some of the subjects in Walker's group showed a rise in cholesterol levels, although their weights fell.

We believe that the fall in serum cholesterol which occurs after a myocardial infarction is directly due to the infarction. Possible mechanisms for the fall are increased breakdown, increased excretion via the bile, or impaired biosynthesis. Regarding the last suggestion, the demonstration by Rosin (1961) of impaired liver function within 24 hours of a myocardial infarction may be relevant.

Summary

Serum cholesterol levels were followed serially in 20 male patients admitted to hospital on the first day of a first myocardial infarction. Fourteen of these were studied during the first 22 days—10 until the 12th week—and six were followed up the fifth month.

The serum cholesterol falls rapidly after a myocardial infarction. It reaches its lowest levels about the sixth to ninth day and begins to rise again some time after the ninth to the twelfth day. Baseline control levels prior to hypocholesterolaemic therapy should not be taken earlier than the 22nd to 29th day after infarction, and when the clinical syndrome has been severe readings up to the eighth week after infarction may be more reliable.

The reason for the fall is not known, but it may be related to the severity of the myocardial damage.

We wish to thank Professor L. J. Davis, now retired, for encouragement in this work and for permission to study patients under his care. We are also grateful to Professor E. M. McGirr for reading this paper and for his helpful suggestions.

REFERENCES

- Biörck, G., Blomqvist, G., and Sievers, J. (1957). *Acta med. scand.*, **156**, 493.
 Bronte-Stewart, B. (1956). *Brit. med. J.*, **2**, 659.
 Gofman, J. W., Lindgren, F. T., Strisower, B., De Lalla, O., Glazier, F., and Tamplin, A. (1955). *Geriatrics*, **10**, 349.
 Henly, A. A. (1957). *Analyst*, **82**, 286.
 Herbert, F. A., Beamish, R. E., and Perry, W. F. (1959). *J. Lab. clin. Med.*, **53**, 442.
 Kuo, P. T., Joyner, C. R., and Reinhold, J. G. (1956). *Amer. J. med. Sci.*, **232**, 613.
 Kyle, L. H., Hess, W. C., and Walsh, W. P. (1952). *J. Lab. clin. Med.*, **39**, 605.
 LaDue, J. S., and Wroblewski, F. (1955). *Circulation*, **11**, 871.
 ——— and Karmen, A. (1954). *Science*, **120**, 497.
 McQuarrie, I., and Stoesser, A. V. (1932). *Proc. Soc. exp. Biol. (N.Y.)*, **29**, 1281.
 Moore, N. S., Young, C. M., and Maynard, L. A. (1954). *Amer. J. Med.*, **17**, 348.
 Nikkilä, E. A. (1952). *Scand. J. clin. Lab. Invest.*, **4**, 369.
 Riseman, J. E. F., and Brown, M. G. (1937). *Amer. J. med. Sci.*, **194**, 392.
 Rosin, A. J. (1961). *Brit. med. J.*, **2**, 675.
 Soffer, A., and Murray, M. (1954). *Circulation*, **10**, 255.
 Thompson, J. S., Abraham, A., Elias, A. W., and Scott, C. C. (1959). *Amer. J. med. Sci.*, **237**, 319.
 Walker, W. J., Lawry, E. Y., Love, D. E., Mann, G. V., Levine, S. A., and Stare, F. J. (1953). *Amer. J. Med.*, **14**, 654.
 Wood, P. (1936). *Quart. J. Med.*, **5**, 1.
 Zlatkis, A., Zak, B., and Boyle, A. J. (1953). *J. Lab. clin. Med.*, **41**, 486.

THE MAIN CAUSE OF INCREASED DEATH RATE FROM DISEASES OF THE HEART: 1920 TO 1959

BY

MAURICE CAMPBELL, O.B.E., D.M., F.R.C.P.

From the Cardiac Department, Guy's Hospital, and the Institute of Cardiology, London

The great increase in the registered death rates from *diseases of the heart* since about 1924 is very striking, especially when compared with the steadiness of these rates during the preceding 50 years. At least some of this increase is generally accepted as due to the greater number of older persons in the population; and this has been influenced largely by the number of young lives that were saved by the better control of infectious diseases and tuberculosis, though also by changes in the birth rates.

The great decrease in the death rates *from all causes combined* is equally well known, but not perhaps the times at which this decrease occurred. There had been little change for 40 years up to 1880, when the death rate fell to a lower level, near which it stayed for 15 years. In 1895 it fell again, and this time continuously until 1925, since when the fall has been much smaller. This fall was mainly due to the reduced number of deaths of younger patients.

