

PULMONARY TUBERCULOSIS IN WALES BETWEEN 1911 AND 1931

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THE importance of pulmonary tuberculosis as a cause of death in Wales has been the subject of much consideration. Many of the investigations, however, have been of a definitely local character, though this fact does not detract from their merit as is evinced by the work done by Wade, Bowen and the King Edward VII Welsh National Memorial Association. For a really comprehensive study we are indebted to the late Dr Brownlee. His contribution to the epidemiology of phthisis was unique in its suggestiveness. He postulated the theory that phthisis as a disease was not an entity, but that it consisted of three types—"Young Adult," "Middle Age," and "Old Age," corresponding with separate strains of the infecting bacillus. According to his conception the great bulk of the phthisis deaths in Wales was due to early or late types of the disease. He reached this conclusion from a study of the pulmonary death-rates of males between 1851 and 1870 in the registration districts of Wales.

In view of the original and challenging character of Dr Brownlee's investigation it was unfortunate that the data were not of a more satisfactory nature. They suffered from defects beyond his control. Prior to 1911 no allowance was made in official records for the transference of deaths to the usual place of residence, with the result that the mortality of those areas possessing hospitals, sanatoria and workhouses was considerably overstated. Furthermore the old registration districts which formed the regional basis of tabulation were not homogeneous. They varied in the proportion of urbanisation within their boundaries. In 1911 a satisfactory change was made as the Registrar General's Department published the statistical records, not for registration districts but for the county boroughs, and the urban and rural districts within each administrative county. These new areas represent broadly various types of environment, and as such are pre-eminently suitable for the statistical study of a particular disease. Accordingly, in the present paper, an attempt has been made to study generally the mortality from phthisis in Wales between 1911 and 1931, but particularly its relation to certain specific factors, such as migration, housing and occupation.

THE DATA

The data consisted of the deaths from phthisis in age groups as enumerated in the *Annual Reports* of the Registrar General for the three four-yearly periods 1911-1914, 1921-1924, and 1928-1931. The deaths were extracted for

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(1) the urban and rural divisions of Wales and Monmouth as a whole, (2) for the aggregate of urban and the aggregate of rural divisions of each administrative county, and (3) for every individual administrative area within each county. For the last period 1927-1930 had to be used, as the data for the individual administrative areas were not procurable for 1931. From the year 1921 the number of areas in category (3) was considerably reduced as, after that date, the Registrar General published figures only for those districts with a population of 10,000 and upwards. The population or the average number exposed to risk in each period was regarded as corresponding to that enumerated at each census, 1911, 1921 and 1931. This is, of course, not strictly accurate, as the censal year is not the central year of the period, but the error introduced thereby will not appreciably affect the result.

PHTHISIS MORTALITY IN WALES

Is the mortality from phthisis in Wales a problem of more serious import than it is in England and, if so, to what extent? To answer these questions the standardised death-rates at age 5 years and upwards have been tabulated for the county boroughs, urban and rural districts in Wales, and are compared in Table I with the corresponding values for similar divisions in England. In

Table I. *Showing (a) Standardised death-rates per 1000 amongst persons at age 5 and upwards from phthisis in Wales and Monmouth and also in England. (b) The values in the subsequent periods expressed as percentages of those during 1911-1924. (c) The mortality rates in Wales and Monmouth expressed as percentages of those in England.*

Year	County boroughs		Urban districts		Rural districts	
	Wales and Monmouth	England	Wales and Monmouth	England	Wales and Monmouth	England
(a)						
1911-1914	1.417	1.400	1.017	0.952	1.166	0.815
1921-1924	1.290	1.065	0.941	0.809	1.019	0.720
1928-1931	1.134	0.974	0.879	0.657	0.887	0.568
(b)						
1911-1914	100	100	100	100	100	100
1921-1924	91	76	93	85	87	88
1928-1931	80	70	86	69	77	70
(c)						
1911-1914	101	100	107	100	143	100
1921-1924	121	100	116	100	142	100
1928-1931	116	100	134	100	156	100

