Cohort analysis of cigarette smoking and of mortality from four associated diseases

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1. Introduction

1.1 "Cohort analysis" means an analysis in which the basic material is classified by the year of birth of the subjects rather than by the year in which the event of interest (such as death) happened to them. This paper presents analyses in cohort form both of death rates from the four main cardiovascular and respiratory diseases, namely, heart disease, stroke, lung cancer and bronchitis, and of cumulative cigarette consumption. It also gives observations on the extent to which the pattern of cumulative cigarette consumption by successive cohorts of men and women is consistent with the pattern of death rates. The advantage of using cohort data, where the available statistics enable this to be done, is that causes and effects are analysed in the same group of people. By contrast, if people dying at, say, ages 60-64 and 65-69 in a particular period are compared one is comparing different cohorts which may have had differing exposure to factors influencing mortality. An outstanding example of erroneous deduction from comparison of contemporary death rates of different cohorts was the deduction that male lung cancer death rates declined after the age of 65-69. This conclusion was drawn by comparing the lung cancer death rates of one cohort of men at age 65-69 with the rates for the same period of the previous cohort at age 70-74. When the same male cohort in England and Wales is followed throughout its lifetime, it can be seen that the lung cancer death rate at age 70-74 was always higher than the rate at 65-69. In so far as there was a reduction in male lung cancer rates with increasing age, it occurred, if at all, only at age 80-84 or 85+ (as can be seen in table 1.M of this paper).

1.2 The main tables in this paper have been arranged so that mortality rates, or cigarette consumption levels, of a given cohort for each age are represented by a row of figures opposite the central year of birth of the cohort. On this basis, contemporary death rates (i.e. those for the same calendar year) for different ages at death can be found from the figures in ascending diagonals. The death rates of different cohorts can, of course, be obtained from the usual tables of death rates by age groups for successive 5-year

periods by reading the figures of ascending or descending diagonals, but the form of presentation adopted here is clearer when the analysis is primarily concerned with cohorts.

1.3 Some information on cigarette consumption by four cohorts of men and women has already been given in Changes in Smoking Patterns in the U.K. (Todd, 1975; referred to hereafter as Smoking Patterns). Smoking Patterns also introduced the concept of "constant tar cigarettes" which takes account of the reductions that have occurred in the tar yields of British cigarettes since 1965. The present paper extends the cohort figures so as to allow as complete a comparison as possible with mortality information.

1.4 Section 2 of this paper presents the mortality rates from the four main smoking associated diseases. Appendix A gives the precise definitions of these diseases and contains comments on the comparability of the mortality rates for different periods.

1.5 Section 3 presents estimates, on certain assumptions, of the average cumulative cigarette consumption on a constant tar basis by men and women in successive cohorts. Details of the procedure by which the cigarette consumption figures were calculated are given in Appendix B. While the mortality figures in this paper relate to England and Wales, the cigarette consumption figures are those of the U.K. as a whole. Cigarette consumption details are not available for England and Wales separately but are likely to have been similar to those of the U.K. Section 3 also contains comments on certain features of the mortality and cigarette consumption figures, but as the purpose of this paper is primarily to present basic data, no attempt has been made to interpret the findings.

2. Mortality from four smoking-associated diseases

2.1 This section of the paper presents the death rates in England and Wales from the four main cardiovascular and respiratory diseases, namely, coronary heart disease, stroke, lung cancer and bronchitis. Nearly 300,000 men and 300,000 women died in England and Wales from all causes in 1973. The percentages of these totals represented by deaths from coronary heart disease, stroke, lung cancer and bronchitis were 29%, 10%, 9% and 7% respectively for men and 22%, 17%, 2% and 2% respectively for women. In total, therefore, these four diseases accounted for over 55% of all male deaths and nearly 44% of all female deaths in 1973.

2.2 The lung cancer death rates of men and women for all the five year periods from 1911-15 to 1966-70 are given in tables 1.M and 1.W. These figures have been published previously but the mean death rates for 1971-73 have been added at the foot of each column in order to show the latest trends. The death rates from heart disease (tables 2.M and 2.W), stroke (tables 3.M and 3.W) and bronchitis (tables 4.M and 4.W) have been compiled from figures published in the Registrar General's Annual Statistical Review of England and Wales. Owing to major interruptions in earlier years in the comparability of the death rates, those for heart disease are given only for the five year periods 1951-55 to 1966-70 and those for stroke and bronchitis for 1946-50 to 1966-70. As with lung cancer, the mean death rates for 1971-73 have been included. The average number of deaths per annum from heart disease, stroke and bronchitis for the periods concerned are given in tables A.1 to A.3 as an indicator of the inherent variability of the death rates. The numbers of deaths from lung cancer have been published in the O.P.C.S. Study No. 29, Cancer Mortality, England and Wales, 1911-70.* The death rates have been calculated by taking the recorded deaths as a proportion of the total population at the middle of each period covered, on the basis of the contemporary population estimates contained in the Registrar General's Statistical Reviews.

2.3 The comparability of the death rates for different years of the four diseases included in this paper was affected to a varying extent by the changes in definitions of the diseases caused by

the revisions of the International Statistical Classification of Diseases introduced in 1950, 1958 and 1968. The changes in the definition of lung cancer had little effect on the comparability of the death rates. The changes in the definition of heart disease in 1950 and 1968 were of major importance, but it proved possible to put the death rates for 1951-67 and 1968-73 on a reasonably comparable basis. Minor breaks at 1950 and 1968 in the continuity of the definitions of stroke and bronchitis could not be overcome, so the breaks were accepted and met by giving death rates in tables 3.M and 3.W and 4.M and 4.W on both a temporal basis and a cohort basis. In compiling the figures on a temporal basis, the period 1966-70 was split into the two periods 1966-67 and 1968-70 representing the years before and after the 1968 changes in the definition of the diseases so that the death rates for these two periods could be compared with the death rates of earlier and later periods respectively. On the other hand, the death rates of each cohort during the period 1966-70 had to be based on the definitions used in practice although changes had occurred in them. The problems of comparability of the death rates of different periods are discussed in some detail in Appendix A.

2.4 In considering the mortality rates given in tables 1 to 4, it has to be borne in mind that the death rates of successive cohorts have in some cases been markedly affected by changes in the standards of diagnosis, in particular with lung cancer where a number of significant advances in diagnostic aids have been made in this century, with the successive advent of X-rays, bronchoscopy and open-chest operations. Little firm evidence is available to indicate the actual effects on the death rates of these advances, but it is believed to have been considerable. One study which demonstrates that diagnosis was by no means perfect in the 1950's was that by Heasman and Lipworth (1966). They found, in a large study of deaths in 1959, that in addition to 253 cases clinically diagnosed as lung cancer and confirmed at autopsy, there were also 197 cases clinically diagnosed but not confirmed at autopsy (false-positives), and in a further 281 cases, lung cancer was found to have been the primary cause of death at autopsy but the cases were diagnosed clinically as dying of other diseases (false-negatives).

2.5 The patterns of the death rates of successive cohorts of men from the four diseases given in tables 1.M - 4.M may be summarised as follows:-

2.5.1 The male lung cancer death rates at ages 50+ increased with each successive cohort up to the cohorts born around 1901-06, and those at ages 30-49 increased with each successive cohort up to the cohorts born around 1911-16. Thereafter, the male lung cancer death rates decreased at all ages with each successive cohort.

2.5.2 The male death rates from heart disease increased almost continuously at all ages with each successive cohort from the cohort born around 1871 up to the latest cohort.

2.5.3 The change in the definition of stroke in 1950 caused the male death rates from stroke of most age groups to reach a peak in 1951-55. Since then, the male death rates from stroke at ages 50-84 have decreased continuously in cohorts born up to 1921. At younger ages, the death rates were approximately level in successive cohorts born around 1921 and later.

2.5.4 Excluding the age groups aged 80+ where the death rates were irregular, the male death rates from bronchitis increased almost continuously in each cohort up to the cohorts born around 1896-1901. Thereafter, the death rates decreased with each successive cohort until 1968 when the rates increased in 1968-70 as a result of the change in the definition of the disease in 1968. The death rates resumed their decline in 1971-73.

2.6 These conclusions are based on death rates. Using data supplied by the South Thames Cancer Registry, Todd and Skeet (private communication) analysed the lung cancer new case rates of men in the South West Thames Region. They concluded that cohorts born prior to 1904-12 had increasing new case rates with each successive cohort, but that after the 1904-12 cohorts, each successive cohort had lower

new case rates than its predecessor. The conclusions derived from new case rates were therefore similar to those drawn from death rates.

2.7 The patterns of the death rates of successive cohorts of women from the four diseases given in tables 1.W - 4.W may be summarised as follows:-

2.7.1 The lung cancer death rates of successive cohorts of women have increased continuously up to the cohort born around 1926 and decreased in later cohorts.

2.7.2 Apart from a few irregularities in the 70+ age groups, the death rates of women from heart disease have increased at all ages with each successive cohort since the 1871 cohort.

2.7.3 The change in the definition of stroke in 1950 caused the female death rates from stroke of almost all age groups to reach a peak in 1951-55. Since then, the female death rates from stroke at ages 45-84 have decreased continuously in almost all cohorts born up to 1926. At younger ages, the death rates were approximately level in successive cohorts born around 1921 and later.

2.7.4 The female death rates from bronchitis decreased with each successive cohort from the cohort born around 1866 to the 1906-11 cohorts. The bronchitis death rates increased in later cohorts, part of the increase being due to the change in the definition of the disease in 1968. However, the death rates for 1971-73 were lower than those for 1968-70 in all age groups.

2.8 The male and female patterns were thus different for lung cancer and bronchitis but broadly similar for heart disease and stroke.

TABLE 1.M

Male death rates per 100,000 per annum from malignant neoplasms of the trachea, bronchus, lung and other respiratory organs (I.C.D. 162 and 163 from 1950 with I.C.D. 164 from 1950 to 1967) in England and Wales on a cohort basis

Central date of birth	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Jan. 1 1826 or earlier												3.5
Jan. 1 1831											2.1	0.8
Jan. 1 1836										5.2	4.1	3.1
Jan. 1 1841									6.9	5.2	5.0	2.9
Jan. 1 1846								7.6	7.1	8.6	9.4	16.7
Jan. 1 1851							7.0	8.8	9.7	13.3	18.9	17.6
Jan. 1 1856						6.2	7.6	11.3	15.8	27.6	32.4	24.8
Jan. 1 1861					4.6	5.5	10.1	16.9	34.9	46.4	38.5	49.7
Jan. 1 1866				3.0	4.0	8.7	18.1	35.4	53.3	68.5	79.1	92.7
Jan. 1 1871			1.7	2.5	6.6	14.8	36.4	63.6	79.9	113.0	144.4	143.8
Jan. 1 1876		1.1	1.5	4.4	11.2	34.8	64.6	103.1	144.2	208.7	227.1	206.2
Jan. 1 1881	0.7	1.1	2.7	7.6	25.6	58.6	107.3	179.8	265.1	334.5	342.3	349.0
Jan. 1 1886	0.6	1.8	5.2	18.6	43.1	92.4	174.9	294.5	389.6	453.0	457.8	420.1
Jan. 1 1891	0.8	2.2	8.7	27.4	62.6	137.5	257.5	394.1	499.4	593.1	573.6	
Jan. 1 1896	1.1	5.4	14.0	40.4	97.2	201.8	333.0	486.1	622.3	741.4		
Jan. 1 1901	2.0	6.8	20.3	55.5	123.2	232.6	367.3	528.1	701.6			
Jan. 1 1906	3.0	8.7	24.2	58.4	125.4	229.0	370.3	530.4				
Jan. 1 1911	3.9	9.7	25.0	59.4	122.6	220.8	363.6					
Jan. 1 1916	4.1	10.0	25.3	56.6	116.5	210.1						
Jan. 1 1921	3.7	9.4	22.5	53.2	107.8							
Jan. 1 1926	3.6	9.1	21.8	52.2								
Jan. 1 1931	3.3	7.6	18.6									
Jan. 1 1936	2.5	6.1										
Jan. 1 1940	2.5											

TABLE 1.W

Female death rates per 100,000 per annum from malignant neoplasms of the trachea, bronchus, lung and other respiratory organs (I.C.D. 162 and 163 from 1950 with I.C.D. 164 from 1950 to 1967) in England and Wales on a cohort basis