Most figures quoted for diseases of the heart are the "crude death rates" (with or without adjustments that may have been made by the Registrar-General)—that is, the rate found from a simple comparison of the total number of deaths in a year with the corresponding total live population. For the deaths from all causes I have used the standardized death rates, taken from the sources given in Table I.

As just stated, the fall in the death rate from all causes was mainly due to the reduced number of deaths of younger patients from infectious diseases and tuberculosis. If we assume that the mean age of all the subjects whose lives were saved was 20 years (see below), that one-quarter of them died from diseases of the heart, and that the average

age of death for these subjects was 60 years, then the main effect of the fall of the death rate from all causes in 1880–95 would not be reflected in the rise in the death rate from diseases of the heart until 1920–35. The true state of affairs is, of course, much more complicated than this, but if we consider the items separately it should be possible to reach some approximation to the truth and then see how much correspondence there is between our calculations of the expected numbers of deaths from heart disease and the actual registered numbers. This should give us some indication of whether the apparent increase in the death rate from diseases of the heart is a real increase or whether it can all be explained by the older age of the population.

We shall consider (1) the changes in the death rates from all causes from 1838 to 1930, (2) the age of the subjects whose lives were saved, (3) the age at death of subjects with diseases of the heart, and (4) the inevitable effect of these three factors on the death rate from heart disease, particularly after 1920.

Fall in Death Rate from All Causes: 1838–1930

The Registrar-General in his *Annual Report for 1910* (p. xxviii) reviewed the fall in the death rate from all causes since 1838, when his statistics started, after corrections for variations in the age and sex constitution of the population. He stated that it reached its peak in 1846–50 and then fell gradually and intermittently until 1891–5, and after this at a faster rate.

The peak in 1846–50 was so small that the following statement is almost equally true and more convenient for my calculations. The death rate varied within narrow limits with little significant change from 1838 to 1870, and

fell only slightly between 1871 and 1880: for this whole period, 1838–80, it averaged 21.7 per 1,000 persons living. From 1881 to 1895 it was again very steady but a good deal lower—18.6 per 1,000 living. From this quinquennium it fell faster and fairly steadily to 10.9 in 1921–5 and 10.3 in 1926–30, since when the fall has been much slower, and,

greatest change was between 1921 and 1931 (see Table II). The percentage of deaths under 45 years decreased from 18 in 1910 to 2 in 1959, and the percentage of deaths at 75 years or over increased from 16 in 1910 to 51 in 1959. For the same years the mean age at death increased from 59.2 to 73.2 years. For the purposes of my calculation it

TABLE I.—*Death Rates from All Causes per Thousand Living: Standardized Rates, 1838–1930; Crude Rates, 1911–59*

Year	1838–	1881–	1886–	1891–	1896–	1901–	1906–	1911–	1916–	1921–	1926–	1931–	1941–	1950–
Standardized death rates	21.7	18.7	18.5	18.5	17.6	16.0	14.4	13.7	13.4	10.9	10.3	—	—	—
Figures used for 2nd calculation	21.7	18.7	18.7	18.7	17.7	15.7	14.7	13.7	13.7	10.7	10.3	—	—	—
Crude death rates								14.4		12.1		12.3	12.4	11.6

The standardized death rates for 1838–1905 are taken from the Registrar-General's Annual Report for 1910 (p.xxviii); those for 1906–30 from his Statistical Review or 1931; and the crude death rates from his Statistical Review for 1959.

in any case, hardly concerns us for the present purpose. In these 50 years the death rate from all causes has been reduced to a little less than half of what it was: the average fall in each quinquennium has been rather more than 1 per 1,000 living. These figures are shown in Table I, and below the standardized death rate for each quinquennium are some figures that made the second calculation rather simpler, without introducing much additional error.

Age of Subjects Whose Lives Were Saved

Most of these were persons who would have died from tuberculosis or from some other infectious disease. The former were more than half the total, and most of them died in early adult life with a peak at about the age of 30 years. The largest number of the latter died in their first five years, and their effect would be increased by the reduction in the neonatal deaths (though this was mainly in the later part of the period).

It would be near the truth to say that a large number died in the first decade, mainly in the first three years or so, and that the rest were distributed through the second, third, and fourth decades, not very unequally. I have assumed, therefore, that the persons whose lives were saved would have died at a mean age of 20 years.

