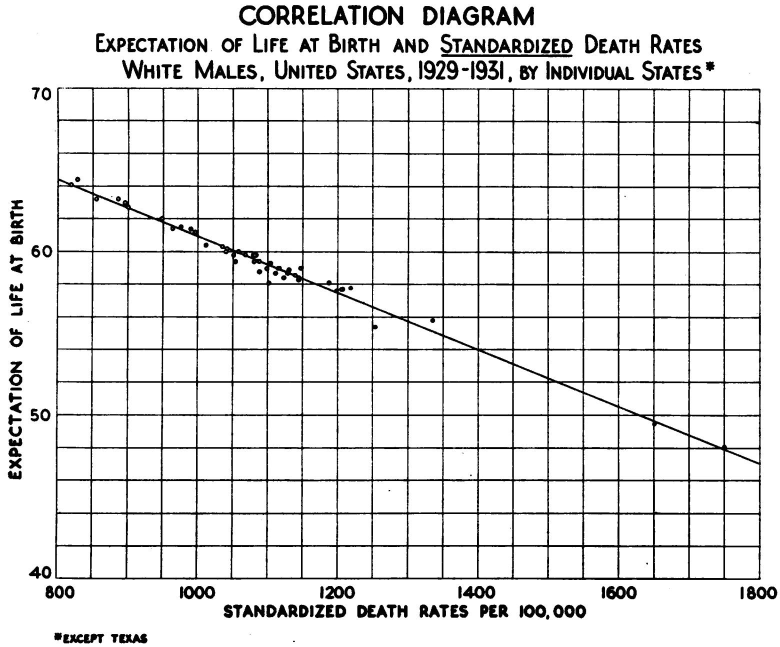
TABLE II

Expectation of Life at Birth and Standardized Death Rates per 100,000 for Each State of the United States, Except Texas, 1929–1931—White Males ‡ All Ages*

State	Expectation of Life at Birth $\mathring{e}_0$	Standardized Death Rate	$\mathring{e}_0$ Computed from Stand. D.R. by Regression Equation	
			$\mathring{e}_0$	Col. (4)–Col. (2)
(1)	(2)	(3)	(4)	(5)
South Dakota †	64.38	828.0	63.95	—.43
Kansas	63.24	885.8	62.94	—.30
North Dakota	63.24	855.1	63.47	+.23
Iowa	63.04	896.3	62.76	—.28
Nebraska	62.92	895.5	62.77	—.15
Oklahoma	62.72	900.3	62.69	—.03
Minnesota	61.97	947.9	61.86	—.11
Wisconsin	61.51	975.5	61.38	—.13
Idaho	61.44	962.5	61.61	+.17
Washington	61.37	990.2	61.13	—.24
Oregon	61.17	995.5	61.03	—.14
Arkansas	60.43	1,013.2	60.73	+.30
Mississippi	60.34	1,035.1	60.35	+.01
New Hampshire	60.24	1,042.0	60.23	—.01
Indiana	60.04	1,057.9	59.95	—.09
Vermont	59.97	1,040.7	60.25	+.28
Michigan	59.80	1,083.3	59.51	—.29
Ohio	59.78	1,079.5	59.57	—.21
Wyoming	59.78	1,050.7	60.08	+.30
Connecticut	59.77	1,081.8	59.53	—.24
Missouri	59.76	1,068.4	59.77	+.01
Montana	59.40	1,080.7	59.55	+.15
Alabama	59.37	1,088.4	59.42	+.05
Kentucky	59.37	1,054.1	60.02	+.65
United States §	59.31	1,103.7		
Massachusetts	59.29	1,104.5	59.14	—.15
Illinois	59.02	1,115.9	58.94	—.08
Florida	58.99	1,098.1	59.25	+.26
New Jersey	58.96	1,146.7	58.41	—.55
North Carolina	58.95	1,116.5	58.93	—.02
Georgia	58.92	1,130.6	58.69	—.23
Tennessee	58.76	1,087.7	59.43	+.67
Maine	58.70	1,112.3	59.00	+.30
Virginia	58.69	1,128.6	58.72	+.03
California	58.56	1,139.6	58.53	—.03
Louisiana	58.42	1,145.4	58.43	+.01
Utah	58.42	1,124.2	58.80	+.38
Delaware	58.25	1,145.1	58.43	+.18
West Virginia	58.14	1,102.4	59.18	+1.04
Rhode Island	58.06	1,187.9	57.69	—.37
New York	57.84	1,219.5	57.14	—.70
Maryland	57.72	1,206.2	57.37	—.35
Pennsylvania	57.68	1,207.1	57.36	—.32
South Carolina	57.64	1,198.2	57.51	—.13
Nevada	55.77	1,334.8	55.14	—.63
Colorado	55.40	1,254.4	56.54	+1.14
New Mexico	49.46	1,650.5	49.65	+.19
Arizona	48.08	1,750.4	47.91	—.17

