DEATH RATE FROM DISEASES OF THE HEART: 1876 TO 1959

BY

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The large increase in the number of registered deaths from all heart disease, and from coronary disease in particular, is well known and is indeed a source of concern to the public. Doctors are aware that some, at least, of this increase is due to the reduction of infectious diseases, to the older age of the population, and to more accurate diagnosis. There is, however, no agreement about how much of the increase can be explained in this way.

Relatively little has been written about this in Britain, but Ryle and Russell (1949) discussed the changes in the period 1921-45, and Morris (1951) and Martin (1956) have written since, the latter showing that the rise in the death rate from coronary heart disease was still continuing up to 1954. Bronte-Stewart (1959) wrote that "improvement in diagnosis and age survival, while they probably contribute, can hardly account for the fact that over the last 10 to 15 years the age-standardized death rate has been doubled and at some ages even trebled (Martin, 1956)"; yet Martin confined himself to a discussion of the deaths reported by the Registrar-General and did not discuss any possible influence of changes in diagnosis. Epstein (1960), reviewing the epidemiology of coronary heart disease, accepts a large increase in the last forty or fifty years but agrees that some of it is fictitious.

The present paper deals mainly with the changes in the death rates from all the major forms of heart disease, including coronary heart disease, from 1876 to 1959 as set out in the Registrar-General's figures. It includes only a few additional comments about the changes of classification adopted by the Registrar-General from time to time, and about the advances and changes in the diagnosis of heart disease, in so far as these must affect the causes given on death certificates. In a second paper (Campbell, 1963) the reasons for the changes in the death rates will be discussed and an attempt be made to assess how far they can be explained by the older age-structure of the population at risk.

Before proceeding to the main subject of this paper a general comparison of the common causes of death in 1910 and in 1959 is included. This section can be omitted by those who are familiar with the subject but may help to make the subsequent account easier for those who are less familiar with it.

Comparison of Causes of Death in 1910 and 1959

The general picture of the causes of death fifty years ago is compared with those found to-day, partly because of its intrinsic interest but also because any changes must have some influence on the deaths from heart disease. The proportions due to the main causes of death were given in the *Registrar-General's Annual Report** for 1910, and have been calculated for 1959 from the figures given in Table 7 of his *Statistical Review for 1959*. Both these are shown in Table I and Fig. 1.

In 1910 infectious diseases were still responsible for nearly one-fifth of all the deaths (tuberculosis 10.6%; others 8.0%), but in 1959 this proportion had fallen to one-fortieth (tuberculosis 0.7%; others 1.9%). In 1910

pneumonia (8.2%) and other diseases of the respiratory system (8.6%, including bronchitis 7%) were responsible for about one-sixth of all deaths, but in 1959 this had fallen to about one-ninth (pneumonia 5.0%; others 6.5%). Most other groups had decreased, though much less than the infectious diseases. Cancer and diseases of the heart were the only two groups that had increased significantly.

Diseases of the heart and blood-vessels were responsible for one-sixth of all deaths in 1910 (16.7%), but this proportion had increased to over one-third (36.3%) in 1959, or to just over one-half of all deaths if those from vascular disease of the nervous system (14.2%) were included. Cancer, in all its forms, had increased its share from one-fourteenth (7.2%) to nearly one-fifth (18.6%), an increase of the same order. Fortunately the two years chosen happened to show much the same number of deaths from influenza, for this varies widely and was responsible for more deaths than cancer and nearly as many as heart disease in 1919.

TABLE I.—Causes of Death in 1910 and 1959

Causes of Death	Deaths from Each Cause as Percentage of Deaths from All Causes		
	1910	1959	1959 Expected
Influenza	1.4	1.5	} (2.6)
* Other infectious diseases	6.6	0.4	
Tuberculosis	10.6	0.7	} (2.7)
Premature birth and malformations	4.6	2.7	
Old age	6.5	1.5	(1.5)
Other causes	10.3	2.2	(2.2)
Diseases of heart	10.1	36.3	} 25.2
" blood vessels	6.6	14.2	
Vascular diseases of nervous system		18.6	10.9
Cancer	7.2		
Pneumonia	8.2	5.0	12.6
Diseases of respiratory system	8.6	6.5	13.0
Other diseases of nervous system	6.2	1.3	9.4
Diseases of digestive system	5.6	2.8	8.5
Genito-urinary diseases	3.6	2.0	5.5
Violence	3.9	4.3	5.9
All causes	100	100	100
Total No. of deaths (thousands)	483.2	527.6	—
Crude death rate per million living	13,500	11,600	—

* Measles 1.7, whooping-cough 1.8, diphtheria 0.9, and diarrhoea 2.2 in 1910.

FIG. 1.—Diagrammatic representation of the changes in the main causes of death between 1910 and 1959. (1) Diseases of the heart and blood-vessels, (2) diseases of the central nervous system (C.N.S.), of which 90% are now vascular lesions of the C.N.S., and (3) cancer were responsible for less than one-third of the deaths in 1910 but for more than two-thirds in 1959. On the other hand, groups 7 (prematurity) and 8 (tuberculosis and other infectious diseases) have decreased to less than one-third of their number in 1910, and group 4 has decreased by two-fifths. The decrease in group 6 (old age and other causes) is probably mainly due to more accurate diagnosis.

*To save repetition the words *Registrar-General's* have often been omitted before *Annual Report* and *Statistical Review*.

To sum up, in 1910 there were only three causes that were each responsible for one-tenth or more of all the deaths—infectious diseases (19%), pneumonia and diseases of the lungs (17%), and diseases of the heart and blood vessels (17%). Between them these three causes were then responsible for 52% of all deaths. By 1959 infectious diseases had ceased to be of great numerical importance and had been replaced by cancer as one of three causes of more than one-tenth of all deaths. Diseases of the heart and blood-vessels (including vascular diseases of the nervous system) were responsible for half, cancer for nearly a fifth, and pneumonia and diseases of the lungs for a ninth. Between them these three causes were now responsible for over 80% of all deaths.