This is the most inexact part of my calculations and 16 years may be more accurate than 20, for I may not have allowed enough for the heavy mortality in the first five years of life at this early period. The error cannot be much more than five years in either direction, and the reader will be able to see how much influence five years one way or the other could have.

Age at Death of Persons with Heart Disease

The average age at death from all causes has been increasing slowly for some centuries, but never before as it has from 1900 to 1940. In England at the end of the seventeenth century it was about 30 years, the same as had been thought in Greek and Roman times (Dublin, Lotka, and Spiegelman, 1949). By 1750 it had increased to 36 years, by 1850 to 40 years, and by 1900 to 46 years; but by 1940 it had jumped to more than 60 years.

I must admit to my surprise as a clinician at finding how many patients dying from heart disease were in the eighth and ninth decades and how old the mean age of death was. I happened to choose the year 1921, when the mean age of death was 62, as a year shortly before the rise in the death rate from heart disease started, and 1938, when it was 69, as a year some time after it had been well established.

These two years were so different that I took some others at intervals of about 10 years. The age at which subjects with heart disease died has been steadily getting higher, basing this on the years 1910, 1921, 1938, and 1959: the

seemed appropriate to take the average of the years 1910 and 1921, both of which are shown in Table II.

For comparison the ages at death from all causes in 1931 have been added. The number of infants dying was so large that the mean age at death from all causes was several

TABLE II.—*Age at Death of Persons with Heart Disease*

Age	Percentages of Deaths at Each Age with Heart Disease					All Causes
	1910	1921	1931	1938	1959	1931
0–24	5.9	3.5	2.0	1.4	0.2	18.6
25–34	4.4	4.3	1.6	1.4	0.3	4.4
35–44	7.9	6.4	2.8	2.6	1.5	5.7
45–54	13.8	11.2	7.2	6.4	5.6	9.8
55–64	23.2	19.7	17.2	17.2	14.1	15.7
65–74	28.6	29.8	31.8	30.8	27.1	22.5
75–84	16.2	25.1	37.4	40.2	35.7	23.3
85+					15.5	
Mean age	59.2	62.4	68.0	68.9	73.2	53.8

These percentages are calculated from the Summary of Causes of Death by Age in the Registrar-General's Statistical Review: p. 288 for 1910, Table 17 for 1921, Table 21 for 1931, Table 21 for 1938, and Table 17 for 1959.

years younger (53.8) than for those dying from heart disease in any of the years. I was surprised again that the mean age of those dying from cancer in 1938 was as old as it was found, 63, which is only six years younger than the average age at death from heart disease in that year.

Although this paper is concerned with "persons," men and women were calculated separately for 1959 and the mean age of the women was 5.4 years more than that of the men. At all ages up to 74 the number of deaths among the men was greater than among the women; at 75 and older this state of affairs was reversed, and there were twice as many women as men who lived on to 85 years or over.

Method of Calculating Expected Death Rate from Heart Disease

All the calculations that follow are based on a hypothetical population of one million persons and the expected effects on this population. In 1880 the death rate from all causes was 21.7 per thousand living—that is, 21,700 deaths among the one million. The death rates in the next five years, 1881–5, were 18.8, 18.8, 18.7, 18.6, and 18.6 respectively, so that in these five years the numbers of lives saved have been taken as 2,900, 2,900, 3,000, 3,100, and 3,100. The total increase in all deaths from the total number of lives saved was calculated first, and later reduced to one-quarter as the fraction that seemed likely to have died from diseases of the heart.

Similarly by the five years 1916–20 the death rate had fallen from the original 21.7 to 13.4 per thousand, so that 8,300 (8.3 per thousand) lives were saved in each of these five years. And in the five years 1926–30 the death rate had fallen to 10.3 per thousand, so that there were 11,400 persons whose lives were saved each year. All these persons

must have died at some later date and so increased the death rate from the causes that were still operative.

The next problem is to which subsequent years these deaths should be attributed. We have discussed the age of persons who died from diseases of the heart at various periods and have chosen the average of the periods 1910 and 1921 (Table II). For this calculation the number of deaths has been distributed in each year rather than in each decade. When 10% or more died in a 10-year period they have been distributed equally to each year, any small excess or deficiency being put at the upper or lower end of the decennium according to the general trend. When the number was less than this they have been distributed to alternate years. When there were 20%, two were allotted to each year, and so on.