Central date of birth	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Jan. 1 1826 or earlier												2.3
Jan. 1 1831											1.7	0.8
Jan. 1 1836										4.0	3.1	6.3
Jan. 1 1841									5.4	2.9	2.9	4.0
Jan. 1 1846								4.6	3.8	3.9	4.9	6.6
Jan. 1 1851							3.9	3.4	5.0	7.3	9.5	9.0
Jan. 1 1856						3.1	3.6	5.0	7.4	12.1	15.2	14.3
Jan. 1 1861					2.7	3.4	5.0	8.9	11.7	18.4	17.2	20.1
Jan. 1 1866				2.0	2.2	3.4	6.1	13.2	19.2	23.8	29.7	31.6
Jan. 1 1871			1.1	1.4	2.6	5.8	11.8	17.9	25.1	32.8	40.2	39.9
Jan. 1 1876		0.8	1.0	2.1	3.2	7.8	15.3	22.2	33.7	43.8	46.1	48.0
Jan. 1 1881	0.3	0.5	1.2	2.3	5.5	10.7	18.6	31.5	39.3	49.4	56.5	62.9
Jan. 1 1886	0.3	0.4	1.6	4.1	7.8	13.5	23.5	35.7	45.2	58.2	66.1	75.0
Jan. 1 1891	0.3	0.9	2.5	4.9	10.2	17.6	28.8	38.4	54.7	74.1	86.2	
Jan. 1 1896	0.3	1.3	3.2	6.3	12.3	20.6	33.3	51.9	73.5	87.8		
Jan. 1 1901	0.7	1.6	3.9	7.7	13.9	24.3	42.4	66.2	86.5			
Jan. 1 1906	0.8	2.5	5.1	8.9	17.0	31.0	51.9	78.3				
Jan. 1 1911	1.4	2.7	5.2	10.6	21.8	40.2	64.5					
Jan. 1 1916	1.5	2.9	6.1	13.7	28.6	47.5						
Jan. 1 1921	1.5	3.2	6.8	15.7	31.6							
Jan. 1 1926	1.5	3.2	8.2	18.8								
Jan. 1 1931	1.1	3.1	6.8									
Jan. 1 1936	1.1	2.7										
Jan. 1 1940	0.9											

TABLE 2.M

Male death rates per 100,000 per annum from arteriosclerotic heart disease including coronary disease and other myocardial degeneration with arteriosclerosis 1951 to 1967 (ICD 420 & 422.1, 6th & 7th revs.), from ischaemic heart disease from 1968 (ICD 410-414, 8th rev.) in England and Wales on a cohort basis

Central date of birth	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Jan. 1 1866												5266.4
Jan. 1 1871											3383.7	4815.5
Jan. 1 1876										2378.0	3576.7	5482.8
Jan. 1 1881									1573.9	2467.1	3776.7	5588.7
Jan. 1 1886								1019.6	1714.4	2691.2	3704.7	5637.0
Jan. 1 1891							634.2	1122.0	1880.6	2705.4	3809.9	
Jan. 1 1896						372.3	721.3	1281.6	1964.3	2963.8		
Jan. 1 1901					217.3	449.7	837.3	1336.2	2067.9			
Jan. 1 1906				103.1	251.1	510.6	863.7	1413.2				
Jan. 1 1911			44.2	126.1	293.5	542.6	889.5					
Jan. 1 1916		18.2	60.2	160.6	324.9	563.6						
Jan. 1 1921	6.1	25.6	76.5	178.6	358.5							
Jan. 1 1926	8.7	34.5	91.1	210.3								
Jan. 1 1931	9.5	32.9	95.1									
Jan. 1 1936	10.1	35.7										
Jan. 1 1940	10.9											

TABLE 2.W

Female death rates per 100,000 per annum from arteriosclerotic heart disease including coronary disease and other myocardial degeneration with arteriosclerosis 1951 to 1967 (ICD 420 & 422.1, 6th & 7th revs.), from ischaemic heart disease from 1968 (ICD 410-414, 8th rev.) in England and Wales on a cohort basis

Central date of birth	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Jan. 1 1866												4340.5
Jan. 1 1871											2418.2	4045.5
Jan. 1 1876										1432.9	2394.2	4270.2
Jan. 1 1881									822.6	1498.7	2538.1	4191.4
Jan. 1 1886								447.8	876.0	1565.7	2381.5	4218.8
Jan. 1 1891							212.3	467.2	936.0	1506.3	2529.6	
Jan. 1 1896						94.7	229.7	504.1	911.2	1618.4		
Jan. 1 1901					40.7	101.8	255.3	510.3	930.5			
Jan. 1 1906				17.0	43.4	115.1	259.3	516.2				
Jan. 1 1911			6.6	19.1	49.2	118.1	268.0					
Jan. 1 1916		2.6	8.3	24.0	57.5	120.8						
Jan. 1 1921	0.9	2.8	11.1	26.5	65.4							
Jan. 1 1926	1.4	4.4	14.1	33.3								
Jan. 1 1931	1.6	5.4	14.9									
Jan. 1 1936	1.9	4.9										
Jan. 1 1940	2.1											

TABLE 3.M

Male death rates per 100,000 per annum from intracranial lesions of vascular origin 1946 to 1949 (ICD 83, 5th rev.), from vascular lesions affecting central nervous system 1950 to 1967 (ICD 330-334, 6th & 7th revs.), from cerebrovascular disease from 1967 (ICD 430-438, 8th rev.) in England and Wales on a temporal basis and a cohort basis

	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Temporal basis												
Period covered												
1946-50	3.1	5.2	12.2	29.0	65.5	130.1	268.6	486.8	870.6	1400.1	2068.4	2967.1
1951-55	4.7	8.0	14.9	32.6	71.6	137.2	282.8	530.8	964.9	1681.6	2540.9	3806.4
1956-60	4.6	8.1	15.8	31.1	64.4	134.9	268.3	506.2	929.7	1628.8	2673.0	3645.2
1961-65	4.7	7.9	14.9	30.0	58.7	122.0	245.4	486.0	889.5	1571.7	2600.6	4131.5
1966-67	5.0	8.7	15.5	27.7	57.1	111.2	227.8	460.2	849.2	1476.9	2457.8	4201.0
1968-70	4.4	8.1	14.9	29.6	57.9	111.3	218.7	439.2	824.4	1448.6	2420.8	4247.0
1971-73	4.7	8.0	14.4	30.4	54.3	101.1	202.5	418.0	801.1	1439.4	2389.6	4148.8

Note: Broken lines denote breaks in comparability due to changes in official definitions of disease.

Cohort basis

Central date of birth												
Jan. 1 1861												2967.1
Jan. 1 1866											2068.4	3806.4
Jan. 1 1871										1400.1	2540.9	3645.2
Jan. 1 1876									870.6	1681.6	2673.0	4131.5
Jan. 1 1881								486.8	964.9	1628.8	2600.6	4273.6
Jan. 1 1886							268.6	530.8	929.7	1571.7	2448.8	4148.8
Jan. 1 1891						130.1	282.8	506.2	889.5	1462.6	2389.6	
Jan. 1 1896					65.5	137.2	268.3	486.0	840.9	1439.4		
Jan. 1 1901				29.0	71.6	134.9	245.4	441.7	801.1			
Jan. 1 1906			12.2	32.6	64.4	122.0	222.4	418.0				
Jan. 1 1911		5.2	14.9	31.1	58.7	111.5	202.5					
Jan. 1 1916	3.1	8.0	15.8	30.0	57.8	101.1						
Jan. 1 1921	4.7	8.1	14.9	28.7	54.3							
Jan. 1 1926	4.6	7.9	15.2	30.4								
Jan. 1 1931	4.7	8.3	14.4									
Jan. 1 1936	4.6	8.0										
Jan. 1 1940	4.7											

TABLE 3.W

Female death rates per 100,000 per annum from intracranial lesions of vascular origin 1946 to 1949 (ICD 83, 5th rev.), from vascular lesions affecting central nervous system 1950 to 1967 (ICD 330-334, 6th & 7th revs.), from cerebrovascular disease from 1968 (ICD 430-438, 8th rev.) in England and Wales on a temporal basis and a cohort basis

Temporal basis

Period covered	Age at death 30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
1946-50	3.3	6.6	14.2	36.3	77.7	133.1	247.9	451.5	823.8	1371.6	1995.8	2689.9
1951-55	4.6	8.2	16.8	38.4	79.5	135.1	241.9	459.7	850.0	1485.9	2409.6	3787.3
1956-60	4.5	8.6	16.7	33.1	65.9	115.8	215.5	412.0	802.3	1466.6	2414.3	3761.8
1961-65	4.5	7.7	15.0	31.0	55.7	96.7	188.9	364.7	739.6	1365.7	2409.5	4035.3
1966-67	4.7	8.6	14.7	28.3	52.7	86.8	170.1	334.1	665.2	1262.8	2249.8	4059.7
1968-70	4.2	8.5	15.9	30.1	51.6	82.3	160.4	316.0	647.5	1248.9	2223.9	4240.5
1971-73	4.5	7.8	15.6	27.4	46.9	78.5	143.2	292.4	611.2	1248.7	2269.1	4199.3

Note: Broken lines denote breaks in comparability due to changes in official definitions of disease.

Cohort basis

Central date of birth	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Jan. 1 1861												2689.9
Jan. 1 1866											1995.8	3787.3
Jan. 1 1871										1371.6	2409.6	3761.8
Jan. 1 1876									823.8	1485.9	2414.3	4035.3
Jan. 1 1881								451.5	850.0	1466.6	2409.5	4187.3
Jan. 1 1886							247.9	459.7	802.3	1365.7	2234.2	4199.3
Jan. 1 1891						133.1	241.9	412.0	739.6	1255.8	2269.1	
Jan. 1 1896					77.7	135.1	215.5	364.7	655.4	1248.7		
Jan. 1 1901				36.3	79.5	115.8	188.9	323.1	611.2			
Jan. 1 1906			14.2	38.4	65.9	96.7	164.0	292.4				
Jan. 1 1911		8.6	16.8	33.1	55.7	84.2	143.2					
Jan. 1 1916	3.3	8.2	16.7	31.0	52.2	78.5						
Jan. 1 1921	4.6	8.6	15.0	29.2	46.9							
Jan. 1 1926	4.5	7.7	15.4	27.4								
Jan. 1 1931	4.5	8.5	15.6									
Jan. 1 1936	4.4	7.8										
Jan. 1 1940	4.5											

TABLE 4.M

Male death rates per 100,000 per annum from bronchitis 1946 to 1967 (ICD 406, 5th rev., ICD 500-502, 6th & 7th revs.), and from bronchitis, emphysema and asthma from 1968 (ICD 490-493, 8th rev.) in England and Wales on a temporal basis and a cohort basis

Temporal basis

Period covered	Age at death 30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
1946-50	3.8	6.5	14.2	37.6	77.5	145.4	263.9	356.0	483.8	727.0	1102.3	1743.9
1951-55	1.5	4.3	10.3	28.8	72.4	147.9	268.6	417.4	578.4	797.3	1112.4	1827.0
1956-60	1.4	3.2	9.1	22.4	60.7	142.3	272.3	419.0	604.6	792.6	1023.3	1335.9
1961-65	1.2	2.9	7.5	21.9	54.0	131.0	280.0	470.4	675.8	958.7	1199.4	1591.1
1966-67	1.3	2.9	6.8	18.0	48.2	110.0	239.7	433.3	651.2	905.2	1154.6	1457.7
1968-70	2.0	4.0	8.3	20.1	51.0	110.3	246.9	458.7	727.2	983.3	1234.3	1584.9
1971-73	1.6	3.2	6.0	16.8	40.3	91.2	185.9	356.9	626.5	969.6	1178.4	1529.3

Note: Broken lines denote breaks in comparability due to changes in official definitions of disease.