The reduction in deaths from infectious diseases and premature births must enable many younger subjects (23.2–5.3=17.9%) to live longer, so that ultimately they die from other causes. Further, more accurate diagnosis has reduced the number of deaths attributed to old age and some other causes, and so adds another 13.1% to be distributed among the other causes of death. These 31% have been added to the remaining causes of death, in the same proportion that was found in 1910, in the last column of Table I, to show the proportion of deaths from various causes to be expected in 1959: figures that have not been changed from those registered in 1959 are shown in parentheses.

Except for cancer and diseases of the heart and blood-vessels, nearly every major cause of death was responsible for a smaller proportion of the total deaths in 1959 than in 1910, and the actual proportions were much less than the "expected" proportions on the assumptions just described. On the other hand, the proportion of cancer deaths in 1959 was two and a half times that in 1910 and nearly twice the "expected" proportion. The proportion of deaths from diseases of the heart and blood-vessels was three times those in 1910 and twice the "expected" proportion—similar but rather worse figures than those for cancer.

Without considering the mortality rates, the total number of deaths, and the age structure of the population at risk, we cannot decide how much of the apparent increase in the deaths from cancer and from heart disease is a real increase and how much is due to the ultimate deaths of those whose lives had been saved by the reduction in infectious diseases and in other groups. In any case, the physicians concerned with these two groups of diseases have been less successful in bringing about the reduction that has been found in the other groups.

Annual Death Rates from 1876 to 1910

My original intention was to consider the changes from 1910 to 1959. A longer period should, however, give a better perspective, and the *Annual Report for 1910* gave a summary of the crude annual death rates for the previous 35 years. This seems the best method to use, since it eliminates changes in the size (but not in the age) of the total population. From here onwards, unless otherwise stated, death rate means the crude annual death rate per million persons living, as given by the Registrar-General. Throughout the paper all figures refer to men and women—the "persons" of the Registrar-General—though some of the trends discussed would have been even more striking if the figures for men had been used alone.

The Registrar-General's figures were given as averages for each five-year period, and those for five of the most common causes of death, excluding old age, are repeated in Table II. The death rates from diseases of the heart and

blood-vessels varied very little—much less than the other main causes—and were always between 2,300 and 2,600 per million persons living. The deaths from phthisis and

TABLE II.—Crude Annual Average Death Rates per Million Persons Living, 1876–1910*

	1876–	1881–	1886–	1891–	1896–	1901–	1906–
							10
All causes	20,791	19,468	18,894	18,718	17,686	16,043	14,699
1. Diseases of heart and blood vessels	2,474	2,383	2,581	2,504	2,417	2,303	2,312
1. As percentage of all causes	12.4	12.2	13.6	13.4	13.7	14.3	15.7
2. Phthisis	2,040	1,830	1,635	1,462	1,322	1,218	1,107
3. Bronchitis	2,377	2,154	2,136	2,074	1,563	1,240	1,094
4. Pneumonia	999	1,002	1,131	1,261	1,202	1,274	1,234
5. Cancer	494	548	622	711	800	869	939

* Taken from Table 20, Registrar-General's Annual Report for 1910.

bronchitis decreased considerably, while those from cancer nearly doubled and those from pneumonia increased by about a quarter. The Registrar-General's Annual Report for 1910 gave a diagram comparing the first and last of these five-year periods and referred with pleasure to the diminution in the infectious diseases (including epidemic diarrhoea), in tuberculosis, in bronchitis, and to a much smaller extent in diseases of the heart. Evidently there was not yet any sign of the rise in deaths from heart diseases that was to come. He added that cancer (in all its forms) showed the one important and significant rise; and that much of this was real, although it was difficult to say how much of it might be due to better diagnosis.

The annual death rate from all causes had, however, decreased during these 35 years to 71% of its earlier level. Although the proportion of deaths from any cause is not a good way of measuring changes, it seems worth mentioning that the proportion of deaths from heart disease among 100 deaths from all causes had increased a little, from 12.4 to 15.7%. The proportion of deaths from phthisis had decreased from 9.8 to 7.5% and from bronchitis by about the same amount (from 11.4 to 7.4%), but the deaths from pneumonia had increased (from 4.8 to 8.4%), so these two changes could be partly explained by a more frequent diagnosis of bronchopneumonia instead of bronchitis.

There was no absolute rise and only a small relative rise in the deaths from heart disease from 1876 to 1910, though the rise in the registered deaths from cancer, from 2.4 to 6.4% of all deaths, was already evident.

Diseases of the Heart: 1891–1910

The deaths from diseases of the heart after 1891 are considered more fully and those for the years 1891–1910 are shown in Table III. Their classification was then very simple, for there were only five groups, and nearly 97% of the total were included in the first and fifth. They were: (1) valvular diseases of the heart, (2) pericarditis, (3) hypertrophy of the heart, (4) angina pectoris, and (5) other diseases of the heart. The annual death rate per million living for all diseases of the heart fell slowly and steadily from 1891 to 1910, from 1,701 to 1,361, a reduction of 20% (see Table III), but the total deaths from all causes fell by about the same amount.

The two main causes of cardiac deaths, however, behaved very differently. Roughly speaking, those from valvular disease rose from 310–330 to 450–470, an increase of 44%, while those from other diseases of the heart fell from 1,300 to 900 or even 850, a decrease of 33%. Considering the extreme frequency with which the diagnosis of mitral regurgitation was made whenever there was a systolic murmur, it seems almost certain that much of this

rise and fall was due to a transfer of cases because of the increasing diagnosis of valvular disease.

After 1901 other diseases of the heart (5) were divided into (a) dilatation of the heart, (b) fatty degeneration of the heart, and (c) syncope, heart disease (not specified). I have no idea how these diagnoses were supposed to be made without necropsy, so I have made no use of the distinction and have added them together: most of the cases, in fact, remained in the third group (c), and probably had coronary heart disease.