We assumed that for each 100 persons there was one death at each of the ages 26, 28, 30, and 32 to 52 ($24 \times 1 = 24$); two deaths at each year from 53 to 63 ($11 \times 2 = 22$); three deaths at each year from 64 to 75 ($12 \times 3 = 36$); and two deaths at each year from 76 to 84 years of age ($9 \times 2 = 18$). This is reasonably close to the actual deaths from heart disease and gives a similar mean age (61.8 compared with 60.8 years). As changes in the death rate of 0.1 per thousand living give changes of 100 per million living—the population we are considering—it is easy to distribute these among the different years according to the percentage dying at each year of age.

As the persons whose lives were saved were on the average already 20 years old, 20 years must be deducted from all these ages just given. The first addition for the deaths of those whose lives had been saved in any one year will therefore be six years after that year and the last 64 years after it. Thus for the persons whose lives were saved in 1881, 1%—that is, 29—will be added to the deaths in each of the years 1887, 1889, 1891, and 1893–1913; 2% (58) will be added to each of the years 1914–24; 3% (87) to each of the years 1925–37; and finally 2% (58) to each of the years 1938–45.

Similarly, of the 10,800 lives saved in 1921, 1% (108) was added to each of the years 1927, 1929, 1931, and 1933–53; 2% (216) to each year 1954–64; 3% (324) to each year 1965–76; and 2% (216) to each year 1977–85; and so on for every year separately. The last entry for addition is 58 years after the first, and 64 years after the year when the lives were saved.

Since 1926 there has been very little further fall in the death rate from all causes. For this reason, and to simplify the calculations somewhat, I have assumed that it remained quite constant after this date. With these assumptions the calculated death rate must stabilize 64 years after 1926—that is, in 1990—and this was shown to be the case. The

fact that the extra deaths in and after 1990 stabilize at 11,400 (Table V) is some confirmation of the accuracy of the arithmetic, since this was the number of lives assumed to have been saved in 1926 and each year thereafter.

The method is simple and requires no more than accurate addition, but it is tedious and time-consuming. Our final table contained 37 sections, and most of these had 10 to 12 columns, giving the numbers to be added to that year; and 15 horizontal lines giving the calculated numbers that are to be added because of the lives saved in the earlier years, which are shown in the vertical column on the left. The years in the horizontal line above are those in which some of the persons whose lives were saved are presumed to have died: the numbers of deaths carried forward from earlier sections (if any) are shown at the top and those to be added for each relevant year below. The total number or the number to be carried forward to the next section (indicated by +) is shown at the bottom of each column. I hope this description makes the method reasonably clear, because it is not possible to reproduce the full table: 3 of the 37 sections are, however, shown as Tables III to V to make the method as clear as possible.

Table III gives the first section (A1) and shows the small effects of the relatively early deaths of those whose lives were saved in 1881–90 on the years 1887–99. At this stage the increases to be added are very small. The figures in bold type in this Table and in Table V indicate the year after which the addition of at least 1% of the deaths was due to be added each year. Table IV gives a later but

TABLE IV.—Section B4, Showing the Additions to be Made in a Middle Period

Year in which Lives Saved are being dealt with	Years to which Extra Deaths are to be Added and Numbers Carried Forward from Section A4									
	1928 1,059	1929 1,090	1930 1,122	1931 1,154	1932 1,186	1933 1,218	1934 1,250	1935 1,282	1936 1,314	1937 1,317
1896	35	70	70	70	70	70	70	70	70	70
1897	35	35	70	70	70	70	70	70	70	70
1898	41	41	41	82	82	82	82	82	82	82
1899	47	47	47	47	94	94	94	94	94	94
1900	47	47	47	47	47	94	94	94	94	94
1901	53	53	53	53	53	53	106	106	106	106
1902	53	53	53	53	53	53	53	106	106	106
1903	57	57	57	57	57	57	57	57	114	114
1904	61	61	61	61	61	61	61	61	61	122
1905	61	61	61	61	61	61	61	61	61	61
1906	73	73	73	73	73	73	73	73	73	73
1907	73	73	73	73	73	73	73	73	73	73
1908	73	73	73	73	73	73	73	73	73	73
1909	73	73	73	73	73	73	73	73	73	73
1910	73	73	73	73	73	73	73	73	73	73
Total	1,914 +	1,980 +	2,047 +	2,120 +	2,199 +	2,278 +	2,363 +	2,448 +	2,537 +	2,601 +