Cohort basis

Central date of birth	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Jan. 1 1861												1743.9
Jan. 1 1866											1102.3	1827.0
Jan. 1 1871										727.0	1112.4	1335.9
Jan. 1 1876									483.8	797.3	1023.3	1591.1
Jan. 1 1881								356.0	578.4	792.6	1199.4	1541.8
Jan. 1 1886							263.9	417.4	604.6	958.7	1209.0	1529.3
Jan. 1 1891						145.4	268.6	419.0	675.8	954.2	1178.4	
Jan. 1 1896					77.5	147.9	272.3	470.4	702.9	969.6		
Jan. 1 1901				37.6	72.4	142.3	280.0	448.9	626.5			
Jan. 1 1906			14.2	28.8	60.7	131.0	244.2	356.9				
Jan. 1 1911		6.5	10.3	22.4	54.0	110.4	185.9					
Jan. 1 1916	3.8	4.3	9.1	21.9	50.1	91.2						
Jan. 1 1921	1.5	3.2	7.5	19.2	40.3							
Jan. 1 1926	1.4	2.9	7.7	16.8								
Jan. 1 1931	1.2	3.5	6.0									
Jan. 1 1936	1.7	3.2										
Jan. 1 1940	1.6											

TABLE 4.W

Female death rates per 100,000 per annum from bronchitis 1946 to 1967 (ICD 406, 5th rev., ICD 500-502, 6th & 7th revs.), and from bronchitis, emphysema and asthma from 1968 (ICD 490-493, 8th rev.) in England and Wales on a temporal basis and a cohort basis

	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Temporal basis												
Period covered												
1946-50	2.8	4.1	6.6	10.4	18.8	34.1	63.7	118.4	232.3	428.8	717.7	1261.9
1951-55	1.3	2.6	3.8	7.6	13.6	29.3	56.5	110.1	196.2	369.2	640.5	1263.9
1956-60	1.3	2.0	3.9	6.8	11.7	23.7	47.8	83.3	149.0	257.4	429.7	784.9
1961-65	0.8	2.1	4.2	7.8	13.5	23.0	46.9	82.1	147.3	250.8	398.1	683.5
1966-67	0.9	1.8	3.7	7.1	13.5	23.6	37.8	72.1	124.5	201.4	310.4	562.3
1968-70	1.8	3.5	6.1	10.8	19.2	29.4	46.5	81.6	128.0	190.0	281.9	505.5
1971-73	1.7	3.0	4.6	10.5	17.4	27.3	43.5	65.8	103.7	165.0	246.0	392.5

Note: Broken lines denote breaks in comparability due to changes in official definitions of disease.

Cohort basis												
Central date of birth												
Jan. 1 1861												1261.9
Jan. 1 1866											717.7	1263.9
Jan. 1 1871										428.8	640.5	784.9
Jan. 1 1876									232.3	369.2	429.7	683.5
Jan. 1 1881								118.4	196.2	257.4	398.1	515.5
Jan. 1 1886							63.7	110.1	149.0	250.8	292.9	392.5
Jan. 1 1891						34.1	56.5	83.3	147.3	194.7	246.0	
Jan. 1 1896					18.8	29.3	47.8	82.1	126.8	165.0		
Jan. 1 1901				10.4	13.6	23.7	46.9	77.9	103.7			
Jan. 1 1906			6.6	7.6	11.7	23.0	43.0	65.8				
Jan. 1 1911		4.1	3.8	6.8	13.5	27.1	43.5					
Jan. 1 1916	2.8	2.6	3.9	7.8	16.8	27.3						
Jan. 1 1921	1.3	2.0	4.2	9.3	17.4							
Jan. 1 1926	1.3	2.1	5.1	10.5								
Jan. 1 1931	0.8	2.8	4.6									
Jan. 1 1936	1.5	3.0										
Jan. 1 1940	1.7											

3. Estimates of cumulative constant tar cigarette consumption per adult

3.1 The purpose of this section is to provide estimates of the cumulative constant tar cigarette consumption (CCTCC) by cohorts of men born after 1830 and of women after 1855, and to consider these estimates in relation to the death rates given in section 2. As explained in Smoking Patterns, "constant tar cigarettes" are the number of cigarettes which would have been smoked if smokers had drawn the same total weight of particulate matter (i.e. tar) into their mouths as they had obtained from the cigarettes actually smoked but had been smoking cigarettes which were the same as the average cigarette smoked in 1965.

3.2 As the cigarette consumption of successive cohorts of men and women was not observed at the time, the estimates of consumption are an exercise in historical reconstruction. While they are based on what are thought to be the most probable assumptions, the estimates inevitably contain areas of uncertainty: the procedure has therefore been described in some detail here and in Appendix B. In particular, two basic assumptions have been made.

Basic assumptions

3.3 The first basic assumption is that, before 1935, the age distribution of cigarette smokers of each sex was similar to that of the same sex in 1935-39. The second assumption is that the average amount of tar delivered per cigarette in each year prior to 1965 was the same as in 1965.

3.4 This first assumption has the effect of freezing the age-distribution of smokers in each sex. Consequently, as reported in paragraph A.4 of Smoking Patterns, if a surge in consumption had been working its way through first the youngest and next the middle age groups - as may have happened when women first started to smoke - this would not show up in the consumption estimates which have been made for the different age groups in successive years. On the other hand, errors of this nature are likely to have been largest when consumption levels were lowest. In consequence, the CCTCC estimates are still likely to provide a reasonable representation of the ways in which cumulative cigarette consumption by successive cohorts has changed. Further, from 1935 onwards the CCTCC estimate for each cohort will tend more

and more to be dominated by components of consumption from more recent years where knowledge of the age-distribution is more reliable.

3.5 The second assumption, namely that the average amount of tar delivered per cigarette in each year prior to 1965 was the same as in 1965, is based on three observations. Firstly, as Table B.4 shows, the average weight of British cigarettes remained approximately unchanged from 1920 to 1935. Secondly, some evidence is available from surveys of butt lengths left by smokers, although back only as far as 1958, which showed that there had been no significant change in the proportion of each cigarette smoked by the average smoker over the years. Thirdly, it was a major objective of the cigarette manufacturers to meet in as unchanged form as practicable the precise types of demand which cigarette smokers had long established. Although the yield per acre of U.S. flue-cured tobacco, which has been the main constituent of British cigarettes, increased from 856 lbs. in 1934-39 to 2,211 lbs. in 1964 causing the "body" and weight of individual leaves to decline, the resultant reduction in tar delivery per leaf would have been compensated to some extent by the increase in the number of leaves required to make up a given weight of tobacco. Nor is the fact that, after 1955, the demand for filter cigarettes began to become significant (the proportion which filter cigarettes formed of total sales increased from 2% in 1955 to 53% in 1965) likely to have made our assumption seriously inaccurate, as the effect of filters on tar delivery did not become marked until after 1965.

3.6 Estimates of cumulative constant tar cigarette consumption (CCTCC) on the two assumptions described are given in tables 5.M and 5.W. The principal conclusion which emerges from a comparison of CCTCC and the lung cancer death rates of men in table 1.M is that in several age groups there were some later cohorts which had greater CCTCC than the cohort with the highest lung cancer rate. The following table gives for each age group the cohort or cohorts which had CCTCC greater than or equal to that of the cohort with the highest lung cancer rate. The cohort with the greatest CCTCC at each age is underlined:

Table 6

Age group	Male cohort which had the highest lung cancer rate for this age	Male cohorts which had CCTCC greater than or equal to that of the cohort with the highest lung cancer rate
30-34	1916	1921
35-39	1916	1921, 1926
40-44	1916	1921
45-49	1911	1916, 1921
50-54	1906	1911, 1916, 1921
55-59	1901	1906, 1911, 1916

3.7 It is natural to ask what changes in the basis of estimating the tar deliveries of cigarettes prior to 1965 would be required in order to cause the peak levels of CCTCC and of the lung cancer death rates to be reached in the same cohort, and whether these changes would be large. Assumptions about pre-1965 tar deliveries which might bring about this synchronization of CCTCC and lung cancer death rates for at least some ages are, for convenience, termed "the synchronization assumptions", and while many such assumptions are possible, two in particular are considered here.

Synchronization assumptions

3.8 Table 7 gives for six periods of time, namely, up to 1929, 1930-39, 1940-49, 1950-59, 1960-64 and 1965 onwards, three alternative sets of tar indices. The first of these is the one we have used for our main conclusions and is based on the second of the two basic assumptions (described in paragraph 3.5). The other two represent alternatives based on assuming that tar yields in earlier years were higher than in 1965. We have not considered alternatives in which they were lower in early years as it is clear that these would have the effect of moving the peaks of CCTCC and lung cancer apart. Nor have we considered alternatives in which there was a short period of high tar rather than a trend as such a period would contribute approximately equally to each cohort passing through it

and affect the position of the peaks very little.

Table 7

Alternative tar indices

Assumption	Up to 1929	1930-39	1940-49	1950-59	1960-64	1965 Onwards
2nd basic assumption	100	100	100	100	100	As table B.2
Synchronization assumption I	110	110	105	100	100	As table B.2
Synchronization assumption II	150	140	130	120	110	As table B.2

A relatively small increase in tar deliveries above those in the basic assumption, such as those given in synchronization assumption I in table 7, would cause the peaks in CCTCC at ages 30-34, 35-39 and 40-44 to occur in the 1916 cohorts of men instead of in the 1921 cohorts, and thereby to coincide with the lung cancer peaks. Rather larger increases in the assumed tar deliveries in earlier years would be necessary to cause synchronization of the CCTCC and lung cancer peaks in men aged 45-49. On the other hand, not even relatively extreme assumptions about the level of earlier tar deliveries per cigarette, such as those given in synchronization assumption II in table 7 (which assumes that tar deliveries would have been 50% higher prior to 1930 than we have estimated) would cause the peaks in CCTCC and lung cancer at ages 50-54 and 55-59 to coincide. The conclusion that the cohorts with peak CCTCC were born later than the cohorts with peak lung cancer rates seems therefore to be soundly based, especially when ages of 50-59 are considered.

3.9 Like the male lung cancer death rates, male bronchitis death rates in each age group (table 4.M) reached a peak in a cohort born earlier than the cohort in which CCTCC reached a peak. The following table gives for each age group the cohort or cohorts which had CCTCC greater than or equal to that of the cohort with the highest bronchitis rate. The cohort with the greatest CCTCC at each age is underlined:

Table 8

Age group	Male cohort which had the highest bronchitis rate for this age	Male cohorts which had CCTCC greater than or equal to that of the cohort with the highest bronchitis rate
30-34	1916	1921
35-39	1911	1916, 1921, 1926
40-44	1906	1911, 1916, 1921, 1926
45-49	1901	1906, 1911, 1916, 1921, 1926
50-54	1896	1901, 1906, 1911, 1916, 1921
55-59	1896	1901, 1906, 1911, 1916
60-64	1901	1906, 1911
65-69	1896	1901, 1906

There are no plausible assumptions about tar deliveries in years prior to 1965 which would cause the peaks in CCTCC for the age groups 40-59 to occur in the same cohorts as those in which the bronchitis death rates reached their peak.

Interpretation of the evidence

3.10 There are some points which should be borne in mind when interpreting the cohort evidence on smoking and death rates, though they do not affect the conclusions reached in paragraphs 3.8 and 3.9.

3.11 Firstly, where the peak level of consumption up to a particular age by a cohort has not greatly exceeded the consumption by adjacent cohorts, there is doubt as to the precise cohort in which cigarette consumption by that age had reached its peak. This is because the two assumptions described may not have been wholly accurate. There is thus some doubt whether CCTCC by the 50-54 age group reached its peak in the 1911 or 1916 cohort.

3.12 Secondly, it is necessary to bear in mind that successive cohorts may have been subject, at the same ages, to different standards of diagnosis. Consequently, where a peak lung cancer death rate did not greatly exceed the rates in later years, there may be some doubt as to the actual year in which the peak was reached. In the 50-54 age group of men for example, the highest lung cancer death rates for the 1901, 1906 and 1911 cohorts were within about 2% of

each other. The effect of improved standards of diagnosis, however, is to increase the death rates of later years relatively to those of earlier years so that, on a comparable basis, rates for earlier years tend to be under-stated.

3.13 The third problem of interpretation lies in the fact that CCTCC estimates by cohorts in tables 5.M and 5.W represent arithmetic totals of cigarette consumption, on a constant tar basis, over periods in which individual durations of the smoking habit may have varied. Papers by Armitage, Doll, Lee, Peto and others in recent years have shown that data relating to cancer, particularly lung cancer in men and skin cancer in laboratory animals induced by cigarette smoke condensate, can be explained by multi-stage models which are basically similar in principle. In all these models, the contribution of the carcinogen to the risk of cancer takes the form of a function which depends non-linearly on the duration of exposure to the carcinogen. In particular, Peto et al. (1975) have quoted figures which showed that, under certain assumptions, "lung cancer incidence rates are proportional to the fourth power of duration of smoking". This would imply that a person who had smoked a given daily amount for a given length of time would be at much more than twice the risk of lung cancer of a smoker who had smoked the same amount for half that length of time although the CCTCC estimate of the former would be only double that of the latter. Nevertheless, CCTCC is a useful statistic when applied to cohorts of men or women who have been smoking since age 16. (Cigarettes smoked by children have been excluded from the estimates made in this paper.)