It is interesting that the very small number of deaths attributed to angina pectoris remained almost constant during this period, the death rate per million living not varying outside the limits of 20 and 28, with no tendency to rise or fall.

In summary, between 96 and 97% of all the deaths from heart disease were attributed to (1) valvular disease of the heart (V.D.H.) or to (5) other diseases of the heart: these last were probably in the main the fashionable diagnosis of myocarditis and myocardial degeneration. The percentage attributed to V.D.H. increased from 19% in 1891 to 34% in 1910 and the myocardial group decreased from 78 to 62% in the same period.

Diseases of the Heart: 1911-21

The figures on which this section is based are shown in the upper half of Table IV, and those for the next section in the lower half. The former are taken from Table 5 of the *Statistical Review for 1921* and the latter from Table 7 of the *Statistical Review for 1931*. The classification for 1911-21 (Table IV) differs from that of 1891-1910 (Table III), but the two tables seem closely comparable. Often the figures for 1911 and 1910 are in very close agreement, and

where they differ it seems to be chance, for then the figures for the three years 1911-13 generally agree more closely with those for 1908-10: there is no significant exception to this for the groups of diseases quoted. The largest groups among diseases of the heart (87-90) were valvular disease of the heart (90, 1-4) and other myocardial diseases (90, 6-8), presumably much the same as the earlier group that has been attributed mainly to myocardial degeneration. The other and much smaller groups were pericarditis (87), acute endocarditis (88), and angina pectoris (89).

There was no great change in the death rate from diseases of the heart during the decade 1911-21. It was a little higher in 1919-21 (1,439) than in 1911-13 (1,392) or in 1908-10 (1,407), but the change was very small. If we take diseases of the circulatory system (groups 87-96), the largest being arteriosclerosis (91), the change was a little more, the death rates being 1,789 for 1919-21 and 1,597 for 1911-13, but the increase was only about 10%. The death rate from all causes had decreased from 14.3 in 1908-10 and 13.9 in 1911-12 to 12.8 in 1919-21—about 10%. It seems best to neglect the increase in the death rate from all causes in 1918 as due mainly to influenza and in that from heart disease (and to a lesser degree from all causes) during 1915-18, since they were based on the civilian population and many of the younger and fitter men were serving in the armed Forces.

The period 1911-21, therefore, does not show any great change in the death rate from all diseases of the heart. There was no absolute increase and only a slight relative increase—the same tendency that had been observed from 1891 to 1910. Some of the subgroups also showed the same general tendency as in this earlier period. Thus valvular disease was still being diagnosed more often, certainly until

TABLE III.—Crude Annual Death Rates per Million Living. 1891-1910. Persons

Year:	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
All causes (thousands)	20.2	19.0	19.2	16.6	18.7	17.1	17.4	17.5	18.2	18.2	16.9	16.3	15.5	16.3	15.3	15.5	15.1	14.8	14.6	13.5
1. Valvular diseases of heart	318	297	307	309	331	332	342	352	380	399	383	395	403	431	437	450	470	465	481	468
2. Pericarditis	23				17					19	20				13					12
3. Hypertrophy of heart	12				8					7	6				7					6
4. Angina pectoris	25	22	21	23	23	23	20	22	22	23	21	22	21	22	25	26	27	26	27	28
5. Other diseases of heart	1,323	1,213	1,151	1,082	1,184	1,070	1,104	1,088	1,145	1,128	1,049	1,022	964	1,000	941	924	951	907	915	847
1-5. All diseases of heart	1,701	1,563	1,510	1,439	1,563	1,450	1,483	1,484	1,574	1,576	1,479	1,460	1,408	1,472	1,423	1,419	1,468	1,418	1,441	1,361
Cerebral haemorrhage and embolism	908	850	823	750	805	765	781	770	791	782	734	723	708	706	682	716	724	727	734	706
Grand total	2,609				2,368					2,358	2,213				2,105					2,067

From Table 22, Registrar-General's Annual Report for 1910.

TABLE IV.—Crude Annual Death Rates at All Ages per Million Living. 1911-31. Persons

Year:	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921
All causes (thousands)	14.5	13.3	13.8	14.0	15.6	14.4	14.4	17.5	13.7	12.4	12.2
90. (1-4). V.D.H.	484	555	587	613	706	717	730	711	678	651	652
89. Angina pectoris	29	30	31	32	35	30	28	27	29	27	29
87-90. Diseases of heart (mostly other diseases)	1,326	1,402	1,447	1,472	1,692	1,674	1,659	1,542	1,493	1,406	1,418
Aneurysm	32	31	32	31	31	28	28	24	24	26	26
87-96. Diseases of circulatory system	1,493	1,609	1,690	1,741	1,984	1,970	1,957	1,860	1,822	1,745	1,800
74. Cerebral haemorrhage, etc.	679	700	712	722	790	772	805	748	717	685	677
Year:	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
All causes (thousands)	12.1	12.8	11.6	12.2	12.2	11.6	12.3	11.7	13.4	11.4	12.3
92. V.D.H.	650	692	642	649	641	616	606	684	727	657	681
94. Diseases of cor. art. (A.P.)	29	38	41	46	47	48	71	94	121	148	166
90-95. Heart disease	1,418	1,568	1,481	1,565	1,647	1,650	1,835	1,951	2,456	2,284	2,535
96. Aneurysm	26	27	26	27	27	26	29	31	32	33	33
90-103. Diseases of circulatory system	1,824	2,036	1,965	2,062	2,192	2,211	2,517	2,802	3,057	2,826	3,138
82. Cerebral haemorrhage, etc.	761	791	771	770	759	761	696	649	686	650	658
97 (1 and 2). Arteriosclerosis with vasc. lesions	106	124	130	138	149	150	226	272	267	265	294

Taken from the Registrar-General's Statistical Review: 1921, Table 5, for 1910-21; and 1931, Table 7, for 1921-31.