each type of area, as will be seen in section (c) of the table, the rates in Wales are higher than those in England, but the difference is more accentuated in the rural districts. In the county boroughs the Welsh death-rate was only 1 per cent. in excess of the English in 1911-1914, but the increment in 1928-1931 was 16 per cent. This does not necessarily represent an increase in the Welsh mortality, in fact the rate had declined, but only that the decline in the death-rate between 1911-1914 and 1928-1931 was less than the decline

recorded in England. In the urban areas the mortality in Wales exceeded that in England by 7 per cent. in 1911-1914 and by 34 per cent. in 1928-1931. As regards the rural areas it is in these that the divergence between the mortality in the two countries is most strongly indicated. In 1911-1914 the death-rate from pulmonary tuberculosis in rural Wales was 43 per cent. greater than that in the corresponding areas in England; it was of this order in the ensuing period, but during 1928-1931 the disparity increased as the excess was no less than 56 per cent. Despite this disadvantage in the relative preponderance of rural mortality in Wales as compared with England, it is interesting to note that it is in such Welsh areas that the greatest reduction in the death-rate has occurred. In the course of twenty years the death-rate declined 23 per cent. in the Welsh rural areas, as compared with 14 per cent. and 20 per cent. in the urban districts and county boroughs respectively. In fact the progressive decrease of the phthisis death-rate in rural Wales is closely in accord with the experience in similar parts of England.

AGE INCIDENCE

In the past the age distribution of the mortality from phthisis in Wales was bi-modal—peaks in young adult and old age, particularly in South Wales. This fact was clearly demonstrated by Dr Brownlee in a series of graphs for decennial periods between 1851 and 1900. As will be seen in Table II the distribution has changed since then, and has changed quite appreciably in comparison with that for England. In the county boroughs of Wales the

Table II. *Showing the mortality from phthisis according to age, and the decline relative to 1911-1914.*

Year	Wales and Monmouth Age group					England Age group				
	5-	15-	25-	45-	65+	5-	15-	25-	45-	65+
	County boroughs									
1911-1914	0.32	1.40	1.95	2.11	1.17	0.31	1.29	1.96	2.14	0.99
1921-1924	0.25	1.81	1.77	1.46	0.51	0.20	1.25	1.46	1.39	0.65
1928-1931	0.16	1.65	1.66	1.09	0.26	0.14	1.22	1.31	1.27	0.59
1911-1914	100	100	100	100	100	100	100	100	100	100
1921-1924	78	129	91	69	43	65	97	75	65	66
1928-1931	50	118	85	52	23	45	95	67	59	60
	Urban districts									
1911-1914	0.21	1.09	1.41	1.39	0.69	0.22	0.99	1.32	1.31	0.64
1921-1924	0.14	1.35	1.28	1.02	0.55	0.14	1.03	1.12	0.95	0.50
1928-1931	0.12	1.39	1.16	0.88	0.42	0.10	0.87	0.91	0.77	0.38
1911-1914	100	100	100	100	100	100	100	100	100	100
1921-1924	67	124	91	73	80	64	104	85	73	78
1928-1931	57	128	83	63	61	45	88	69	59	59
	Rural districts									
1911-1914	0.23	1.33	1.66	1.37	0.91	0.17	0.89	1.23	0.92	0.52
1921-1924	0.17	1.33	1.41	1.14	0.79	0.12	0.93	1.08	0.71	0.36
1928-1931	0.12	1.24	1.21	0.93	0.69	0.07	0.74	0.84	0.59	0.31
1911-1914	100	100	100	100	100	100	100	100	100	100
1921-1924	74	100	85	83	87	71	104	88	77	69
1928-1931	52	93	73	68	76	41	83	68	64	60

maximum mortality was in the age group 45–65 years for the period 1911–1914 but, in the two later periods, the peak shifted to age group 15–45 years. Over the same periods the oscillation was from age group 25–45 to the age group 15–25 years in the urban districts. The change in the rural districts was not contemporaneous with that shown for either of the urbanised areas, as in each of the periods 1911–1914 and 1921–1924 the maximum death-rate occurred in the age group 25–45 years. It was not until 1928–1931 that there was a suggestion that the modal age had altered its position. Interpreted according to Brownlee's theory this transference of maximum mortality from old age to young adult type means that the old-age type of phthisis has become of less importance as a cause of death. Is it the type itself which has become less predominant or has there been a change in those environmental causes which, in the past, tended to produce phthisis in old age?