TABLE 5.M

Cumulative cigarette consumption on constant tar basis (CCTCC) in thousands of cigarettes by cohorts of men, 1831-1956

Central date of birth	Age 15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Jan. 1 1831											1	1	2	4
Jan. 1 1836										1	2	3	5	7
Jan. 1 1841									1	3	5	7	10	12
Jan. 1 1846								1	3	7	10	13	16	18
Jan. 1 1851							1	3	8	12	17	21	25	27
Jan. 1 1856						1	3	8	14	21	27	31	35	38
Jan. 1 1861					1	3	8	14	23	32	39	44	48	52
Jan. 1 1866				1	4	8	15	24	35	45	53	58	64	69
Jan. 1 1871			1	4	9	15	25	37	48	60	69	76	82	86
Jan. 1 1876		1	3	9	16	25	37	50	64	77	88	96	102	107
Jan. 1 1881		2	7	15	25	37	49	64	80	97	110	117	124	130
Jan. 1 1886		4	11	22	35	48	63	80	101	120	131	140	148	154
Jan. 1 1891	1	6	16	30	44	59	76	98	122	139	152	163	171	176
Jan. 1 1896	1	8	21	36	52	70	92	117	138	156	172	182	188	
Jan. 1 1901	2	11	24	42	61	83	108	130	152	171	185	193		
Jan. 1 1906	2	11	28	48	71	97	119	142	164	180	191			
Jan. 1 1911	2	13	32	56	81	103	127	150	168	180				
Jan. 1 1916	3	16	38	62	83	107	131	150	164					
Jan. 1 1921	3	19	41	62	85	109	129	144						
Jan. 1 1926	4	20	39	61	83	104	119							
Jan. 1 1931	4	17	37	57	77	92								
Jan. 1 1936	3	17	38	56	71									
Jan. 1 1941	4	21	41	56										
Jan. 1 1946	5	21	36											
Jan. 1 1951	4	17												
Jan. 1 1956	3													

TABLE 5.W

Cumulative cigarette consumption on constant tar basis (CCTCC) in thousands of cigarettes by cohorts of women, 1856-1956

Central date of birth	Age													
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
Jan. 1 1856														1
Jan. 1 1861												1	1	1
Jan. 1 1866											1	1	2	3
Jan. 1 1871									1	1	2	3	4	5
Jan. 1 1876								1	2	3	5	7	8	9
Jan. 1 1881							1	2	4	7	10	12	13	14
Jan. 1 1886						1	2	5	8	12	15	18	20	21
Jan. 1 1891					1	2	5	9	14	18	22	25	27	28
Jan. 1 1896				1	2	5	10	16	21	26	31	34	36	
Jan. 1 1901			1	2	4	9	17	23	30	36	41	44		
Jan. 1 1906			1	3	8	16	23	32	40	47	52			
Jan. 1 1911		1	2	8	15	22	33	43	53	59				
Jan. 1 1916		1	6	14	22	32	44	56	64					
Jan. 1 1921		4	11	19	29	41	54	64						
Jan. 1 1926	1	6	13	23	35	47	58							
Jan. 1 1931	1	6	14	24	36	46								
Jan. 1 1936	1	6	16	27	38									
Jan. 1 1941	1	9	20	29										
Jan. 1 1946	2	11	21											
Jan. 1 1951	2	11												
Jan. 1 1956	3													

Appendix A

Classification of deaths by Registrar General of England and Wales

A.1 The underlying cause of death is classified by the Registrar General according to the International Statistical Classification of Diseases. The last condition mentioned in section I of the British death certificate, which initiated the train of events leading to the fatal outcome, is accepted as the underlying cause of death unless coding rules alter this. The comparability of the death rates of successive cohorts over the periods covered in this paper may have been interrupted by changes in definitions of the diseases whenever a new revision of the International Statistical Classification of Diseases was introduced. The 5th revision of I.C.D. completed in 1938 was adopted in the Statistical Review of the Registrar General of England and Wales from 1940, the 6th revision completed in 1948 was adopted from 1950, the 7th revision completed in 1955 was adopted from 1958 and the 8th revision completed in 1965 was adopted from 1968. The introduction of the 6th revision in 1950 made a number of changes in the official definitions of the diseases covered in the present paper, and the death rates for 1946-50 from heart disease, stroke and bronchitis were consequently not strictly comparable with later figures. The changes introduced in the 7th revision in 1958, on the other hand, were very slight, so that the death rates from 1950 to 1967 were closely comparable. The changes made in the 8th revision, introduced in 1968, were again considerable. The Registrar General has provided formulae (Part III, Commentary, of the Registrar General's Statistical Review of England and Wales for 1967) whereby deaths classified under the 7th and 8th revisions of I.C.D. can be made more comparable. The same formulae, however, is provided for all age groups in respect of each cause of death whereas comparison of the deaths before and after the 8th revision suggest that at least in deaths from bronchitis, different conversion factors are required for older and younger age groups.

A.2 The death rates of the cohorts in tables 1.M and W to tables 4.M and W are arranged so that the death rates at successive ages of the same cohort

are on the same line. Consequently, the death rates at different ages for the same period of five years (e.g. 1951-55) are to be found in the appropriate ascending diagonal. This can be seen more clearly in tables 3.M and W and 4.M and W, where the death rates are given on both a cohort basis and a temporal (usually 5-year) basis. The death rates by cohorts in tables 1.M onwards are based on the death rates for five years except for the last figure in each line, which is based on three years only (namely, 1971-73). The first death rate figure for each age group in the cohort table is based on the death rates for 1911-15 for lung cancer, on those for 1946-50 for stroke and bronchitis, and those for 1951-55 for heart disease. The central years of birth of each cohort are five years apart, except for the last cohort born around January 1st, 1940, which was only four years later than the preceding cohort, born around January 1st, 1936. The year 1936 was central to the five years 1934-38, whereas 1940 was central to the three years 1939-41.

A.3 The lung cancer death rates in tables 1.M and W are those classified under I.C.D. 162-164 of the International Classification of Diseases for the years 1950-67 and under I.C.D. 162-163 thereafter. The death rates in tables 1.M and W for the six five year periods from 1911-15 to 1936-40 are those published by Case and Pearson (1957). The death rates for the last six periods from 1941-45 to 1966-70, have been obtained from O.P.C.S. Study No. 29, Cancer Mortality, England and Wales, 1911-70. A major change of definition took place from 1968, when deaths from malignant neoplasms of the lung, unspecified as to whether primary or secondary, were transferred from I.C.D. 163 to 162, and I.C.D. 164 (malignant neoplasms of the mediastinum) was transferred to 163, but there has been little change in the coverage of I.C.D. 162-164 combined since 1950. The full definition of the figures in tables 1.M and W since 1968 has been death rates from malignant neoplasms of the trachea, bronchus, lung and other respiratory organs, whether the disease was primary, secondary or unspecified. The "other" respiratory organs are the pleura, mediastinum or unspecified respiratory sites.

greatest changes in the definitions of the diseases covered by is paper made by the revisions to the International Classification Diseases were in the definitions of heart disease. Heart disease as defined by I.C.D. 94 of the 5th revision, introduced in England and Wales in 1940, as diseases of the coronary arteries and angina pectoris. This definition was changed in 1950, when the 6th revision of I.C.D. was introduced, to arteriosclerotic heart disease including coronary disease (I.C.D. 420 of the 6th revision). In addition, there were I.C.D. 421 ("chronic endocarditis not specified as rheumatic") and 422 ("other myocardial degeneration"). This last was sub-divided into 422.0 ("fatty degeneration"), 422.1 ("with arteriosclerosis") and 422.2 ("other diseases included under 422"). The same classifications were continued in the 7th revision of I.C.D. When the 8th revision was introduced in 1968, further extensive changes were made in the official definitions of heart disease. I.C.D. 420 of the 6th and 7th revisions was re-distributed among the new I.C.D. 410 ("acute myocardial infarction"), 411 ("other acute and sub-acute forms of ischaemic heart disease"), 412 ("chronic ischaemic heart disease"), 413("angina pectoris") and 414 ("asymptomatic ischaemic heart disease" - for which no deaths are recorded in England and Wales). The combined totals of I.C.D. 410-414 currently represent deaths from ischaemic heart disease. The problem of maintaining continuing comparability of the heart disease death rates was thus difficult, but the problem was largely solved when Wald (1976), referring to unpublished work by J.I. Mann, pointed out that I.C.D. 420 and 422.1 of the 7th revision of I.C.D. together closely matched 410-414 of the 8th revision (ischaemic heart disease). In 1967, 5,288 male deaths and 9,342 female deaths were recorded under I.C.D. 422.1 of the 7th revision, and these formed respectively 49.5% of the male deaths and 46.9% of the female deaths recorded under I.C.D. 422 in 1967. When the Registrar General (in Statistical Review, 1967, Commentary, p. 295) analysed the changes effected by the 8th revision of I.C.D. he estimated that 44.3% of male deaths and 42.1% of female deaths included in 1967 under 422 of 7th revision would have been included under I.C.D. 410-414 of the 8th revision. The closeness of the two sets of percentages suggest that I.C.D. 422.1 of the 7th revision should, as Wald has stated, be regarded as having been included in 410-414 of the 8th revision. The

figures further suggested that deaths which would have been classified under I.C.D. 420 and 422.1 of the 7th revision together formed a very large proportion of the deaths recorded under 410-414 of the 8th revision. The relevant figures are given in tables A.4M & W.

A.5 The case for combining I.C.D. 420 and 422.1 for the period 1950-67 is strengthened by two further considerations. Firstly, as age increased the deaths recorded under I.C.D. 422.1 increased more rapidly than those recorded under 420, and for the years 1951-60, the numbers of deaths of men and women aged 85+ recorded under 422.1 exceeded those recorded under 420. Secondly, during the period 1951-67, the death rates from diseases recorded under I.C.D. 422.1 declined sharply in both sexes at almost all ages. In most age groups, the reduction between 1951-55 and 1966-67 was at least 50% and in the 60-69 age groups it was 70%. This suggests that many deaths which would have been recorded under I.C.D. 422.1 in the early part of the period 1951-67 were increasingly recorded under 420 in later years, and that the increasing death rates reported from forms of heart disease recorded under 420 during this period were to some extent a statistical artefact. It was therefore decided to define deaths from heart disease in the main tables (namely, tables 2.M & W) of this paper for the years 1951-67 as being the deaths under I.C.D. 420 and 422.1 combined. This procedure, however, has increased the break in continuity of the heart disease death rates at 1950, and figures prior to 1951 have therefore been omitted from tables 2.M & W.

A.6 The definition of stroke has also undergone several changes. Under I.C.D. 83 of the 5th revision introduced in 1940, the disease was defined as intracranial lesions of vascular origin, and the death rates of the years 1946-49 are based on this definition. In the 6th revision introduced in 1950, the definition was enlarged to vascular lesions affecting the central nervous system and became I.C.D. 330-334. The definitions and the I.C.D. numbers were not changed in the 7th revision but with the introduction of the 8th revision in 1968, the official definition was altered to cerebrovascular disease, I.C.D. 430-438. These changes, however, appear to have had only minor effect on the continuity of the death rates. The Registrar General provided factors in 1967 for converting

deaths on the old definition to deaths on the new definition. It has been thought preferable to adopt a different procedure in this paper. It has been decided to accept the breaks in the continuity of the death rates in 1950 and 1968, and consequently the average death rates have been presented on a temporal basis for 5-year or shorter durations for three discrete periods (in tables 3.M & W). On the other hand, the death rates of the different cohorts are those which were actually recorded on the basis of the definitions in operation in the years concerned.

A.7 The death rates from bronchitis for 1946-49 in tables 4.M & W are based on the definitions of bronchitis contained in I.C.D. 406 of the 5th revision of I.C.D. introduced in England and Wales in 1940. The disease was reclassified under I.C.D. 500-502 when the 6th revision was introduced in 1950. This change appears to have had relatively little effect on the comparability of the bronchitis death rates. The 7th revision of the I.C.D. left the definition of bronchitis unchanged. The 8th revision, introduced in 1968, widened the definition of the disease to include emphysema without bronchitis and asthma in I.C.D. 490-493, which currently therefore covers bronchitis, emphysema and asthma. As with the death rates from stroke, it has been thought preferable, with these changes of definition, to present the death rates from bronchitis in tables 4.M & W, on both a temporal and a cohort basis, and in the former to present the figures in three discrete periods of comparability.