* Standardized on the basis of " Standard Million " of England and Wales, 1901.
‡ White Males include Mexicans
† Based on deaths for 1930 only.
§ Exclusive of Texas and South Dakota.

FIGURE I



terest to compute the correlation coefficient using the crude death rates. The correlation in that case is considerably less close, namely r = — .752 ± .063. Figure II illustrates the much wider scatter of the values of the crude death rate and the expectation of life at birth. The correcting effect of standardizing the death rate shows itself in these results.

Historical study of past longevity—The expectation of life at birth, which we thus recognize as a more efficient measure for purposes of comparison than the simple death rate, gives us an interesting index by which to establish a historical survey of longevity at different periods.

Naturally, data for the remote past are scant and unreliable. Estimates based on tombstone inscriptions in ancient times, indicate that in certain Roman provinces of Africa, the expectation of life at birth may have been about 35 years. In the city of Rome itself, possibly conditions were less favorable, and we may broadly surmise that the expectation of life at birth there was somewhere between 20 and 30 years.

For the long stretch of years from the time of the Roman Empire to the latter part of the 17th century, we have not the basis for even the roughest of estimates. About the end of the 17th century, judging by a somewhat crude table prepared by Halley on the basis of mortality in the German city of Breslau, the expectation of life at birth was about 33½ years. From the early 18th century on, life table construction became more systematic, and indications are that, at the beginning and up to about the middle of the 19th century, an average length of life of 35 or 40 years may have been common in various localities among civilized people. By the beginning of the present century, the figure had risen to about 49 years. Thus there was a gain of about 9 years in the second half of the 19th century, far outstripping, in proportion, the gain of about 7 years in the preceding 150 years. Since 1900, the improvement has been even faster. At the time of the last census, 1930, our expectation of life at birth here in the United States was just about 60 years, and according to our life table for the year 1933 we had definitely reached 61 years. But we still have 5 more years to gain in expectation of life at birth before we equal the world record which today is held by New Zealand, namely 66 years.

The life table gives the expectation of life not only at birth, but at each year of life, and the question arises how persons of different ages have shared in the gain in expectation of life. Without going into detail, we may recall the familiar fact that the greatest reductions in mortality have taken place in infancy, so that the gain in expectation of life is greatest at birth. However, there are gains in childhood and adolescence and maturity, although one of the facts which we have to record with regret, is that, from midlife on, gains have in recent years been but slight, and in some recent decades the expectation of life at these ages has actually suffered a setback. This is shown, for example, in the case of white males, in the accompanying graph, Figure III.