TABLE III.—Section, A1, Showing the Additions to be Made to the Death Rate at the Start of the Calculation

Year in which the Lives Saved are being dealt with	Additions to the Death Rate in the Years												
	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
1881	29	•	29	•	29	•	29	29	29	29	29	29	29
1882		29	•	29	•	29	•	29	29	29	29	29	29
1883			30	•	30	•	30	•	30	30	30	30	30
1884				31	•	31	•	31	•	31	31	31	31
1885					31	•	31	•	31	•	31	31	31
1886						32	•	32	•	32	•	32	32
1887							32	•	32	•	32	•	32
1888								32	•	32	•	32	•
1889									32	•	32	•	32
1890										32	•	32	•
Total addition	29	29	59	60	90	92	122	153	183	215	214 +	246 +	246 +

The figures followed by + in this Table and Table IV indicate the years for which there were subsequent additions to be made from other Tables.

still fairly early section (B4), and shows the effect of the lives saved in 1896–1910 on the deaths in the years 1928–37. All the figures at the bottom are shown with a +, as they have to be carried forward to a later section before the final total is reached. The bold figures, on a slope passing across and down the table, show the year in which 1% of the deaths is increased to 2%. These sloping lines, passing across and down nearly all the sections of the full table, are a check on the accuracy of the distribution of the expected deaths.

Table V gives the final section (G 9), which shows—on the assumptions that have been made—the effect of the lives that will be saved in 1971–86 on the deaths to be expected in 1985–92. The stabilization of the additional

TABLE V.—Section, G9, Showing the Additions to be Made at the End of the Calculation

Year in which Lives Saved are being dealt with	Years to which Extra Deaths are to be Added and Numbers Carried Forward							
	1985 10,656	1986 10,554	1987 10,452	1988 10,350	1989 10,248	1990 10,146	1991 10,032	1992 9,918
1971	114	114	114	114	114	114	114	114
1972	114	114	114	114	114	114	114	114
1973	114	114	114	114	114	114	114	114
1974	•	114	114	114	114	114	114	114
1975	114	•	114	114	114	114	114	114
1976	•	114	•	114	114	114	114	114
1977	114	•	114	114	114	114	114	114
1978	•	114	•	114	114	114	114	114
1979	114	•	114	114	114	114	114	114
1980	•	114	•	114	114	114	114	114
1981			114	•	114	•	114	•
1982				114	•	114	•	114
1983					114	•	114	•
1984						114	•	114
1985							114	•
1986								114
Total	11,340	11,352	11,364	11,376	11,388	11,400	11,400	11,400

death rate in 1990 and onwards at 11,400 is an inevitable consequence of this being the number of lives saved each year since 1926, as the death rate from all causes, which became relatively constant after 1926, has been assumed to remain absolutely constant.

The final figures in the tables show the number of extra deaths to be expected as the result of all the lives that were saved. Obviously not all these deaths are cardiac, and from the lower proportion of such deaths in the earlier part of the period 1910–59 it seems reasonable to assume that one-quarter of the totals shown would be deaths due to diseases of the heart, excluding diseases of the blood-vessels and vascular diseases of the nervous system. There should be no large arithmetical mistakes that have not been detected, because the totals of each column form a fairly regular series.

Calculated Death Rate from Diseases of the Heart: 1880–1990

The death rate from diseases of the heart, calculated in the way described, starts to rise by 1887 but only very slowly for another 30 years. It rises rather more quickly

from 1917 to 1927 and continues to rise much more quickly, with a fairly steady rate of increase until 1967. After this it rises more slowly again and is almost steady by 1977 and completely so by 1990 (see Chart and Table VI).

Comparison of reported annual death rates from all diseases of the heart from 1876 to 1959, shown by open circles, with the calculated rates from 1876 to 2000 on the assumptions made in the text, shown by closed circles. The observed death rate showed little change from 1876 to 1920 and then rose sharply from 100 to 263% in 1951–6, since when it has shown signs of stabilizing at the new high level. The calculated death rate rose very slowly from 1890 to 1917 and then faster till 1930, when it was overtaken by the observed rate: it continued to rise only a little more slowly than the observed rate, and it too had risen from 100 to 263% by 1965, was nearly stabilized by 1977, and completely so by 1990. Some of the irregularities in the curve—for example, in the observed death rate about 1930—are due to changes in classification (see Campbell, 1963).