1915 and perhaps until 1917. Angina pectoris continued very steady: the figure was 29 in both 1911 and 1921 and never fell below 27 or rose above 35 in the years between. This was also true for a condition like aneurysm (see Table IV).

To sum up the position from 1891 to 1921, the crude death rate from all heart disease in 1921 was very much the same as it had been since 1891, and probably since 1876. Crude death rates are generally accepted as a reasonably valid comparison over short periods like 10 or perhaps 20 years, but are less valid for longer periods where the age structure of the population may have changed considerably; it seems unlikely, however, that such a change would be a factor in keeping the death rate from heart disease relatively constant. The absolute fall was very small—from 1,555 (1891–5) to 1,504 per million living (1917–21)—which is much less than the fall in the death rate from all causes—that is, from about 18,700 in 1891–5 to 14,000 in 1917–21. The proportion of deaths from heart disease had therefore increased a little, but only from 8.3 to 10.7%. At first sight this seems less than might be expected from the reduction in deaths from infectious diseases, but most of these had taken place at an early age, and deaths from heart disease would occur nearly 40 years later. The death rate recorded as due to angina pectoris had increased only slightly from 1891 to 1921, being 22.3 per million living in the first half and 28.7 in the second half of this period. This short summary has been inserted here because we have now reached the end of the period of relative stability.

Diseases of the Heart: 1921–31

When we come to this decade there is an enormous change. In 1931 diseases of the circulatory system were 172%, diseases of the heart 178%, and diseases of the coronary arteries and angina pectoris 572% of the levels they had shown in 1921 (Table IV). Up to 1921 the proportion of all cardiac deaths attributed to angina pectoris was under 2%, so that a very small increase in the number of cardiac deaths diagnosed correctly as coronary heart disease would cause an enormous rise in its importance as a recorded cause of death. Perhaps, therefore, the increase in the death rate from all heart disease to 178% of the earlier level, which had not changed much during the previous 40 years, is more significant than the much larger proportional rise in deaths attributed to coronary disease.

Although the increase in the death rate from heart disease was so dramatic, it is not easy to pinpoint the exact year of change. All diseases of the circulatory system

passed their previous highest peak of 1915–18 in 1922 and again in 1924, after which they increased regularly each year for the next five years. All diseases of the heart did not pass their previous peak till 1927 and increased enormously in 1929, being then 150% of the level in 1926—such a remarkable rise that it must lead to a search for some special cause. Deaths attributed to diseases of the coronary arteries passed their previous highest (1915) in 1922 and thereafter increased every year but one till 1959, especially after 1927. It would be fair to say that the rise started in 1922–4 and was most striking in 1927–9 and after.

There is little to say about the other groups. The regular increase that had been taking place in valvular disease of the heart was arrested in 1915–18, the level remaining about the same till 1931. It was then four times as high as the number of deaths from diseases of the coronary arteries, which were still less than 7% of all deaths from heart disease.

Although, as can be seen from Table IV, there was a further change in the classification used between 1911–21 and 1921–31, this did not make much difference to the figures. Those for 1921 are shown twice by the Registrar-General with the different classifications, and they are almost identical for the diseases of the heart quoted. The change of classification is not, therefore, the explanation of any great part of the rise. The diagnosis of coronary thrombosis (cardiac infarction), both in life and as a cause of death, must, however, have played a large part, since it was rarely made before 1924–8. The recognition of the importance of coronary heart disease as a cause of death should have been made more widely after Herrick's first paper in 1912. In fact, it was hardly considered, even in America, until a decade later, when Herrick spoke again on the subject, and in British medical practice not until after the papers of Gibson (1925), McNee (1926), and Parkinson and Bedford (1928). Sir Humphry Rolleston (1927), in an interesting address to the Medical Society of London on "Changes in the Clinical Aspects of Disease," did not mention coronary heart disease or angina pectoris. Even after this time, many years would be needed for the wide spread of this new knowledge among general practitioners, who sign most of the death certificates and tend to be conservative in signing such important documents.

Diseases of the Heart: 1931–40

The general trends in 1931–40 continued to be much the same as in the previous decade. The figures on which this section is based are shown in the upper half of Table V, taken from Table 7 of the *Statistical Review for 1940*.

TABLE V.—Crude Annual Death Rates at All Ages per Million Living. 1931–49. Persons

Year:	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
All causes (thousands)	12.3	12.0	12.3	11.8	11.7	12.1	12.4	11.6	12.1	14.4
92. V.D.H.	622	587	564	531	518	500	472	433	434	480
93. Dis. of myocardium	1,290	1,335	1,439	1,464	1,558	1,744	1,804	1,850	2,003	2,278
94. Dis. of cor. art. (A.P.)	149	172	206	237	273	305	337	374	433	467
90–95. All heart disease	2,298	2,316	2,424	2,434	2,549	2,752	2,805	28.25	3,052	3,416
90–103. Diseases of circ. system	2,582	2,600	2,706	2,715	2,824	3,042	3,107	3,140	3,405	3,810
83. Intracranial vascular lesions	1,003	1,026	1,009	1,028	1,059	1,087	1,081	1,084	1,180	1,294
Year:	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949
All causes (thousands)	14.4	13.6	12.3	13.0	12.7	12.6	12.5	12.3	11.0	11.6
92. V.D.H.	480	449	433	427	432	413	363	348	310	320
93. Dis. of myocardium	2,278	2,071	1,979	2,070	2,109	2,152	2,095	2,196	1,876	2,143
94. Dis. of cor. art. (A.P.)	467	455	486	542	602	656	704	794	857	996
90–95. All heart disease	3,416	3,145	3,049	3,185	3,278	3,354	3,286	3,460	3,152	3,579
90–103. Diseases of circ. system	3,810	3,513	3,621	3,581	3,689	3,773	3,714	3,923	3,697	4,094
83. Intracranial vascular lesions	1,294	1,242	1,263	1,292	1,346	1,365	1,338	1,393	1,260	1,374

Taken from the Registrar-General's Statistical Review: Tables 7, 1940, for 1931–40; and 1949 for 1940–9.