Curtailment of life due to individual causes of death—The life table is capable of more refined applications than its gross use in connection with the general mortality from all causes combined. As ordinarily constructed, the table makes no distinction of deaths according to cause. But it is a relatively simple matter so to modify the computation, as to obtain a life table representing, for example, the mortality such as it would be if some one cause of death, or a group of such causes, were eliminated, assuming, however,

FIGURE II

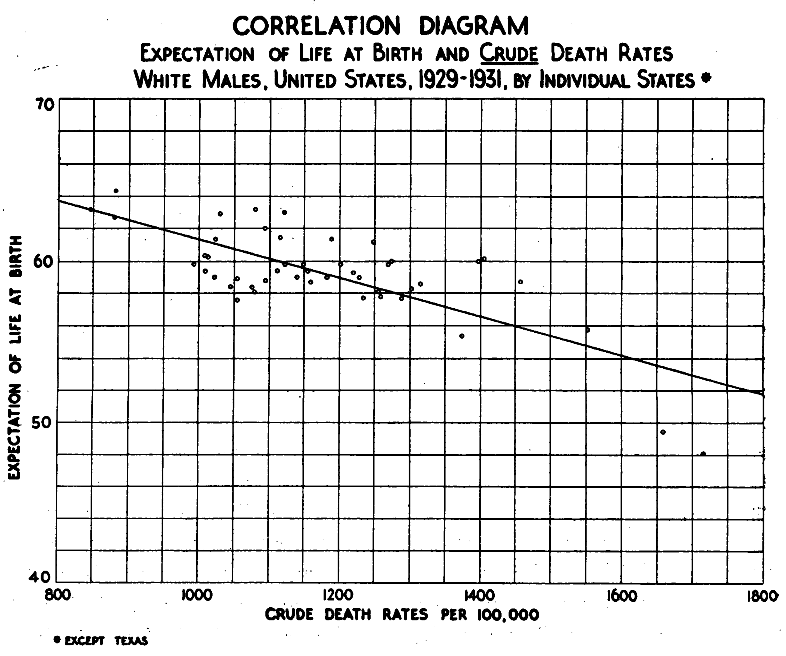
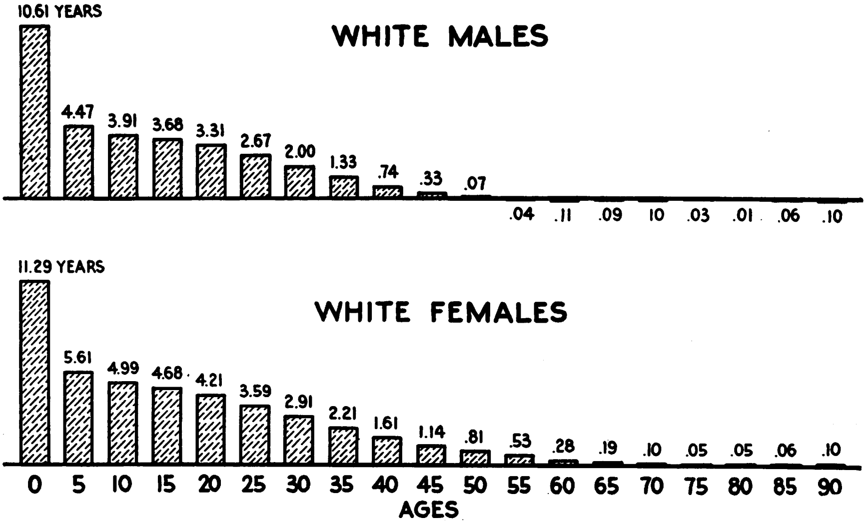


FIGURE III

IMPROVEMENT IN EXPECTATION OF LIFE
1929-31 COMPARED WITH 1901
United States Original Registration States



that the persons thus preserved from death by the particular causes eliminated, were subject to and ultimately succumbed to the mortality from the remaining causes. This computation has been carried out for 8 of the principal causes of death, namely diseases of the heart; cancer, all forms; tuberculosis, all forms; chronic nephritis; cerebral hemorrhage; diabetes; angina pectoris; accidental and unspecified violence. The results of these computations are shown in Table III. The table is so arranged as to show the years of life that would be gained if the specified cause of death could be completely eliminated. So it is seen that the expectation of life at birth would be increased by nearly 2½ years if heart disease could be eliminated. Accidents and unspecified violence also represent a large item in the case of males, accounting for 2 years of life. In the case of females, this is a less serious item, namely 0.80 year. Another large item is cancer, especially in the case of females, 1.79 years. In surveying these figures, it must be borne in mind that, other things equal, a cause of death which operates early in life, or through the whole range of life, naturally produces a greater loss of years than a cause which operates later in life.