DECLINE AT PARTICULAR AGE PERIODS

The decline in the mortality at specific age periods has not been uniform in either Wales or England. The best results occurred between age 5–15 and after age 45. In England the decline at these two periods of life is approximately 55 and 40 per cent. between 1911–1914 and 1928–1931. The fall in Wales at the same ages approximates to these in England, but attention must be drawn to the large decrease which occurred at age 65 and over in the Welsh county boroughs in which in 1928–1931 the mortality was no less than 77 per cent. below that in 1911–1914. There is, however, one period of life—the age group 15–25 years—in which the trend of the phthisis death-rate in both countries, but particularly in Wales, is very unsatisfactory. In the Welsh county boroughs the mortality at this age in the post-war periods was higher than in 1911–1914, the excess being 29 per cent. in 1921–1924 and 18 per cent. in 1928–1931. The corresponding increments in the urban districts were 24 and 28 per cent. respectively. In the rural districts of Wales the mortality which was stationary in 1921–1924 showed a decline of 7 per cent. in 1928–1931. In England the mortality in both the urban and rural districts during 1921–1924 was higher than in 1911–1914. The diminution of the phthisis mortality at this particular age group in the rural districts between 1921–1924 and 1928–1931 is more satisfactory than that in the urbanised areas. Possibly the reduction in migration from the countryside in consequence of the great unemployment in the towns may be an explanatory factor of this phenomenon, the age group 15–25 years being the modal age of migrants.

DIFFERENTIATION IN DIAGNOSIS

Before we can decide that the mortality from phthisis in Wales is greater than in England we must be certain that the apparent excess is not attributable to a purely diagnostic differentiation. If there be a greater tendency in Wales than in England to ascribe bronchitis and other respiratory deaths to the pulmonary respiratory group, then obviously we should expect to find a

deficiency in the Welsh mortality in the bronchitic classification as compared with that in England. The figures in Table III reveal no such defect. On the contrary they show quite definitely that for bronchitis, pneumonia and other respiratory diseases the mortality both in the urban and rural parts of Wales is considerably in excess—some 20–30 per cent.—of that in the corresponding divisions of England.

Table III. *Showing the standardised rates of mortality per 1000 at age 5 + from certain respiratory diseases during 1911–1914 in (A) Wales and Monmouth, (B) England.*

District	Bronchitis			Pneumonia			Other respiratory diseases		
	A	B	A/B	A	B	A/B	A	B	A/B
Urban	0.857	0.715	120	0.578	0.512	113	0.212	0.169	125
Rural	0.601	0.500	120	0.522	0.378	138	0.193	0.144	134

INCIDENCE IN COUNTIES

Having thus shown that there is a real excess mortality from phthisis in Wales, we will now examine the incidence in the various counties to see if the excess has any defined geographical location. For this purpose the standard rates of mortality were calculated for the three four-yearly periods and the death-rate in each county expressed as a percentage of the corresponding value for Wales and Monmouth as a whole. The results are given in Table IV. It will be seen that high phthisis mortality occurs in five counties—Cardigan, Carnarvon, Merioneth, Carmarthen and Anglesey. In Cardigan the urban mortality in 1911–1914 exceeded the corresponding value in urban Wales by 51 per cent., and a similar comparison for the rural divisions of the county reveals an excess of 77 per cent. The corresponding excesses for the period 1928–1931 were 29 and 35 per cent. respectively. Similarly in Carnarvon the values in 1911–1914 were 54 per cent. in excess in the urban districts and 40 per cent. in the rural areas, while in 1928–1931 the urban death-rate was 23 per cent. greater than that for urban Wales and the rural mortality was no less than 75 per cent. in excess. In fact the high rural mortality in the counties of Cardigan and Carnarvon is an outstanding characteristic of the geographical incidence of phthisis mortality in Wales. In Denbigh and in Flint, especially the latter, and particularly in the last period 1928–1931, the death-rates are in defect of the standard—25 per cent. in the urban districts and 22 per cent. in the rural districts.