TABLE A.1

England and Wales; Mean numbers of deaths per annum from arteriosclerotic heart disease including coronary disease, and from other myocardial degeneration with arteriosclerosis, 1950-1967; and from ischaemic heart disease from 1968

Sex and years covered	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Males												
1951-55	102.4	273.4	734.8	1671.8	3049.6	4237.0	6070.0	7993.8	9254.6	9036.2	6124.6	3475.8
1956-60	134.2	420.8	891.4	2042.4	3877.6	5913.4	7242.0	8976.0	10217.4	9671.0	7010.2	4237.6
1961-65	145.8	540.0	1274.6	2359.8	4556.4	7369.0	9983.6	10705.8	11422.6	10417.8	7610.0	5170.2
1966-70	152.8	498.2	1405.8	2906.0	4588.0	7912.4	11165.8	13241.4	12396.4	10799.8	7654.0	5650.2
1971-73	161.0	507.7	1385.7	3168.3	5291.7	7804.7	11770.3	15094.7	14659.0	11722.0	8172.3	6088.0
Females												
1951-55	16.6	40.0	111.8	282.6	623.6	1295.8	2604.6	4742.0	7091.4	8454.2	7230.4	6076.8
1956-60	22.2	46.8	127.4	316.8	703.6	1505.6	2994.8	5222.8	7979.4	9816.6	8810.6	7605.4
1961-65	23.6	68.6	184.4	365.4	806.2	1799.8	3563.8	5995.8	9001.4	10963.2	10431.6	9804.2
1966-70	26.4	78.0	214.6	436.0	855.8	1871.6	3847.2	6535.0	9416.0	11351.6	11057.4	11530.6
1971-73	29.3	68.0	215.3	507.3	1011.3	1933.3	4021.0	6941.3	10265.0	12371.0	12122.0	13508.7

TABLE A.2

England and Wales; Mean numbers of deaths per annum from intracranial lesions of vascular origin 1946-49, from vascular lesions affecting central nervous system, 1950-67; and from cerebrovascular disease, 1968-73

Sex and years covered	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Males												
1946-50	48.2	90.0	202.0	424.2	794.6	1407.4	2522.2	3812.0	5127.8	4970.4	3268.0	1672.2
1951-55	77.8	120.0	247.8	528.0	1004.4	1561.2	2706.4	4161.6	5673.8	6300.0	4599.0	2512.2
1956-60	71.2	133.4	233.6	504.2	994.4	1774.0	2693.4	4049.8	5541.0	6385.0	5239.0	3207.8
1961-65	72.0	123.2	248.4	440.8	912.0	1760.4	2926.4	4060.2	5402.6	6084.0	5240.2	3896.0
1966-67	76.0	132.5	247.0	426.0	860.0	1632.5	2907.0	4204.0	5323.0	5859.5	5095.0	4310.0
(1966-70)	(70.2)	(125.6)	(235.0)	(467.2)	(816.4)	(1625.8)	(2875.8)	(4377.2)	(5306.8)	(5838.8)	(5059.2)	(4320.6)
1968-70	66.3	121.0	227.0	494.7	787.3	1621.3	2855.0	4492.7	5296.0	5825.0	5035.3	4327.7
1971-73	69.7	114.0	209.0	458.0	802.0	1400.0	2680.0	4464.7	5678.7	5693.0	5125.7	4480.7
Females												
1946-50	51.6	114.4	239.0	573.6	1110.2	1732.4	2895.2	4555.6	6434.0	6940.2	5289.0	3631.4
1951-55	76.8	126.6	285.0	636.4	1216.4	1850.2	2967.8	4868.2	7326.8	8767.0	7204.8	5302.2
1956-60	68.8	144.8	256.6	550.8	1069.4	1712.6	2810.2	4606.4	7301.2	9606.2	8884.8	7072.2
1961-65	65.6	118.8	249.8	472.0	913.0	1513.6	2635.8	4337.4	7113.2	9562.4	9903.0	9265.0
1966-67	66.0	126.5	229.5	441.5	837.5	1379.0	2494.0	4175.0	6733.0	9316.0	10078.0	10784.5
(1966-70)	(62.4)	(123.4)	(234.0)	(480.6)	(776.6)	(1335.2)	(2434.0)	(4137.4)	(6773.4)	(9464.0)	(10373.4)	(11519.2)
1968-70	60.0	121.3	237.0	506.7	736.0	1306.0	2394.0	4112.3	6800.3	9562.7	10570.3	12009.0
1971-73	63.3	107.7	225.0	417.3	725.7	1169.0	2149.0	3931.7	6743.0	9545.3	10873.3	13446.3

TABLE A.3

England and Wales; Mean numbers of deaths per annum from bronchitis 1946-67 and from bronchitis, emphysema and asthma 1968-73

Sex and years covered	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Males												
1946-50	58.6	110.8	235.4	550.0	941.4	1573.6	2478.4	2787.8	2849.6	2581.0	1741.6	1081.2
1951-55	25.4	64.4	172.0	466.8	1015.6	1683,6	2570.6	3272.8	3401.0	3029.8	2013.4	1205.8
1956-60	22.0	53.4	134.4	362.2	937.6	1871.4	2734.0	3351.6	3603.4	3107.0	2005.6	1175.6
1961-65	19.0	45.8	125.8	322.2	838.2	1890.8	3339.2	3929.8	4104.8	3711.0	2416.8	1500.4
1966-67	19.0	44.0	108.5	277.5	726.0	1615.0	3058.5	4083.0	4082.5	3591.5	2393.5	1474.5
(1966-70)	(25.8)	(53.8)	(118.8)	(312.6)	(707.2)	(1610.2)	(3157.0)	(4449.0)	(4435.8)	(3809.0)	(2497.8)	(1558.8)
1968-70	30.3	60.3	125.7	336.0	694.7	1607.0	3222.7	4693.0	4671.3	3954.0	2567.3	1615.0
1971-73	24.0	45.0	86.7	253.7	594.7	1263.0	2460.3	3812.0	4441.3	3834.7	2527.7	1651.7
Females												
1946-50	43.4	70.6	110.6	164.0	268.8	444.2	744.4	1194.4	1814.2	2169.6	1901.8	1703.6
1951-55	22.6	40.0	63.8	126.0	207.4	401.2	693.6	1165.8	1691.2	2178.4	1915.0	1769.4
1956-60	20.2	34.4	59.8	112.2	190.4	350.2	623.8	931.8	1356.2	1685.8	1581.2	1475.6
1961-65	12.2	32.8	69.2	118.8	221.0	359.2	654.6	977.0	1416.6	1756.4	1636.0	1569.4
1966-67	13.0	27.0	58.0	111.5	214.0	375.0	553.5	901.5	1260.0	1485.5	1390.5	1398.0
(1966-70)	(21.0)	(40.4)	(78.2)	(153.4)	(249.4)	(430.4)	(638.2)	(998.0)	(1310.4)	(1467.0)	(1360.0)	(1418.2)
1968-70	26.3	49.3	91.7	181.3	273.0	467.3	694.7	1062.3	1344.0	1454.7	1339.7	1431.7
1971-73	23.7	41.0	67.0	159.3	269.3	406.0	652.0	885.3	1143.7	1261.3	1178.7	1256.7

TABLE A.4M

England and Wales: Male death rates per 100,000 from heart disease

(a) 1951-67, from arteriosclerotic heart disease including coronary disease (ICD 420, 6th & 7th revs.)
(b) 1951-67, from other myocardial degeneration with arteriosclerosis (ICD 422.1, 6th & 7th revs.)
(c) 1951-67, from (a) and (b) combined
(d) 1968-73, from ischaemic heart disease (ICD 410-414, 8th rev.)

Period covered	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
(a)												
1951-55	6.1	18.1	43.8	101.7	213.0	358.2	587.0	890.4	1230.4	1579.6	1802.4	2058.8
1956-60	8.7	25.5	59.9	125.3	248.4	441.4	693.3	1039.1	1464.4	1878.0	2288.7	2358.2
1961-65	9.5	34.4	76.2	159.9	291.7	505.2	820.0	1225.1	1715.7	2275.9	2800.1	3387.1
1966-67	10.1	33.8	88.4	171.3	303.6	523.2	835.2	1255.0	1764.9	2328.9	2941.9	3724.2
(b)												
1951-55	-	0.1	0.4	1.4	4.3	14.1	47.2	129.2	343.5	798.4	1581.3	3207.6
1956-60	-	0.1	0.3	0.8	2.7	8.3	28.0	82.9	250.0	589.1	1288.0	2427.3
1961-65	-	0.1	0.3	0.7	1.8	5.4	17.3	56.5	164.9	415.3	976.6	2095.7
1966-67	-	0.1	0.3	0.9	1.4	3.9	12.6	38.6	122.7	305.3	671.2	1656.1
(c)												
1951-55	6.1	18.2	44.2	106.1	217.3	372.3	634.2	1019.6	1573.9	2378.0	3383.7	5266.4
1956-60	8.7	25.6	60.2	126.1	251.1	449.7	721.3	1122.0	1714.4	2467.1	3576.7	4815.5
1961-65	9.5	34.5	76.5	160.6	293.5	510.6	837.3	1281.6	1880.6	2691.2	3776.7	5482.8
1966-67	10.1	33.9	88.7	172.2	305.0	527.1	847.8	1293.6	1887.6	2634.2	3613.1	5380.3
(d)												
1968-70	10.1	32.3	91.9	184.3	337.0	551.1	873.1	1363.0	1988.3	2743.6	3732.4	5680.4
1971-73	10.9	35.7	95.1	210.3	358.5	563.6	889.5	1413.2	2067.9	2963.8	3809.9	5637.0

TABLE A.4W

England and Wales: Female death rates per 100,000 from heart disease

(a) 1951-67, from arteriosclerotic heart disease including coronary disease (ICD 420, 6th & 7th revs.)
(b) 1951-67, from other myocardial degeneration with arteriosclerosis (ICD 422.1, 6th & 7th revs.)
(c) 1951-67, from (a) and (b) combined
(d) 1968-73, from ischaemic heart disease (ICD 410-414, 8th rev.)

Period covered	Age at death											
	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
(a)												
1951-55	0.9	2.5	6.3	16.2	37.9	86.1	183.3	362.2	581.4	838.7	1111.1	1368.1
1956-60	1.4	2.8	8.2	18.7	42.1	97.0	211.9	412.6	705.3	1037.8	1350.1	1656.1
1961-65	1.6	4.4	11.0	23.6	48.2	112.0	243.8	468.9	816.6	1233.3	1720.8	2270.6
1966-67	2.0	4.9	12.5	25.6	52.1	115.6	247.1	477.6	823.3	1258.8	1795.3	2532.1
(b)												
1951-55	-	0.1	0.3	0.8	2.8	8.6	20.0	85.6	241.2	594.1	1307.1	2972.4
1956-60	-	-	0.1	0.4	1.3	4.8	17.8	64.6	171.6	460.9	1044.1	2389.4
1961-65	-	-	0.1	0.4	1.0	3.1	11.5	37.4	119.4	332.4	817.3	1999.6
1966-67	-	-	0.1	0.4	0.7	1.9	9.0	22.7	81.3	230.3	594.2	1564.0
(c)												
1951-55	0.9	2.6	6.6	17.0	40.7	94.7	212.3	447.8	822.6	1432.9	2418.2	4340.5
1956-60	1.4	2.8	8.3	19.1	43.4	101.8	229.7	467.2	876.9	1498.7	2394.2	4045.5
1961-65	1.6	4.4	11.1	24.0	49.2	115.1	255.3	506.3	936.0	1565.7	2538.1	4270.2
1966-67	2.0	4.9	12.6	26.0	52.8	117.5	256.1	500.3	904.6	1489.1	2389.5	4096.1
(d)												
1968-70	1.7	5.8	15.2	27.1	60.9	118.1	261.9	516.8	913.3	1514.3	2376.0	4224.2
1971-73	2.1	4.9	14.9	33.3	65.4	129.8	268.0	516.2	930.5	1618.4	2529.6	4218.8

Appendix B

Cigarette consumption estimates

Method of estimating cigarette consumption by age group in each year

B.1 The method used to estimate cigarette consumption per adult male and female for each five year age group in each year during the period 1935-72, when survey-based figures were not available, has been described in Smoking Patterns. For convenience it is re-stated in the paragraphs which follow.

B.2 The first step was to estimate the missing consumption per head figures for 1946 and for 1948 onwards by assuming that the ratio of the cigarette consumption of a five year age group to a broader age group enclosing it in any year was the same as the ratio which later existed in 1966-72. For example, consumption by men in the broad age group 35-49 was known for the years 1956-65. It was assumed, therefore, that the levels of cigarette consumption per adult male for the 35-39, 40-44, 45-49 age groups of the 35-49 age group during the years 1956-65 bore the same ratio to each other as they later bore during 1966-72.