There was no change in the classification shown in Table V during this and the following decade, because the upper half had been adjusted to the newer classification of 1940 by the Registrar-General. In 1940 and after causes of death were classified in accordance with the fifth revision (1938) of the *International List*. Coincident with this a change was made in selecting the assigned cause of death where more than one cause was mentioned on the certificate, "the choice now being that inferred from the statement on the certificate instead of being determined by arbitrary rules." This leads to some discrepancy between the figures for 1931 in Table IV and those for 1931 in Table V, which were calculated by the Registrar-General by the newer method and make the death rates from diseases of the heart and of the circulatory system lower. The question was discussed by the Registrar-General in the text of his *Statistical Review* for 1937 (p. 129) and for 1938 and 1939 (p. 105): he concludes that the changes could be very large for some groups, but that for heart disease as a whole they are probably less than 20%. The differences in Tables IV and V are large looked at over a short period of two or three years, but looked at in a longer perspective they make only a slight interruption in the steady rise that was taking place in death rate from several forms of heart disease (Fig. 2).

FIG. 2.—Crude death rate per million living from 1876 to 1959 from various causes. (1) From all cardiovascular disease (increase 242%). (2) From all diseases of the heart (increase, 261%). (3) From vascular disease of the central nervous system (increase, 220%). (4) From coronary heart disease (increase, 6,992%). All four rates were fairly steady till after 1920, since when they have increased greatly. The enormous proportional rise of deaths from coronary heart disease is minimized on this arithmetical scale because it started from such a low level. The proportional rise in vascular disease of the C.N.S. (220%) is not much less than that from all diseases of the heart (261%), but looks less on this arithmetical scale because it starts from a lower level. There is some evidence that the rise in (1) and (2) is slowing down or ending in the last few years.

During this period diseases of the heart were divided into six groups. The first two were so small as to be numerically insignificant. Pericarditis (group 90) showed a steady death rate that varied only between 7 and 11 during 1931–49; and acute endocarditis (group 91) had a death rate falling from 27 to 10, perhaps from the use of penicillin for subacute bacterial endocarditis in the latter part of this period. Groups 92, 93, and 94, which were responsible for between 90 and 96% of all cardiac deaths, are shown in Table V. The sixth (group 95) consisted of other diseases of the heart and was larger than the first two but never as much as 10% of the total.

From 1931 the death rate from all diseases of the heart was still rising fast, increasing from a level of 100% (2,346) in 1931–3 to 132% (3,098) in 1938–40; and that from all diseases of the circulatory system was much the same, increasing to 131%. The rise in the recorded death rate from disease of the coronary arteries was much greater, from 100 to 242% (176 to 425). The death rate from

valvular disease, on the other hand, started to fall, and decreased to 76% of its earlier level (591 to 449). Some of this may have been due to a decrease in the incidence of rheumatic heart disease, but probably much more of it was due to a diminution of the inaccurate diagnosis of mitral regurgitation.

Diseases of the Heart: 1940–9

The increase in the death rate from all heart disease was much less in 1940–9 than in the previous two decades, while that from coronary heart disease continued at the same geometrical rate. The figures are shown in the lower half of Table V, which is taken from Table 7 of the *Statistical Review for 1949*, where all the figures had been adjusted to the newer classification by the Registrar-General.

In this decade the death rate from coronary heart disease again doubled, while that from diseases of the myocardium fell slightly (2,109 in 1940–2, 1940 being the peak year, to 2,072 in 1947–9). This and the fall in deaths attributed to valvular disease of the heart were enough to limit the increase in the death rate from all diseases of the heart to 6% (3,203 in 1940–2 to 3,397 in 1947–9). This contrasts with 1931–40, when coronary heart disease doubled and diseases of the myocardium (group 93) increased by 65% (after omitting the part of the increase that was probably due to a transfer of cases previously wrongly attributed to valvular disease).

From 1940 to 1949, therefore, for the first time since 1921–31, the increase in the death rate from all heart disease was so much less than that from coronary disease that nearly four-fifths of the apparent increase in coronary heart disease must have been due to a change in methods of diagnosis rather than to a real increase. The findings in the next decade lend further support to the view that this is the correct explanation. Ryle and Russell (1949) drew attention to this change and concluded that some of the rise in coronary heart disease in 1940–9 was due to a change in certification, more deaths being attributed to this cause instead of to myocardial disease.

Diseases of the Heart: 1949–59

The recorded death rate from coronary heart disease continued to increase, but if this really was so, some unknown factor caused a decrease of the same magnitude in that from other myocardial degeneration (group 422). This makes it almost certain that the recorded increase was entirely due to a transfer of deaths from myocardial degeneration to coronary heart disease. The figures for this section are shown in Table VI, which is taken from Table 8 of the *Statistical Review for 1959* and shows a further change of classification.