An interesting point brought out by Table III, is that the effect of eliminating two or more causes of death together is cumulative. Thus, in column 10 is shown the sum of the individual years of life, that would be gained by eliminating each of 8 causes *separately.* Column 11, on the other hand, shows the number of years of life that would be gained if all these 8 causes were eliminated *simultaneously*. It will be seen that the effect of jointly eliminating these 8 causes ranges from 52 to 81 per cent, according to the age and sex considered, in excess of the sum of the separate effects for each cause. This is a fortunate situation, for it means that our combined efforts to reduce the mortality from various causes result in

TABLE III

Years of Life That Would be Gained by the Elimination, Singly and Jointly, of 8 Causes of Death—White Males and White Females, United States Registration States of 1920 in 1930

	Years Gained by the Elimination of Single Cause										
Sex and Age	Diseases of Heart	Cancer, All Forms	Tuberculosis, All Forms	Chronic Nephritis	Cerebral Hemorrhage	Diabetes Mellitus	Angina Pectoris	Accidental and Unspecified Violence	Sum of Individual Effects of Each Cause of Death	Cumulative Effect of 8 Causes Combined	Per Cent Excess of Col. (11) Over Col. (10)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Males											
0	2.41	1.12	1.10	.97	0.81	0.19	0.27	2.05	8.92	13.57	52.13
12	2.61	1.22	1.11	1.07	0.90	0.21	0.30	1.84	9.26	14.17	53.02
22	2.60	1.23	1.01	1.07	0.92	0.20	0.31	1.48	8.82	13.69	55.22
32	2.62	1.24	0.76	1.07	0.95	0.19	0.31	1.08	8.22	13.01	58.27
42	2.62	1.22	0.51	1.05	0.97	0.18	0.31	0.79	7.65	12.38	61.83
52	2.52	1.12	0.29	1.01	0.96	0.17	0.27	0.53	6.87	11.44	66.52
62	2.26	0.88	0.15	0.91	0.89	0.14	0.21	0.34	5.78	9.89	71.11
72	1.84	0.53	0.06	0.74	0.70	0.08	0.12	0.21	4.28	7.52	75.70
82	1.27	0.23	0.02	0.48	0.42	0.03	0.05	0.15	2.65	4.58	72.83
Females											
0	2.58	1.79	1.09	1.10	1.04	0.37	0.14	0.80	8.91	13.74	54.21
12	2.73	1.90	1.06	1.17	1.11	0.38	0.15	0.58	9.08	14.25	56.94
22	2.70	1.93	0.85	1.16	1.13	0.37	0.15	0.49	8.78	13.95	58.88
32	2.70	1.94	0.51	1.16	1.16	0.37	0.16	0.43	8.43	13.55	60.74
42	2.69	1.82	0.32	1.13	1.18	0.38	0.16	0.39	8.07	13.13	62.70
52	2.58	1.49	0.19	1.03	1.13	0.35	0.15	0.34	7.26	12.22	68.32
62	2.38	1.04	0.12	0.90	1.03	0.26	0.14	0.31	6.18	10.65	72.33
72	1.98	0.59	0.06	0.69	0.82	0.12	0.09	0.28	4.63	8.26	78.40
82	1.38	0.25	0.01	0.42	0.51	0.03	0.04	0.24	2.88	5.21	80.90

more than merely the summation of the individual effects that would arise from the elimination of each of such causes separately. In other words, our gains in this field of work are cumulative. The reason for this is that if, for example, tuberculosis is eliminated at the same time as heart disease, not only those persons would be restored to life who ordinarily would have died from tuberculosis, but also a further number, namely those who, having been saved from heart disease, would subsequently have succumbed to tuberculosis if heart disease alone had been eliminated; and a similar statement holds with regard to those who, having been saved from tuberculosis would subsequently have died from heart disease, if tuberculosis alone had been eliminated.