B.3 Estimates of the numbers of manufactured cigarettes smoked per adult male and female by the age groups 16-19, 20-24, 25-29, 30-34, 35-59 and 60+ during the years 1935-45 and 1947 had been prepared by D.H. Beese in 1958. These estimates were therefore extended using this constant ratio assumption. Estimates were given in Smoking Patterns of the cigarette consumption per adult for each five year age group of men and women for each year from 1935-1972.

B.4 In order to produce the figures required in Smoking Patterns, it had been necessary also to estimate the number of cigarettes smoked per head per year from age 16 onwards during the years before 1935 by men born in 1900 and by men and women born in 1910. For this purpose, it was assumed that consumption per adult by the age group concerned bore the same ratio to consumption per adult for all age groups aged 15+ in the years prior to 1935 as they bore during 1935-39. Estimates of consumption by men and women separately aged 15 and over from 1920 onwards are shown in Statistics of Smoking in the United Kingdom.

B.5 For the years before 1920, when estimates of the weight of tobacco smoked in the form of cigarettes, but not the number of cigarettes, were available it was assumed that during the years 1905-1919 the weight of tobacco per 1,000 cigarettes sold in the U.K. would have averaged about 2.2 lbs in each year. This figure was therefore used in Smoking Patterns to convert the estimates in weight to number of cigarettes back to 1905. The numbers of cigarettes so obtained were then divided by the U.K. adult male population. Since women did not start smoking manufactured cigarettes in significant quantities until 1921, it could be assumed that all the cigarettes consumed before this year were smoked by men.

B.6 For the purposes of the present paper it was necessary to extend the estimates of the numbers of cigarettes smoked from 1905 back to 1888 when men first started to smoke manufactured cigarettes in quantities which exceeded 100,000 lbs per annum. It was again assumed that the weight of tobacco per 1,000 cigarettes averaged 2.2 lbs in each year. The estimates of the total number of cigarettes consumed were then divided by the U.K. male population aged 15 and over in each year.

B.7 It was further assumed that, for any year before 1935, a reasonable estimate of consumption per head by each age group could be obtained by applying to the total consumption for that year the proportion which consumption by each age group in 1935-39 bore to total consumption. These estimates per year per age group were rounded to the nearest 50 cigarettes. Similar estimates were made for cigarette consumption per head by age group for women for the years 1921-1934. In addition, the estimates of cigarette consumption for men and women for the years 1935-72 published in Smoking Patterns were up-dated to 1975. The complete series of cigarette consumption per adult by age group for men from 1888-1975 is shown in table B.1M and the corresponding figures for women from 1921-1975 in table B.1W.

Correcting for variation in tar yields of cigarettes

B.8 The next step was to convert the estimates from the current cigarette basis to the constant tar basis, as defined earlier in paragraph 3.1, by applying the indices of tar per cigarette given in table B.2, which are based on data supplied by the cigarette manufacturers.

The resulting estimates of cigarette consumption on a constant tar basis are given in tables B.3M & W.

B.9 The estimates of average tar and nicotine deliveries per cigarette of the cigarettes smoked in the U.K. from 1965 to 1973, which were published in Smoking Patterns (tables 8 and 9), are extended to 1975 in table B.2, and further extended in table B.4 to give the average tar and nicotine deliveries for plain and filter cigarettes separately from 1965 onwards. It has to be emphasised, however, that these are averages per cigarette, and that in considering the average tar and nicotine intake per smoker or per adult, it is necessary to take into account the average number of cigarettes smoked per head.

B.10 The measurement of tar and nicotine yields of the smoke of commercial brands of cigarettes on a systematic basis started only about 1963-65 (the figures for 1964 did not differ significantly from those of 1965), and the only data we have available before that period is difficult to interpret, being based on two air-tight tins of cigarettes about 40 years old discovered in 1973. This data is considered later (Appendix C), but we have attached more weight to what can be deduced from the rather more substantial evidence that is available, as described in the following paragraphs, including that about the weights of tobacco smoked per cigarette.

B.11 The average weight of tobacco per 1,000 plain and filter cigarettes can be calculated from figures published in Todd (1972), and the resulting totals back to 1920 are given in table B.4. These figures, however, relate to the weights of tobacco in the cigarettes as manufactured, and what are required are estimates of the average weights of tobacco smoked in plain and filter cigarettes respectively. Allowance has therefore to be made for the amounts of tobacco in the discarded cigarette butts. Surveys of the butt lengths left by smokers of the different types of cigarettes then on the market were carred out on behalf of the Tobacco Research Council in 1958, 1962 and 1972. The results of the surveys in 1958 and 1962 were published by Todd (1963), and the results of the 1972 survey are summarised in table B.5. The 1972 survey was the most comprehensive survey and showed that, at that time, about 70% of the tobacco in plain cigarettes and about 88% of the tobacco in filter cigarettes (on a

sales-weighted basis) was smoked. The results of the surveys in 1962 and in 1958 did not differ significantly from the 1972 estimates. It was therefore decided to take 70% and 88% as representing the proportions of tobacco in plain and filter cigarettes respectively which were smoked in each year. The resulting average weights of tobacco smoked per 1,000 cigarettes are included in table B.4. As will be seen, the average weight of tobacco smoked per 1,000 cigarettes in 1965 was 1.55 lbs., and the highest figure previously recorded was 1.57 lbs.

B.12 A change which might have been expected to have had an effect on the tar delivery of British cigarettes since 1920 is the reduction in the texture and body of U.S. flue-cured tobacco duing the period 1935-65. This reduction has already been referred to in paragraph 3.5 and was brought about by the farmers placing the plants more closely together and applying increasing quantities of fertilizer. However, the reduction in the average tar delivery per leaf would have been offset to some extent by the increase in the number of leaves required to make up a given weight of tobacco, so the overall effect on tar delivery per weight of tobacco smoked may not have been marked.

B.13 Calculation of CCTCC figures from annual components

The final stage in calculating the CCTCC figures of tables 5.M and 5.W was to accumulate consumption over time for the various cohorts using as basic data the consumption by age group figures from tables B.3M and B.3W for 1965 onwards and those from tables B.1M and B.1W before 1965. The method of accumulation used in this paper is somewhat different from that used in Smoking Patterns. In Smoking Patterns, single year cohorts were followed through and CCTCC calculated up to the end of an age group. In this paper CCTCC estimates were calculated in such a way as to make them directly comparable with the mortality figures.

B.14 The clearest way to illustrate the method of calculation used is by an example. In table 1.M the male death rate from lung cancer of 367.3 for the 60-64 age group for the cohort with central date of birth January 1st, 1901 was calculated by averaging the five death rates for 60-64 year olds for the five separate years, 1961, 1962,

1963, 1964 and 1965. As illustrated in figure 1, this procedure involves people born over a 10 year period, from January 1st, 1896 to January 1st, 1906 (actually, December 31st, 1905). In figure 1, the data relating to a particular cohort is represented in the row of figures opposite the date of birth, the data relating to a particular age in the column of figures below the age, and the data for a particular calendar year in the appropriate upward diagonal. The population considered in the mortality estimates are those people falling within the diamond formed by the heavy lines. Although there are slight variations in population distribution by cohort and by age within the diamond, these have been ignored in the estimates and the average CCTCC per adult has been computed assuming the adults to have been uniformly distributed over the diamond.

B.15 Calculation of the CCTCC for these diamonds was complex and details of the derivation of the formulae used are available on request. For present purposes, it is sufficient to illustrate part of the calculations for this particular diamond.

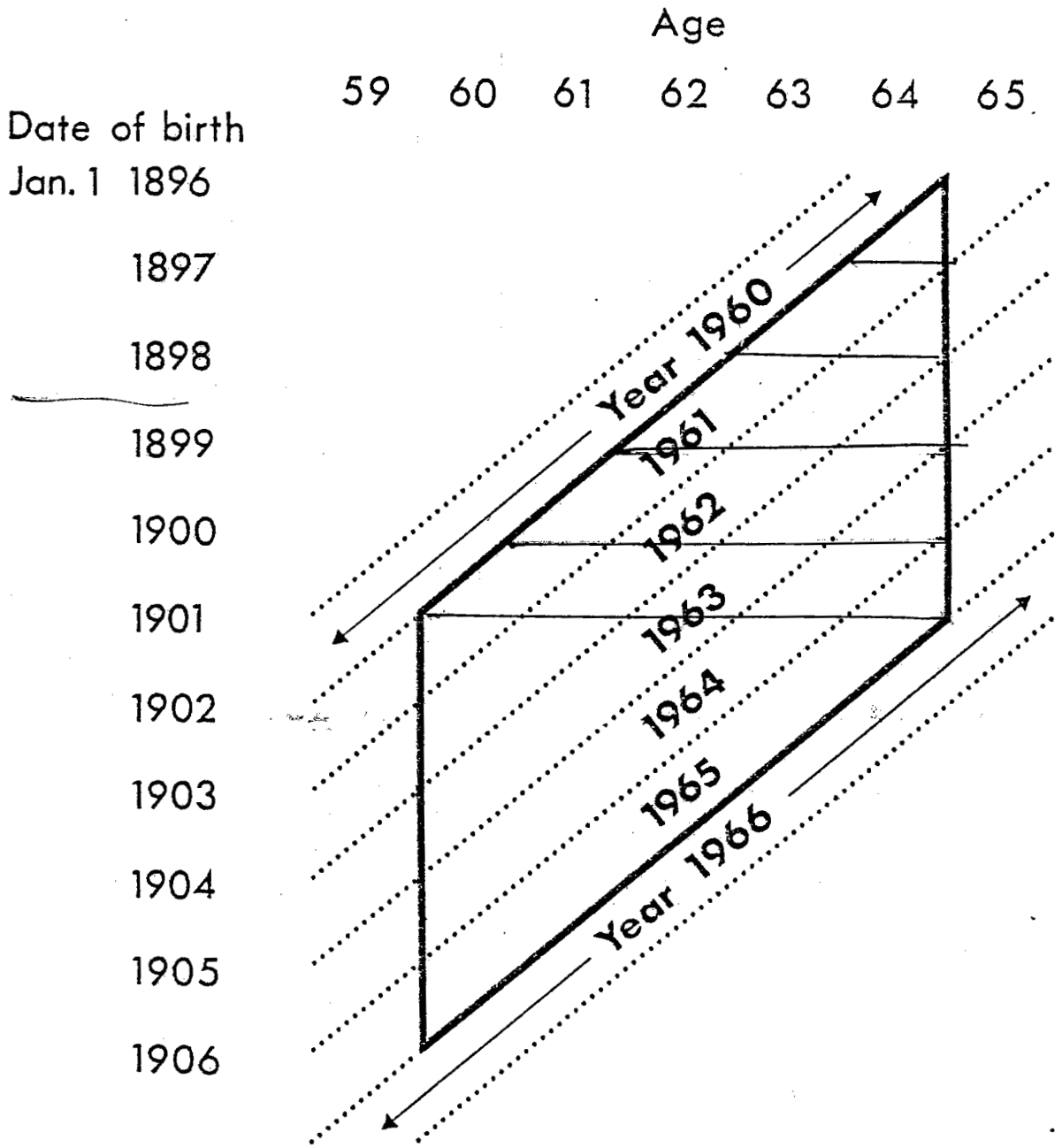
a) Contribution of consumption at age 15-19 to CCTCC

Year	Consumption	Coefficient	Product
1912	750	1	750
1913	800	7	5600
1914	850	19	16150
1915	1000	37	37000
1916	1000	60	60000
1917	1100	82	90200
1918	1150	94	108100
1919	1450	94	136300
1920	1350	82	110700
1921	1250	60	75000
1922	1200	37	44400
1923	1150	19	21850
1924	1200	7	8400
1925	1300	1	1300
		Total	715750

Contribution = Total/150 = 4771.67

FIGURE 1

Cohorts represented in CCTCC and mortality estimates.



b) Contribution of consumption at age 20-24 to CCTCC

Year	Consumption	Coefficient	Product
1916	1900	1	1900
1917	2050	7	14350
1918	2100	19	39900
1919	2750	37	101750
1920	2500	61	152500
1921	2400	88	211200
1922	2250	106	238500
1923	2200	112	246400
1924	2300	106	243800
1925	2450	88	215600
1926	2500	61	152500
1927	2650	37	98050
1928	2800	19	53200
1929	2900	7	20300
1930	3050	1	3050
		Total	1793000

Contribution = Total/150 = 11953.33

c) Contribution of consumptions at age 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59 to CCTCC

The method of calculation for these age groups was identical and the coefficients were the same as those for the 20-24 age groups except that the range of years was progressively shifted 5 years on with each successive age group, e.g. for the 25-29 age group the range was 1921 to 1935 and so on up to 1951 to 1965 for the 55-59 age group.

d) Contribution of consumptions at age 60-64 to CCTCC

Year	Consumption	Coefficient	Product
1956	3600	14	50400
1957	3750	38	142500
1958	3300	56	184800
1959	3650	68	248200
1960	3650	74	270100
1961	3850	61	234850
1962	3250	37	120250

Year	Consumption	Coefficient	Product
1963	3600	19	68400
1964	3150	7	22050
1965	2900	1	2900
		Total	1344450

Contribution = Total/150 = 8963.00

Finally all the contributions were added up and divided by 1,000 to give the figure in table 1.M of 171. The accumulations as carried out were based on the detailed consumption figures before they were rounded to the nearest 50.