Taking the death rate for 1880 as 100%, it does not increase to 110% until 1907 (27 years) or to 120% until 1917 (10 years): it then increases by another 10% in both the next five-year periods, and then by 10% each three or four years until 1967, the fastest rate of increase being between 1938 and 1942. It takes 37 years (1880–1917) for the level to rise from 100 to 120%: in the next 50 years (1918–67) it rises to 260%. It continues to increase, but more slowly, from 1967 to 1977 (see Table VII), and then becomes progressively slower until it stabilizes in 1990.

TABLE VII.—Rate of Increase in Calculated Annual Death Rate from Diseases of the Heart: 1880–1990

Level of Death Rate (1880=100)	Year	Years Needed for Rise of 20%	Level of Death Rate (1880=100)	Year	Years Needed for Rise of 20%
120	1917	37	220	1953	7
140	1927	10	240	1960	7
160	1934	7	260	1967	7
180	1940	6	280	1977	10
200	1946	6	290*	1990	13*

* Rise of 10% only.

The same changes are shown—for some perhaps more clearly—if one divides the total additional number of deaths, 2,850, into 10 parts and looks at the number of years needed for each increase of one-tenth. The numbers of years successively from 1880 were 35, 10, 7, 6, 7, 6, 7, 7, and 19, showing the slow rise at the end and the still slower rise at the beginning, with a long period of a rapid and fairly regular rise in between.

TABLE VI.—Calculated Increase in Annual Death Rate from Heart Disease per Million Living: 1880–1990

Years	1	2	3	4	5	6	7	8	9	10
1881–1890	0	0	0	0	0	0	7	7	15	15
1891–1900	22	23	30	38	46	54	61	69	77	85
1901–1910	93	102	110	120	130	140	148	161	174	185
1911–1920	200	215	230	254	276	290	324	352	380	406
1921–1930	434	461	487	518	553	589	604	668	711	749
1931–1940	794	836	883	932	982	1,031	1,075	1,119	1,166	1,214
1941–1950	1,262	1,311	1,361	1,413	1,467	1,504	1,547	1,585	1,628	1,672
1951–1960	1,716	1,759	1,801	1,849	1,897	1,944	1,991	2,037	2,084	2,130
1961–1970	2,175	2,217	2,256	2,292	2,334	2,374	2,411	2,447	2,480	2,515
1971–1980	2,544	2,562	2,601	2,629	2,657	2,682	2,699	2,711	2,737	2,755
1981–1990	2,772	2,788	2,804	2,819	2,835	2,838	2,841	2,844	2,847	2,850

Comparison of Calculated and Observed Death Rates from Heart Disease

It is difficult to read these calculated changes in the annual death rate from diseases of the heart without being struck by their close resemblance to the changes that have actually taken place from 1880 to 1959. The slow rise in the calculated rate from 1880 to shortly before 1920 corresponds with the absence of any change in the observed figures until shortly after 1920. The much greater calculated rise from 1920 to 1960 corresponds with the enormous rise that was actually observed. We do not know if the increase will continue rapidly up to 1967 and much more slowly up to 1977 and finally settle to a steady figure about 1990, but there is some sign that the observed rise may be slowing down earlier, about 1957 to 1959. If so, the observed rise would be almost entirely concentrated between 1920 and 1960, but the calculated rise, while concentrated mainly in this period (140% of the 190% increase being between 1917 and 1967), is spread at each end of this over a rather wider period.

The magnitude of the change also shows reasonable agreement. The observed deaths were 261% in 1957-9 compared with 100% in 1880-1920, and the calculated deaths had increased to 240% by 1960 and to 261% by 1967. In some ways this close agreement is less convincing than the rates and times at which the changes took place, because it depends on the arbitrary choice of one-quarter of the total deaths as cardiac; but this choice could not influence the correlation between the times and rates of the calculated and observed increases.

A comparison of the observed and calculated death rates from diseases of the heart at various decades is shown in Table VIII. Up to 1900 there was little difference. By 1910, and still more by 1920, the calculated rates had risen more than the observed rates. Then, however, the increase

TABLE VIII.—Comparison of Observed and Calculated Annual Death Rates from Diseases of the Heart per Million Living

	1900	1910	1920	1930	1940	1950	1960	1965
Observed death rate	1,534*	1,445*	1,514*	2,284	3,416	3,926	3,858	—
Calculated rate (1st method) ..	1,585	1,685	1,906	2,249	2,714	3,172	3,630	3,834

* Average figures of this decade.

in the observed rate became so rapid that by 1930 it was a little above the calculated rate, by 1940 it had outstripped the calculated rate, and by 1950 had done so still more. By 1960, however, the difference had become much less and the calculated rate in 1965 was the same as the observed rate in 1959.