Application of the life table to problems of survival—In the second category, applications of the life table to problems related more directly to survival, are such problems of great practical importance as the forecasting of the future population, and the making of estimates of the population classified by sex and age during post-censal current years.

Both these problems require for their solution the construction of a population, classified by age, at some subsequent time, as the survivors, at that time, of two groups of persons, namely first, those living at a given earlier period, and second, those that are born in the interim. The number of these survivors is determined by means of a life table, or a succession of life tables, applicable to the period of time considered. The number of births, so far as forecasts are concerned, can only be estimated on some reasonable hypothesis. In the case of estimates of post-censal current population, we stand on more secure ground in this respect, since we have available statistics of births registered in the years elapsed since the last census.

Application of life table to measure the capacity for growth of a population —An application which has very important bearings on population policy is the computation of the true rate of natural increase, that is, the measure of the excess of fertility over mortality, such as it appears when the influence of temporary features of the age distribution is eliminated. As is by this time well known from our previous publications * the mere excess of the birth rate over the death rate does not give a true measure of this feature. Our low death rate of about 11 per 1,000 gives us a very incorrect idea of the intrinsic mortality in our population. This is evident from the mere fact that in the long run a death rate of 10 per 1,000, after the population had become stationary, would correspond to a mean length of life of 91 years. We all know perfectly well that the average length of life among us today attains no such figure as this. It is only a little over 60 years.

Similarly, our birth rate figure is deceptive. Low as it is, 17.1 per 1,000 (1934), it is still bolstered up by the influence of past high birth rates in giving us a higher proportion of persons within the reproductive ages today than we should have on the basis of our current fertility. If proper allowance is made for this feature, we find for the latest date available a true birth rate of 15.2 per 1,000, a true death rate of 15.8 per 1,000, and, as is now a familiar fact, we find ourselves definitely in the red as regards the balance of fertility over mortality, with a negative true rate of natural increase, namely —.6 per 1,000. The curve of the birth rate, which formerly was above that for the death rate, crossed the latter about 1930 or very soon after.

* To these the reader must be referred for details of method of computation. He will find them described in the *Journal of the American Statistical Association*, 1925, pp. 305–339; also, though with less detail in *Length of Life*, by Louis I. Dublin and Alfred J. Lotka, Ronald Press, 1936, pp. 244 *et seq.*

CONCLUSION

Only a few applications of the life table to problems in vital statistics have been presented by way of example. The list might be extended to include such topics as the probability of dying from specified causes; the age distribution of deaths from specified causes in a generation of persons traced from birth to the extinction of the entire generation; the proportion of widows and of orphans in the population, and the related problem recently discussed by P. Luzzatto-Fegiz in his article The Occupational Evolution of a Generation *; or, to mention one more example, the extinction of a line of descent—a problem which is of interest not only in human vital statistics but also in relation to certain problems in genetics.†

The fact is that possibilities of such applications are legion. It has not been the purpose of this brief paper to attempt even a summary of this subject, but only by a few landmarks here and there to give some idea of the scope and nature of the field. It is the less necessary to attempt here an exhaustive presentation, as we have recently published a volume of some 400 pages dealing, in some detail, with these matters, under the title "Length of Life—A Study of the Life Table." To this volume we must, therefore, refer for further details.

* *Population, J. International Union for the Scientific Investigation of Population Problems,* 1935, Vol. 2, p. 37.

† Lotka, A. J. The Extinction of Families. *J. Washington Academy of Sciences,* 1931, Vol. 21, pp. 377, 453.