B.16 For any diamond covering a five year age group anywhere from 20-24 up to 80-84 the procedure was similar. Three sets of coefficients were used; one for the age group 15-19 (in which it was assumed no cigarettes were smoked at age 15) as in a), one for each five year age group from 20-24 up to, but not including, the actual age group of the diamond as in b) and c), and one relevant to the age group of the diamond. For a diamond actually covering the four year age group 16-19 a fourth set of coefficients was necessary, namely, 1,7,19,37,48,47,41,29 and 11. These covered the years from the cohort central year +11 up to the cohort central year +19.

TABLE B.1M

Annual consumption of cigarettes per adult by age groups, 1888-1975, Men

Current cigarettes

Year	16-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
1888	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1889	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1890	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	50	50	50	50	50	0	0	0	0	0	0	0
92	0	50	50	50	50	50	50	50	50	0	0	0	0	0
93	50	50	50	50	50	50	50	50	50	50	0	0	0	0
94	50	100	100	100	100	100	100	100	100	50	50	50	0	0
1895	50	150	150	150	150	150	150	150	100	100	50	50	50	0
96	100	150	200	200	200	200	200	150	150	100	50	50	50	0
97	100	250	300	250	250	250	250	250	200	150	100	50	50	50
98	150	300	350	350	300	300	300	300	250	200	100	100	50	50
99	200	350	450	400	350	350	350	350	300	250	150	100	100	50
1900	250	450	500	500	450	450	450	450	400	300	150	150	100	50
01	250	500	600	550	500	500	500	500	450	300	200	150	100	50
02	300	550	650	650	550	550	550	550	500	350	200	150	100	100
03	350	700	850	800	700	700	700	700	600	450	250	200	150	100
04	400	750	900	900	750	800	800	750	700	500	300	250	200	100
1905	450	900	1050	1050	900	900	900	850	800	550	350	250	200	150
06	500	950	1150	1150	950	1000	950	950	850	650	350	300	200	150
07	550	1050	1250	1200	1050	1050	1050	1050	900	700	400	300	250	150
08	600	1100	1300	1300	1100	1100	1100	1100	950	700	400	300	250	150
09	600	1100	1300	1300	1100	1150	1100	1100	1000	700	450	350	250	150
1910	650	1200	1450	1400	1200	1250	1200	1200	1050	800	450	350	300	150
11	700	1300	1600	1550	1350	1350	1350	1300	1150	850	500	400	300	200
12	750	1400	1700	1650	1400	1450	1400	1400	1250	900	550	400	300	200
13	800	1500	1750	1750	1500	1500	1500	1450	1300	950	600	450	350	200
14	850	1550	1900	1850	1600	1600	1600	1550	1400	1050	600	450	350	250
1915	1000	1900	2250	2250	1900	1950	1900	1900	1650	1250	750	550	450	250
16	1000	1900	2300	2250	1950	2000	1950	1900	1700	1250	750	550	450	300
17	1100	2050	2450	2400	2050	2100	2050	2050	1800	1350	800	600	450	300
18	1150	2100	2550	2500	2150	2200	2150	2100	1900	1400	850	650	500	300
19	1450	2750	3300	3250	2750	2800	2800	2750	2450	1800	1050	800	650	400
1920	1350	2500	3050	2950	2550	2600	2550	2500	2250	1650	1000	750	600	350
21	1250	2400	2850	2800	2400	2450	2400	2350	2100	1550	950	700	550	350
22	1200	2250	2700	2650	2250	2300	2250	2250	2000	1450	900	650	500	300
23	1150	2200	2600	2550	2200	2250	2200	2150	1950	1450	850	650	500	300
24	1200	2300	2750	2700	2300	2350	2300	2250	2000	1500	900	650	500	350
1925	1300	2450	2900	2850	2450	2500	2450	2450	2150	1600	950	700	550	350
26	1300	2500	3000	2900	2500	2550	2500	2450	2200	1650	950	750	550	350
27	1400	2650	3150	3100	2650	2700	2650	2600	2350	1750	1050	800	600	400
28	1450	2800	3350	3250	2800	2850	2800	2750	2450	1800	1100	800	650	400
29	1550	2900	3450	3400	2900	2950	2900	2850	2550	1900	1150	850	650	400

TABLE B.1M (cont.)

Year	16-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
1930	1600	3050	3650	3600	3050	3150	3100	3050	2700	2000	1200	900	700	450
31	1600	3050	3650	3600	3050	3150	3100	3050	2700	2000	1200	900	700	450
32	1600	3000	3600	3550	3000	3100	3050	3000	2650	1950	1150	900	700	450
33	1650	3100	3750	3650	3150	3200	3150	3100	2750	2050	1200	900	700	450
34	1650	3150	3750	3700	3150	3200	3150	3100	2750	2050	1200	950	700	450
1935	1700	3300	3950	3850	3150	3250	3200	3150	2800	2050	1200	900	700	450
36	1850	3550	4250	4150	3500	3550	3500	3450	3050	2250	1350	1000	800	500
37	2000	3700	4450	4350	3750	3850	3800	3750	3300	2450	1450	1100	850	550
38	2100	3850	4650	4600	3950	4000	3950	3900	3450	2600	1550	1150	900	550
39	2150	3950	4750	4650	4150	4250	4150	4100	3650	2700	1600	1250	950	600
1940	2100	3900	4650	4650	4200	4300	4200	4150	3700	2700	1600	1200	950	600
41	2300	4150	4900	4850	4600	4750	4650	4550	4050	2950	1750	1350	1050	650
42	2400	4250	5050	4950	4850	4950	4900	4800	4300	3100	1850	1400	1100	700
43	2350	4250	4950	4850	4850	4950	4900	4800	4300	3100	1850	1400	1100	700
44	2450	4400	5100	4950	5100	5200	5150	5050	4500	3300	2000	1500	1150	750
1945	2700	4750	5500	5350	5600	5750	5650	5550	4950	3700	2200	1700	1300	800
46	2600	4600	5350	5150	5300	5450	5350	5250	4700	3600	2150	1600	1250	800
47	2150	3950	4450	4350	4550	4650	4600	4500	4000	2900	1750	1300	1000	650
48	1950	3700	4050	4050	4550	4650	4550	4500	4000	2600	1550	1150	900	550
49	1750	3450	3550	3700	4050	4150	4050	4000	3550	2300	1350	1050	800	500
1950	1800	3500	4050	3750	4150	4250	4200	4150	3650	2650	1400	1050	800	500
51	1950	3650	4400	4300	4300	4400	4350	4250	3800	2950	1750	1300	1000	650
52	1600	3600	4150	4400	4500	4600	4550	4450	3950	2850	2050	1550	1200	750
53	1850	3550	4150	4750	4450	4550	4500	4400	3950	3300	2050	1550	1200	750
54	1700	3750	4300	4600	4700	4800	4700	4650	4100	3400	1850	1400	1050	700
1955	2050	3550	4750	4600	4800	4900	4800	4750	4200	3300	1950	1450	1150	700
56	2050	3700	4250	4150	4550	4650	4550	4800	4250	3600	2150	1650	1250	800
57	2350	3500	4200	4200	4850	4950	4900	4350	3850	3750	2400	1850	1400	900
58	2450	3950	3650	4050	4900	5000	4950	4600	4100	3300	2050	1550	1200	750
59	2800	3900	4100	4750	4650	4750	4650	4800	4300	3650	2500	1900	1450	950
1960	3050	4400	4200	4250	5050	5150	5050	4900	4350	3650	2050	1550	1200	750
61	2900	4150	4150	3950	4700	4800	4700	4700	4150	3850	2900	2200	1700	1050
62	3350	4250	4150	4100	4400	4500	4450	4600	4100	3200	2200	1700	1300	800
63	2950	4550	4500	4350	4400	4600	4450	4250	3750	3550	2350	1750	1350	850
64	3100	4350	3950	4000	4450	4550	4450	4250	3800	3150	3050	2300	1800	1100
1965	2600	4400	3950	4100	4150	4250	4150	4100	3650	2900	2750	2050	1600	1000
66	2650	4150	4300	3650	4250	4150	4100	3900	3500	3400	2450	1750	2200	500
67	2900	4200	4300	3800	4500	4450	4150	3600	3800	3300	2450	2050	1300	1200
68	3350	4150	3800	4100	4450	4500	4250	4150	3650	2950	2850	2000	1250	700
69	3100	4450	4500	4200	4200	4900	3850	4400	3650	3000	2700	1800	1300	950
1970	3050	4250	4450	4350	4600	4650	4200	4100	3500	3500	2900	1650	1500	1150
71	3200	4550	4150	4350	4000	4050	5050	4200	3150	3350	2450	2550	1100	1300
72	3450	4550	4550	4450	4350	4350	4900	3950	3650	3250	2600	2150	2100	950
73	3450	4950	4850	4650	4950	4450	4150	4350	3300	3600	2650	1850	1250	1500
74	3200	4300	4250	4350	4750	4100	4950	4000	3900	2950	3300	2100	1600	1050
1975	3350	4250	3750	3750	4150	4050	3800	4800	3850	3950	2950	1700	1550	700

TABLE B.1W

Annual consumption of cigarettes per adult by age groups, 1921-1975, Women

Current cigarettes

Year	16-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	0	50	50	50	50	100	50	50	50	0	0	0	0	0
23	0	50	50	50	50	100	50	50	50	0	0	0	0	0
24	50	100	100	100	150	150	150	100	100	50	50	0	0	0
1925	50	100	100	100	150	150	150	100	100	50	50	0	0	0
26	50	100	100	100	150	150	150	100	100	50	50	0	0	0
27	50	100	150	150	200	200	200	150	100	50	50	50	0	0
28	50	100	150	150	200	200	200	150	100	50	50	50	0	0
29	50	150	200	200	250	300	250	200	150	100	50	50	0	0
1930	50	150	200	200	250	300	250	200	150	100	50	50	0	0
31	100	200	250	300	300	350	350	250	200	100	100	50	50	0
32	100	200	250	300	300	350	350	250	200	100	100	50	50	0
33	100	250	300	350	400	450	400	300	250	150	100	50	50	0
34	100	250	300	350	400	450	400	300	250	150	100	50	50	0
1935	100	200	250	300	500	550	550	400	350	150	100	100	50	50
36	150	300	350	400	550	600	550	400	350	150	100	100	50	50
37	150	350	450	500	550	650	600	450	400	200	150	100	50	50
38	200	450	500	550	600	650	600	450	400	200	150	100	50	50
39	250	550	600	700	650	750	700	550	450	250	150	100	50	50
1940	300	700	800	850	750	850	800	600	500	300	250	150	100	50
41	400	950	1050	1150	1000	1150	1100	800	700	450	300	200	100	100
42	500	1150	1300	1400	1200	1350	1250	950	800	550	400	300	150	100
43	600	1300	1500	1600	1400	1600	1500	1100	950	650	450	300	150	100
44	700	1450	1650	1800	1500	1700	1600	1200	1000	750	500	350	200	150
1945	750	1650	1850	2050	1700	1950	1800	1350	1150	800	550	400	200	150
46	900	1600	1750	1850	1400	1600	1500	1100	950	750	500	350	200	150
47	600	1400	1550	1600	1350	1500	1400	1050	900	650	450	300	150	100
48	550	1250	1350	1350	1100	1250	1200	900	750	550	400	300	150	100
49	550	1300	1450	1450	1200	1350	1250	950	800	650	450	300	150	100
1950	700	1400	1400	1850	1200	1350	1250	950	800	850	600	400	200	150
51	550	1150	1800	1750	1400	1600	1500	1100	950	650	450	300	150	100
52	700	1300	1800	1750	1450	1650	1550	1150	1000	650	450	300	150	100
53	550	1300	1550	2050	1550	1750	1650	1250	1050	750	550	400	200	150
54	600	1350	1700	1950	1650	1900	1750	1300	1150	750	500	350	200	150
1955	700	1350	1900	1900	1850	2100	1950	1450	1250	750	500	350	200	150
56	800	1350	1750	2150	1900	2150	2050	1450	1250	1050	750	500	250	200
57	1000	1450	2100	2200	2050	2300	2150	1550	1300	1150	800	550	250	200
58	900	1550	1850	2300	2150	2450	2300	1650	1450	800	550	400	200	150
59	850	1500	2000	2600	2300	2650	2500	1800	1550	750	550	400	200	150

TABLE B.1W (cont.)