The death rate from all diseases of the heart (now groups 410–447) rose a little up to 1951 and then fell to about the original level. The death rate from arteriosclerotic (including coronary) and degenerative heart disease (groups 420–422) remained remarkably constant, always within the range 96 to 105%, taking the figure for 1949 as 100%. It is true that the recorded death rate for arteriosclerotic (including coronary) heart disease (group 420) continued to rise from 100% (1,114) in 1949 to 163% in 1957–9 (1,818), but this increase of 704 was almost exactly balanced by a fall of 710 in the death rate from other myocardial degeneration (group 422). This was written before the *Annual Report for 1960* was published, but the same trends continued that year. In 1949 arteriosclerotic (including coronary) heart disease was less than other myocardial degeneration (1,114 against 1,789); in 1954 it became more than myocardial

TABLE VI.—*Crude Death Rates at All Ages per Million Living. 1949–59. Persons*

Year:	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
All causes (thousands) ..	11.8	11.6	12.5	11.3	11.4	11.3	11.7	11.7	11.5	11.7	11.6
410–416. Chronic rheumatic H.D. ..	228	255	248	207	200	194	188	184	183	165	156
420. Arteriosclerotic H.D., including cor. dis. ..	1,114	1,274	1,356	1,420	1,420	1,532	1,613	1,696	1,719	1,863	1,871
422. Other myocard. degen. ..	1,789	1,662	1,764	1,472	1,424	1,358	1,371	1,308	1,162	1,192	1,079
420–422. Arteriosclerotic and degen. H.D. ..	3,011	3,001	3,175	2,960	2,908	2,963	3,051	3,071	2,956	3,126	3,017
440–447. Hypertensive disease ..	400	463	493	443	452	465	479	466	442	435	401
All heart disease:	3,854	3,926	4,163	3,845	3,807	3,877	3,976	3,988	3,862	4,017	3,858
400–468. Diseases of circulatory system ..	4,167	4,241	4,489	4,154	4,124	4,200	4,319	4,333	4,194	4,381	4,227
022. Syphilitic aneurysm of aorta ..	13	12	12	12	11	11	11	11	12	12	11
451. Other aortic, and dissecting aneurysms ..	10	12	13	28	28	34	37	41	44	51	50
330–334. Vascular lesions affecting C.N.S. ..	1,393	1,476	1,562	1,579	1,543	1,629	1,669	1,668	1,640	1,689	1,656
331. Cerebral haemorrhage ..	749	758	759	726	705	726	709	689	654	659	623

Abstracted from Table 8 of the Registrar-General's Statistical Review for 1959.

degeneration; in 1960 it was nearly twice as much (2,010 against 1,028); but the sum of the two remained almost constant throughout this decade.

There is no reason to think that the deaths from other myocardial degeneration did, in fact, diminish; and, looking at the yearly figures for these two groups, the rise in one and the fall in the other seem to be caused entirely by the increasing use of the diagnosis of coronary heart disease. It is interesting that 30 years have been needed for the full effect of the spread of the newer knowledge about coronary heart disease in 1922–9, though it may now be almost finished.

These two groups together are now responsible for nearly 70% of all deaths from diseases of the heart, and all the other groups are relatively small. The death rate from chronic rheumatic heart disease (groups 410–416) is still decreasing from 244 in 1949–51 to 168 in 1957–9, so that now it forms no more than 5%. Though the decrease in valvular disease of the heart earlier was almost certainly due to a less general diagnosis of mitral regurgitation whenever there was a systolic murmur, the decrease now is probably a real one caused by the much lower incidence of rheumatic fever and perhaps by the successful operations for mitral stenosis; for the fall could be seen in 1951 and 1952 and was greater in 1958 and 1959. I am not convinced of this last reason, though the dates fit in nicely.

Surprisingly, *hypertension* did not appear as a cause of death before the classification adopted for 1949–59. During this decade the combined death rates for hypertensive heart disease and other hypertensive disease remained steady at about 452 without any tendency to rise or fall. They were responsible for about 12% of all the deaths from disease of the heart. I have combined these two groups because internal evidence, especially for the years between 1949 and 1952, suggests some artificial reason for transfer, the deaths from hypertensive heart disease being 100 higher and those for other hypertensive disease 100 lower in 1950 and 1951.

Aneurysm

The death rates from aneurysm are included in some of the tables because they are of interest though not common enough to be of much numerical significance. From 1911 to 1931 they had a mean of 29 with no tendency to rise or fall, and were always within the range 24–33 (Table IV). From 1932 to 1949 they seemed to have fallen to less than a quarter of this in accordance with the clinical impression that aneurysms became much rarer about 20 years after the lower incidence of syphilis and its more effective treatment. In fact, there was no such reduction in the Registrar-General's figures, but over three-quarters of the aneurysms had been removed from the circulatory system to group 30d under syphilis. Combining these figures to

make them comparable with the earlier ones, the death rates from 1932 to 1949 were hardly changed, averaging 31 per annum and never varying outside the range of 28–34.

During the last decade, 1950–9, syphilitic aneurysms have been less (average 11.6 against 24.2 in the previous two decades), which may be the deferred fall noted in clinical practice. On the other hand, non-syphilitic aortic aneurysms and dissecting aneurysms have shown a remarkable rise from an average of 7 in 1931–49 to 12 in 1950 and to 48 in 1957–9, this being the highest total for aneurysms that I have found. This seems unlikely to be a true picture, and is more likely due to pathologists becoming increasingly aware of dissecting aneurysms as a cause of sudden death.

Cerebral Haemorrhage and Other Vascular Lesions of the Brain

The deaths from cerebrovascular lesions are of interest for comparison. They are due mainly to the condition of the artery wall, especially the degree of atherosclerosis, and the pressure to which it is exposed, hypertension. Atherosclerosis and hypertension are equally important causes of deaths from heart disease. Any similarity between the death rates from heart disease and from cerebrovascular lesions might be due to parallel effects of atherosclerosis and/or hypertension, though naturally the coronary and cerebral arteries might be affected in different ways and might be influenced by different changes in the environment.

The crude annual death rates from cerebral haemorrhage, embolism, etc. (from 1891 to 1910), per million persons living are given in Table III. They fell a little, from 100 to 87%, being 827, 778, 711, and 721 annually in successive quinquennia. The fall in the death rate from all diseases of the heart (from 100 to 82%) was not very different. These falls were rather less than the fall in the death rate from all causes (from 100 to 73%) in the same period (see Table III), so that both these causes became responsible for a somewhat larger proportion of all the deaths.