Discussion

Close similarity between observed figures and figures that have been calculated on certain assumptions does not prove that these assumptions are correct. In this case, however, it does show that *all* the observed increase in the death rate from heart disease *could* be explained in this way. It has made me believe that all the increase is, in fact, due to the older age of the population, which has resulted mainly from the saving of younger lives 40 years before. This in turn resulted from the reduction in the death rate from infectious diseases and tuberculosis, while the death rate from diseases of the heart was not reduced except, possibly, for some of the younger patients with rheumatic heart disease.

At any time after 1910 an observer who had made the assumptions that have been made in this paper could have predicted (1) that the death rate from heart disease would start to increase *greatly* about 1920, although it had been

fairly steady for more than 50 years; and (2) that it would more than double itself in the next 30 or 40 years. He could not, however, have predicted when the increase in the death rate from heart disease would come to an end and would settle down at a new high level until he knew about the relative stabilization of the death rate from all causes after 1921-6.

It is not, therefore, necessary to search for any changed conditions in the environment of the last 40 years as possible causes of the increased death rate from heart disease. It could result entirely from the greatly reduced death rate from all causes in 1880-1920.

The ideas that made me think these calculations might be worth while were (1) that the main decline in the death rate from all causes was spread over the 40 years 1880-1920; (2) that the persons whose lives were saved at an average age of 20 years would be expected to die at an average age of 60 if they behaved like other persons who died from heart disease—that is, 40 years later from 1920 to 1960; and (3) that this last period was the time of the observed rise in the number of deaths from heart disease.

If I had concentrated the additional deaths nearer to the mean age of those who die from heart disease there might have been a still closer similarity between the observed and the calculated figures. I thought that this was less likely to be correct and that the method adopted here was fairer; but it may not be, since the earlier cardiac deaths would be mainly the rheumatic ones that have diminished, and now the deaths are mainly from coronary and hypertensive disease which occur at a later age. A second calculation of what might be expected to happen with the deaths more concentrated round the mean age of death showed the same general similarity but was not much closer, so is not included.

Coronary Heart Disease

This paper has been concerned with the death rate from all forms of heart disease. The enormous reported increase in the death rate from coronary heart disease has not been discussed specifically.

Apart from the Registrar-General's figures, other considerations have supported a large increase in deaths from coronary heart disease. Thus Ryle and Russell (1949) wrote: "When Heberden . . . gave his paper to the Royal College of Physicians his experience of angina pectoris amounted to some 20 cases . . . in 1782 his experience had extended to 100 cases. Osler was admitted to the Fellowship of the Royal College of Physicians before he had seen a case. . . . To-day, as Cassidy (1946) remarks, 'the modern cardiologist . . . counts his cases by thousands.'" I, and no doubt others, was deeply impressed by such evidence that coronary heart disease had increased greatly. But experience with congenital heart disease has made this evidence of doubtful validity, since before 1947 most reports were about two or three cases, at the most, of any particular malformation of the heart and now so many number their experience in hundreds of each of the commoner varieties; and yet no one thinks that their incidence has increased. It seems, therefore, that the decision must be reached on the reported figures and not on such general grounds.

Though the rise in the deaths from coronary heart disease is so much more striking than that from all diseases of the heart, this is only because it was reported so rarely before 1920. It is only a part, though now a large part, of all the deaths from heart disease. The explanation that has been given for the increase of the death rate from all diseases of the heart means that *all* the increase in the death rate

from coronary heart disease may be explained in the same way and is proportionately larger only because of the greater knowledge about this and because of a shift of diagnosis from other groups to this one. There is direct evidence of this shift having taken place since 1940, for the deaths from other diseases of the myocardium diminished enough to account for much of the increase in 1940-9 and for all of the increase in deaths from coronary disease in 1950-9. The cause of coronary heart disease should therefore be searched for mainly on general pathological and biochemical principles, and not specially on any changes in the environment, though these might be of some lesser importance.

Summary and Conclusions

The death rate from all diseases of the heart started to rise sharply about 1920-4, though before this it had been constant for at least 50 years. By 1959 it was more than two and a half times its earlier level.

The death rate from all causes, after little change for 50 years, decreased to about half its previous level from 1880 to 1920. Since 1926 there has been little change, and further large changes are unlikely until something more can be done to prevent deaths from disease of the heart, vascular lesions of the brain, and cancer.