Year	16-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
1960	1200	1650	1700	2450	2150	2500	2300	1650	1400	1000	700	500	250	200
61	1250	1750	2100	2150	2250	2550	2400	1900	1600	1100	750	550	250	200
62	1550	2100	2050	2200	2250	2550	2400	1950	1700	1100	750	550	250	200
63	1350	2200	2300	2100	2650	3000	2850	2050	1750	1300	900	650	300	250
64	1500	2050	2400	2400	2500	2850	2650	1950	1650	1200	850	600	300	200
1965	1300	2350	2450	2300	2400	2750	2550	2250	1950	1150	800	550	300	200
66	1600	2550	2500	2450	2600	2850	2900	2000	1900	1300	750	750	200	50
67	1700	2400	2350	2150	2600	2650	2550	2450	2050	1250	1100	600	250	250
68	1950	2450	2400	2100	2350	2750	2700	2350	2050	1100	950	650	350	150
69	2350	2950	3100	2800	2550	2950	2650	2400	2100	1650	850	850	350	300
1970	2400	3100	2650	2650	2700	3000	2550	2350	2500	1350	1250	750	400	450
71	2250	3000	2650	2650	2300	3550	3050	2550	2250	1500	950	700	350	200
72	2350	2800	3100	3100	3100	3050	3100	2900	1700	1650	1100	550	450	300
73	2750	3350	3300	3150	2850	3250	3750	3150	2700	1900	1200	850	550	350
74	2750	3200	3300	3500	3350	3050	3950	3500	2450	2000	1450	850	500	300
1975	2650	3200	3300	2900	3000	3300	3300	2650	2600	2000	1350	850	550	450

TABLE B.2

Indices of standard tar and nicotine per cigarette, 1965 - 75

Year	Index of standard tar per cigarette	Index of standard nicotine per cigarette
1965	100	100
66	96	96
67	83	88
68	76	83
69	76	80
1970	72	75
71	68	73
72	65	71
73	60	69
74	58	66
1975	57	65

Note

For years prior to 1965, it is assumed, for reasons stated in paragraphs B.10 to B.12, that the index of standard tar did not differ significantly from 100.

TABLE B.3M

Annual consumption of cigarettes per adult by age groups, 1965-1975, Men

Constant tar cigarettes

Year	16-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
1965	2600	4400	3950	4100	4150	4250	4150	4100	3650	2900	2750	2050	1600	1000
66	2550	3950	4100	3650	4100	4000	3950	3750	3350	3250	2350	1650	2100	500
67	2400	3450	3550	3150	3750	3700	3450	3000	3150	2750	2050	1700	1100	1000
68	2550	3150	2900	3150	3350	3400	3250	3150	2800	2250	2150	1500	950	500
69	2350	3400	3400	3200	3200	3750	2950	3350	2800	2300	2050	1350	1000	700
1970	2200	3100	3200	3150	3300	3350	3000	2950	2500	2550	2100	1200	1100	800
71	2200	3100	2800	2950	2700	2750	3400	2850	2150	2250	1700	1750	750	900
72	2250	2950	2950	2900	2850	2850	3200	2550	2350	2150	1700	1400	1350	650
73	2050	2950	2900	2800	2950	2700	2500	2600	2000	2150	1600	1100	750	900
74	1850	2500	2450	2550	2750	2400	2850	2300	2250	1700	1900	1200	950	600
1975	1900	2450	2150	2150	2350	2300	2150	2750	2200	2250	1700	1000	900	400

Note: Details of cigarette consumption by age group for the years before 1965 are shown on Table B.1M

TABLE B.3W

Annual consumption of cigarettes per adult by age groups, 1965-1975, Women

Constant tar cigarettes

Year	16-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80+
1965	1300	2350	2450	2300	2400	2750	2550	2250	1950	1150	800	550	300	200
66	1550	2400	2400	2350	2500	2750	2800	1950	1850	1250	700	700	200	50
67	1400	2000	1950	1800	2150	2200	2100	2050	1700	1050	900	500	200	200
68	1500	1850	1850	1600	1800	2100	2050	1750	1550	850	700	500	300	100
69	1800	2200	2350	2100	1950	2250	2000	1850	1600	1250	650	650	300	150
1970	1750	2200	1900	1900	1950	2150	1850	1700	1800	950	900	550	250	300
71	1550	2050	1800	1800	1600	2400	2050	1700	1550	1050	650	500	250	150
72	1550	1800	2050	2000	2050	2000	2000	1850	1100	1100	750	350	300	200
73	1650	2000	1850	1900	1700	1950	2250	1900	1600	1150	750	500	350	200
74	1600	1850	1900	2000	1950	1800	2300	2000	1400	1150	850	500	300	200
1975	1500	1850	1850	1650	1700	1850	1850	1500	1500	1150	750	450	350	250

Note: Details of cigarette consumption by age group for the years before 1965 are shown in Table B.1W

TABLE B.4

Tobacco smoked and tar and nicotine deliveries per cigarette

Calendar year	Proportions of cigarette sales (in number)		Average weight of tobacco per 1000 cigarettes		Average weight of tobacco smoked per 1000 cigarettes			Tar per cigarette			Nicotine per cigarette		
	Plain	Filter	Plain	Filter	Plain	Filter	Combined	Plain	Filter	Total	Plain	Filter	Total
	%	%	lb.	lb.	lb.	lb.	lb.	mg.	mg.	mg.	mg.	mg.	mg.
1920	100	0	2.22		1.55		1.55						
1925	100	0	2.22		1.55		1.55						
1930	99.8	0.2	2.22		1.55		1.55						
1935	99.6	0.4	2.21		1.55		1.55						
1940	99.3	0.7	2.15		1.51		1.51						
1945	99.3	0.7	2.24		1.57		1.57						
1950	98.0	2.0	2.14		1.50		1.50						
1955	98.1	1.9	2.14		1.50		1.50						
1960	84.2	15.8	2.21	1.86	1.55	1.64	1.56						
61	80.5	19.5	2.21	1.86	1.55	1.64	1.57						
62	74.0	26.0	2.19	1.85	1.53	1.63	1.56						
63	67.2	32.8	2.18	1.83	1.53	1.61	1.56						
64	58.2	41.8	2.15	1.83	1.51	1.61	1.55						
1965	47.0	53.0	2.15	1.81	1.51	1.59	1.55	35.0	29.3	31.4	2.21	2.00	2.08
66	39.4	60.6	2.11	1.76	1.48	1.55	1.52	33.9	28.6	30.3	2.13	1.93	2.00
67	34.1	65.9	2.10	1.73	1.47	1.52	1.50	32.6	23.2	26.0	2.14	1.67	1.82
68	29.3	70.7	2.08	1.69	1.46	1.49	1.48	30.1	21.6	23.9	2.07	1.59	1.72
69	24.5	75.5	2.06	1.63	1.44	1.43	1.43	30.3	21.8	23.9	2.07	1.53	1.67
1970	21.7	78.3	2.01	1.59	1.41	1.40	1.40	29.6	20.6	22.5	2.04	1.43	1.56
71	20.2	79.8	2.02	1.58	1.41	1.39	1.39	27.7	19.8	21.3	1.96	1.40	1.51
72	18.3	81.7	2.01	1.58	1.41	1.39	1.39	27.8	18.9	20.5	2.00	1.36	1.48
73	17.0	83.0	2.00	1.60	1.40	1.41	1.41	24.6	17.4	18.7	1.92	1.33	1.44
74	15.5	84.5	1.98	1.59	1.39	1.40	1.40	24.6	17.1	18.2	1.94	1.28	1.37
1975	13.4	86.6	1.95	1.55	1.37	1.36	1.36	24.8	16.9	17.9	1.98	1.25	1.35

Note: Figures in column 7 for all years can be found in T.R.C. Occasional Paper No. 2, table no. 4.

TABLE B.5

Estimated cigarette lengths, tobacco rod lengths, butt lengths and proportions of tobacco smoked, 1972

Type	Class	Cigarette length (mm)	Tobacco rod length (mm)	Butt length (median) (mm)	Tobacco length smoked (mm)	Proportion of tobacco smoked %
Plain	A	66	66	19.4	46.6	71
Plain	B	70	70	21.0	49.0	70
Plain	C	70	70	21.0	49.0	70
Filter	Sub A	65.3	49.3	21.7	43.6	88
Filter	A	66	50.5	22.0	44.0	87
Filter	Sub-Intermediate	70	52.5	23.3	46.7	89
Filter	B & Intermediate	71.3	54.5	23.6	47.7	88
Filter	King	84	65.3	25.9	58.1	89

Appendix C

The evidence of Gold Flake cigarettes

C.1 In 1973, two air-tight tins of 50 Gold Flake cigarettes were discovered in the industrial archives of the Imperial Tobacco Company. One tin was opened and the cigarettes machine-smoked. The cigarettes were identified as having been manufactured in August 1933 or 1936 - it was not possible to decide which - and were therefore regarded as having been made "about 1935". When smoked in accordance with the present smoking parameters laid down by the Department of Health and Social Security, the cigarettes delivered an average of 38.7 mg tar and 3.6 mg nicotine and thus had a tar/nicotine ratio of 10.8. The cigarettes were 74 mm in length, contained 1.11 g of tobacco and were smoked to the specified butt length in an average of 10.7 puffs of 35 ml each.

C.2 In the mid-1930's, Gold Flake cigarettes were longer than the average of all British cigarettes. As stated in Smoking Patterns, the averages for all British cigarettes, on the basis of the Gold Flake figures, might have been about 32.8 mg tar and 3.0 mg nicotine. On the procedure adopted in this paper, it was assumed that the average tar delivery of British cigarettes in 1935, as in all years prior to 1965, was 31.4 mg. Judged by this one tin of 50 cigarettes, the Gold Flake figures of about 1935 were similar to this assumed figure.

C.3 The second tin of 50 Gold Flake cigarettes was identified as having been manufactured during the war - the exact year could not be ascertained - and the cigarettes were machine-smoked in August 1976. They produced results which differed materially from those of the earlier cigarettes. The wartime Gold Flake cigarettes delivered an average of 49.1 mg tar, 3.26 mg nicotine and had a tar/nicotine ratio of 15.1. The cigarettes had an average length of 73.2 mm, contained 1.11 g of tobacco and were smoked in an average of 12.3 puffs. The tar figure of the wartime Gold Flake cigarettes would imply that the average tar delivery of all British cigarettes at that time was about 45 mg per cigarette. This figure would be seriously inconsistent with the assumption that, prior to 1965, the average tar delivery per cigarette was 31.4 mg.

C.4 There are inevitably difficulties in basing estimates of the tar delivery of a brand of cigarettes on one tin of 50 cigarettes which has happened to survive. The surviving cigarettes may not originally have been a representative sample of the year's output. In addition, it is impossible to know what chemical and physical changes may have taken place in cigarettes stored for 40 or more years, and how these changes may have affected the deliveries of tar and nicotine when the cigarettes were eventually smoked.

C.5 Further, owing to the difficulties of manufacture in wartime, the cigarettes made at that time are likely to have differed in some respects from pre-war cigarettes.

C.6 All measurements of tar and nicotine deliveries quoted in this paper were determined using the present parameters for machine-smoking of cigarettes laid down by the Department of Health and Social Security. These parameters are designed to simulate those used on the average by human smokers in the U.K. at the present time. It is impossible to know how far these particular parameters are representative of those employed by smokers of British cigarettes in the years prior to the last war. For example, there is some evidence that before the war, British cigarettes had higher draw resistance than they now have, and this could have led to them being smoked with a smaller puff volume than, say, the cigarettes of 1965.

C.7 These difficulties in interpreting the results of tests of cigarettes manufactured many years ago led us to adopt the procedure for estimating tar deliveries described in this paper. We have compared the results obtained from the assumptions which we have made with those produced by a number of alternative assumptions and formulations. We believe that, if the truth could be known, the assumptions we have made would not be found to be seriously inaccurate.

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