There was no great change in the death rate from cerebral haemorrhage in the next decade, this being 721 in 1911–15 and 745 in 1916–20 (see Table IV, but most readers may find enough figures for their purpose in summarized form in Table VII without referring back to the more detailed figures in the various Tables quoted as evidence). This was true for the death rate from diseases of the heart also.

The next decade, 1921–30, was the time when the death rate from diseases of the heart, having remained relatively steady for more than 40 years, began to increase, and continued to do so for at least 35 years. As can be seen from the penultimate line of Table IV the death rate from cerebrovascular lesions seemed to fall a little, but this was

found to be due to a change in classification. From 1911 to 1920 the main difference between diseases of the heart and those of the circulatory system had been a small group of arteriosclerosis, from which cause the death rate increased from 108 in 1911 to 330 in 1921. In 1921 this group 97 was subdivided into: (1) arteriosclerosis, with cerebral haemorrhage, (2) with other cerebrovascular lesions, and (3) without record of cerebrovascular lesions. Group 97 (1) was about twice as large as 97 (2), and the two have been combined in the last line of Table IV.

This adjustment means that there was, in fact, a considerable rise in the death rate from cerebrovascular disease in 1921-30, for I have assumed that the Registrar-General has not included these deaths with those already shown under cerebral haemorrhage, etc. There is a further difficulty in deciding just when the increase in these deaths started and how much it was at first, since the Registrar-General has recorded the figures for 1921 differently in his *Statistical Review for 1921* (his Table 5 for 1910-21) and for 1931 (his Table 7 for 1921-31). The adjustments he has made for the change of classification made very little difference for any of the diseases of the heart (see my Table IV) but have increased the recorded deaths from cerebral haemorrhage by 84 (from 677 to 761) before adding the other 106 cases from group 97 (1 and 2).

As explained below, the years 1891-1920, when there was relatively little change, have been taken as a baseline of 100% for subsequent calculations. The addition of these 84 cases makes it appear that the increase in the death rate from cerebrovascular accidents started a little earlier (in 1921-4) than that from diseases of the heart (in 1925-7: see Table VII), but I am doubtful if this was really so. Certainly it was slower, and by 1928-30 it had increased to 124%, compared with 149% for diseases of the heart.

For the next 20 years at least, both continued to increase, but the cerebrovascular death rate rather more slowly than that from diseases of the heart. From 1931-5 to 1951-2 the former, now classified as intracranial vascular lesions (group 83), increased by another 52% above the level in 1931-5; and the death rate from heart disease by another 64% (Tables V and VI). In the last years for which figures are available, 1954-9, the intracranial vascular lesions continued to increase, certainly until 1955, while the deaths from heart disease seemed to have become stationary, with the peak in 1951. By 1957-9 the death rate from cerebrovascular lesions was 220% above its original basic level, while that from diseases of the heart was 261% above.

The changes in the death rates from cerebrovascular lesions and from heart disease have not been quite the same, but throughout the whole period they have been of the same order. This suggests that in the main the death rates from these two causes have been affected by the same factors with only relatively minor differences. We are not concerned with the details of these cerebrovascular lesions, but it is interesting that cerebral haemorrhage was recorded as the cause of 90% of the total in 1910-19, of 73% in 1931, but only of 57% in 1949. This must, I think, be due mainly to an improved medical diagnosis of cerebral thrombosis and embolism rather than to a real pathological change.

Discussion

The classification of diseases of the heart in the early part of this period now appears very old-fashioned, but it represents the general attitude of the physicians of that time and was not peculiar to the Registrar-General. Most systolic murmurs led to a diagnosis of mitral regurgitation

and valvular disease of the heart, and as an example mitral regurgitation overshadowed all other diagnoses in the index of the medical reports of Guy's Hospital up to 1914. Myocarditis and myocardial degeneration were widely accepted as adequate and satisfactory diagnoses and no doubt included most deaths due to coronary heart disease. It was only after 1920 that the importance of the aetiological factor began to be recognized, and the older diagnoses continued to be used for many years. Until angina pectoris was firmly linked to disease of the coronary arteries (1925-9), death from angina pectoris was likely to be attributed to fatty or myocardial degeneration. Hypertension was included as a group among the causes of death only in the last decade.

Such a large part of the recorded increase in deaths from disease of the coronary arteries must be due to our increasing clinical and pathological knowledge that it seems wiser to consider first how much deaths from diseases of the heart as a whole have increased. Here changes in classification and methods of signing a death certificate can lead to great changes, but these should not be enormous, at any rate without their being recognized or, more likely, foreseen by the Registrar-General because of some changed instructions or method of classification that he has issued. The crude death rate per million persons living from all diseases of the heart averaged 1,534 from 1891 to 1900 and had not changed much since 1876. Nor did it change much in the next 20 years, so that it was relatively stable for a period of at least 44 years. By 1901-15 it had fallen a little to 1,454, but by 1916-20 it had risen again to 1,555. The death rate from all causes had fallen rather more than this, so that the proportion of deaths from heart disease had increased a little.

The average annual death rate from all diseases of the heart from 1891 to 1920 was 1,500, and I have chosen this as the baseline of 100% from which all subsequent changes are measured. It would be difficult to choose any reasonable baseline that was lower than 1,454 or higher than 1,549, and, considering the enormous changes with which we are concerned in the next 40 years, it would make little difference if either of these figures had been chosen instead of 1,500, which seems the most accurate estimate. It must be remembered that though crude annual death rates provide a fairly accurate measure of changes taking place over a period such as one or even two decades, they are much less reliable for longer periods when the age structure of the population may have changed greatly.