Assuming (1) that most of the lives saved were young persons who would have died from infectious diseases and tuberculosis, and (2) that one-quarter of them died subsequently from heart disease at the ages when other persons die from this (on the average about 40 years later), a calculation of the expected death rate from all diseases of the heart from 1880 to 1990 has been made. These

expected death rates show close similarities to the death rates observed from 1880 to 1959. This could have been predicted at any time after 1910, though not in such detail until 1926.

It seems that practically all the large increase in deaths from heart disease since 1920, including coronary heart disease, can be explained in this way. This is probably equally true for the deaths from vascular lesions of the central nervous system, though this group has not been discussed in the present paper. No doubt this is the explanation that has been believed by many cardiologists and actuaries: they do not, however, seem to have written much on the subject, though Wood (1956) says that "the increasing age of the population is no doubt partly responsible."

I am grateful to Mr. N. R. Gatenby for reading this and for his suggestions, though he cannot be held responsible for the accuracy of any of the calculations.

REFERENCES

- Campbell, M. (1963). *Brit. med. J.*, **2**, 528.
 Cassidy, M. (1946). *Lancet*, **2**, 587.
 Dublin, L. I., Lotka, A. J., and Spiegelman, M. (1949). *A Study of the Life Table*, 2nd ed. Ronald Press, New York.
 Registrar-General's Annual Report of Births, Deaths, and Marriages in England and Wales (1910). Vol. 73, pp. xxviii and 288. H.M.S.O., London.
 Registrar-General's Statistical Review of England and Wales for 1910. Tables, Part I, Medical. H.M.S.O., London.
 Ibid., 1921. Tables, Part I, Medical.
 Ibid., 1931. Tables, Part I, Medical.
 Ibid., 1938. Tables, Part I, Medical.
 Ibid., 1959. Part I, Tables, Medical.
 Ibid., 1960. Part I, Tables, Medical.
 Ryle, J. A., and Russell, W. T. (1949). *Brit. Heart J.*, **11**, 370.
 Wood, P. H. (1956). *Diseases of the Heart and Circulation*, 2nd ed. Eyre and Spottiswoode, London.

CASE-FINDING BY SERIAL TUBERCULIN-TESTING OF SCHOOLCHILDREN

BY

A. H. GRIFFITH, M.B., B.S., D.P.H.
Senior Medical Officer

M. J. BELLAMY, S.R.N., H.V.C.
Health Visitor

M. F. DAVEY, S.R.N., H.V.C., T.A.C.
Health Visitor

From the Health Department, Cardiff

The main purpose of a serial tuberculin-testing programme is to detect recently infected persons among those tested and to trace the source of their infection in the population at large. It entails screening a group of individuals with tuberculin tests at regular intervals and selecting subjects for radiographical examination according to the results of those tests. Such a programme requires that the tuberculin test used be safe, cheap, reliable, easily carried out, and readily acceptable to those asked to participate, who, on their part, must be an easily organized accessible group exposed to the risk of tuberculous infection.

These were the main considerations leading to the institution, in 1958, of an annual serial tuberculin-testing programme for 45,000 Cardiff schoolchildren.

Methods

The work of tuberculin-testing the schoolchildren, recording results on individual record cards, carrying out epidemiological investigations, and arranging radiographical examinations was carried out by three full-time junior clerks, two part-time nurses, and two health visitors, who were also engaged on other duties. An account of the organization of the programme and the results of the first

year's work have already been published (Griffith, Bellamy, and MacFarlane, 1960).

Only the Heaf tuberculin test was used. The tuberculin reactions, seen on the seventh day, were graded as follows:

- Tuberculin-negative
 No reaction or any reaction not amounting to grade I.
 Tuberculin-positive
 Grade I: Four or more palpable indurated areas.
 Grade II: An unbroken ring of induration.
 Grade III: A plateau of induration.
 Grade IV: Any reaction more severe than grade III (blister, ulcer).

Every school in Cardiff was visited during each of the four school years 1958-9 to 1961-2 inclusive, and every child in each school given an opportunity of receiving a tuberculin test each year. The only children not tested during any particular year were those whose parents had withheld consent, persistent absentees, and a small number who were known to have received treatment for tuberculosis.

Results

The results of the radiographical examination of children and their adult home contacts have been grouped according to the grades of the tuberculin reactions of the children and the known results of their previous tuberculin tests.