The main findings during the last 70 years are shown in Table VII and Fig. 2. Table VII shows the death rates from all diseases of the heart; all diseases of the circulatory

TABLE VII.—Summary of Crude Death Rates per Million Living From Various Causes, 1891-1959

Years	All Heart Disease	All Diseases of Circ. System	Vascular Lesions of C.N.S.	Coronary Heart Disease
1876-80	—	2,474	—	—
1881-90	—	2,482	—	—
1891-1900	1,543	2,460	803	23
1901-10	1,445	2,308	716	25
1911-15	1,472	2,544	721	31
1916-20	1,555	2,616	745	28
Basis (1891-1920)	1,500 (100)	2,449 (100)	751 (100)	26 (100)
1921-24	1,508 (101)	2,870 (117)	899 (120)	38 (146)
1925-27	1,711 (114)	3,220 (131)	914 (122)	55 (212)
1928-30	2,230 (149)	3,825 (156)	930 (124)	121 (465)
1931-35	2,404 (160)	3,710 (151)	1,025 (136)	207 (796)
1936-40	2,970 (198)	4,442 (181)	1,145 (152)	383 (1,473)
1941-45	3,202 (215)	4,937 (202)	1,302 (173)	548 (2,108)
1946-50	3,481 (232)	5,302 (216)	1,368 (182)	937 (3,604)
1951-53	3,938 (263)	5,817 (237)	1,561 (208)	1,399 (5,380)
1954-56	3,947 (263)	5,939 (242)	1,655 (220)	1,614 (6,208)
1957-59	3,912 (261)	5,929 (242)	1,657 (220)	1,818 (6,992)

system, including vascular lesions of the central nervous system (C.N.S.); vascular lesions of the C.N.S.; and coronary heart disease. Generally these are shown for each quinquennium, but sometimes before 1910 in decades, and in two critical decades, 1921-30 and 1951-9, in three-year periods. The changes in classification are probably the main factor in preventing smooth curves—for example, in 1931-5 the relatively small rise in deaths from heart disease and the actual fall in deaths from all cardiovascular disease, and the unusually large rise in cerebrovascular lesions (q.v.) in 1921-4. These and other factors must produce errors, but they can hardly be large enough to upset the general truth of the picture that has been given.

Some time between 1920 and 1925 all the four groups shown in Table VII began to show a higher death rate, and this continued for at least 30 years. The death rate from diseases of the heart began to rise in 1922-5 and rose so rapidly that by 1928-30 it had increased from 100 to 149%, by 1936-40 to nearly 200%, and by 1951-3 to 263%. In the last seven years there is some evidence that after 30 years this rise has come to an end. The highest annual death rate was in 1952, and the last triennium shows a slightly lower rate than the two previous ones. But neither the time that has elapsed nor the size of the fall is enough to make this certain.

During the same period, when the death rate from heart disease rose from 100 to 263%, the death rate from *cerebrovascular lesions* rose from 100 to 220%—an increase that is smaller but of the same order. The figures for the last six years suggest that this rise has come to an end, but this is less certain.

When we turn to the death rate from *diseases of the coronary arteries* the increase is of quite a different order—nearly 7,000% above the low level that was recorded in 1891-1920. From this level the death rate had doubled by 1927, doubled again by 1929, again by 1933, again by 1939, again by 1948, and again for the sixth time by 1956: it has continued till 1959, though in the last year the rise was smaller. This almost geometrical rate of increase is not so difficult when the initial number is very small but becomes increasingly difficult to maintain as the numbers become larger. It may mask the fact that the recorded death rate from coronary heart disease showed a much larger arithmetical increase (nearly six times larger) in the decade of 1949-59 (from 1,114 to 1,871) than in that of 1921-31, when it increased from 29 to 166 per million persons living.

A rate of change increasing in geometrical progression is not very common in medical or biological statistics. It may be found in the early stages of the spread of an infectious disease among a population with little immunity, and for a time in the growth of a small population of animals with a rapid reproduction rate and an almost unlimited food supply. Coronary arterial disease has little resemblance to either of these conditions, but the spread of knowledge in a community may well have; in this case the spread of knowledge of the importance of coronary heart disease among physicians, pathologists, and general practitioners—not necessarily in this order—in ever-widening circles.

Everyone is, I think, agreed that this is an important cause of the increase of recorded deaths from coronary heart disease, though sometimes it seems to be forgotten. Whether, as these figures may suggest, there had been some real increase in the death rate from all heart disease and from coronary heart disease in particular—an increase greater than might be expected from the lives saved by the more effective control of infectious diseases, and the conse-

quent older age of the population in general—will be discussed in a subsequent paper.

Summary and Conclusions

This paper summarizes the crude annual death rates per million persons living (men and women combined), as reported by the Registrar-General. The death rates from all diseases of the circulatory system, from all diseases of the heart, and from vascular lesions of the central nervous system have been considered, fully from 1891 to 1960 and more shortly from 1876 to 1890.

The death rates from the main subdivisions of diseases of the heart also have been summarized. Changes in the Registrar-General's classification have been discussed, but do not seem to be an important cause of our findings. Changes in medical views and knowledge seem more important. They could explain the registered rise in deaths from valvular disease of the heart till about 1917 and its fall after 1931, and much, if not all, of that from coronary heart disease.

The death rate from *all diseases of the heart* changed very little from 1876 to 1920 and probably from 1850. About 1924 it began increasing rapidly and had risen from 100 to 263% by 1952, since when it has shown signs of settling at this higher level. All the figures discussed here are for men and women combined, though some of the trends discussed would have been even more striking for men alone.

The recorded death rate from *coronary heart disease* started increasing about the same time in geometrical rather than in arithmetical progression: this rise is still continuing, though largely after 1940 and entirely after 1951 it must be due to a change of diagnosis, since it is balanced by a fall in the deaths attributed to other myocardial disease. The original level was so low that the death rate from coronary heart disease was not of much arithmetical importance till shortly before 1940.

The death rate from *cerebrovascular lesions* behaved in much the same way as that from all diseases of the heart, and the increase was of the same order but rather less—from 100 to 220% instead of to 263%.

How much of these increases can be explained by the *older age structure of the population*, caused largely by the many young lives that were saved from dying with infectious diseases from 1880 and especially from 1895 onwards, will be discussed in a subsequent paper.

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