DECLINE IN PHTHISIS MORTALITY IN WELSH COUNTIES

Urban divisions

The percentage decline in the death-rates for each county is set out in Table V, the rates in 1921–1924 and in 1928–1931 having been expressed as ratios of the corresponding values in 1911–1914. In Radnorshire—a county which in past experience has usually low phthisis death-rates—there was a

distinct rise in the urban mortality, the rate in 1921-1924 being 17 per cent. and in 1928-1931 no less than 60 per cent. in excess of the rate in 1911-1914. There was also a slightly increased mortality in Monmouth, as the death-rate

Table IV. *Showing (A) the standardised death-rate from phthisis per 1000 at age 5+ in the counties of Wales during certain periods, (B) the death-rate in each county expressed as a percentage of the value in the whole country at the corresponding period.*

Counties	Period	Urban		Rural	
		A	B	A	B
Anglesey	1911-1914	1.280	126	1.358	116
	1921-1924	1.081	115	1.232	121
	1928-1931	1.064	121	1.203	136
Brecknock	1911-1914	0.993	98	0.912	78
	1921-1924	0.899	96	0.889	87
	1928-1931	0.910	104	0.904	102
Cardigan	1911-1914	1.538	151	2.058	177
	1921-1924	1.192	127	1.559	153
	1928-1931	1.136	129	1.196	135
Carmarthen	1911-1914	1.350	133	1.328	114
	1921-1924	1.178	125	1.231	121
	1928-1931	0.756	86	0.896	101
Carnarvon	1911-1914	1.563	154	1.636	140
	1921-1924	1.022	109	1.638	161
	1928-1931	1.078	123	1.554	175
Denbigh	1911-1914	1.227	121	0.858	74
	1921-1924	0.927	99	0.708	69
	1928-1931	0.757	86	0.658	74
Flint	1911-1914	1.006	99	1.164	100
	1921-1924	0.733	78	0.802	79
	1928-1931	0.657	75	0.693	78
Glamorgan	1911-1914	0.952	94	0.977	84
	1921-1924	0.971	103	0.811	80
	1928-1931	0.905	103	0.822	93
Merioneth	1911-1914	1.634	161	1.646	141
	1921-1924	1.255	133	1.358	133
	1928-1931	1.144	130	1.029	116
Monmouth	1911-1914	0.752	74	0.765	66
	1921-1924	0.769	82	0.930	91
	1928-1931	0.824	94	0.683	77
Montgomery	1911-1914	1.137	112	1.127	97
	1921-1924	1.076	114	0.960	94
	1928-1931	0.968	110	0.957	108
Pembroke	1911-1914	1.392	137	1.149	99
	1921-1924	1.263	134	1.016	100
	1928-1931	0.867	99	0.851	96
Radnor	1911-1914	0.701	69	1.067	92
	1921-1924	0.822	87	1.085	106
	1928-1931	1.124	128	0.611	69
Wales and Monmouth	1911-1914	1.017	100	1.166	100
	1921-1924	0.941	100	1.019	100
	1928-1931	0.879	100	0.887	100

in 1928-1931 was 10 per cent. higher than that in 1911-1914. In Glamorgan and in Brecknock a slight fall occurred, 5 per cent. in the former and 8 per cent. in the latter. In most of the other counties the position was more satisfactory; in Cardigan the mortality decreased 26 per cent., in Carnarvon 31 per cent.

and in Merioneth 30 per cent., whilst in Carmarthen the decline was as much as 44 per cent. Considering that the last four counties have much phthisis this substantial decline in the death-rate is very satisfactory.

Table V. *Showing the decline in the phthisis mortality in each county—the death-rates in the two succeeding four-yearly periods being expressed as percentages of the values in 1911–1914.*

Counties	Period	Urban	Rural
Anglesey	1911–1914	100	100
	1921–1924	84	91
	1928–1931	83	89
Brecknock	1911–1914	100	100
	1921–1924	91	97
	1928–1931	92	99
Cardigan	1911–1914	100	100
	1921–1924	78	76
	1928–1931	74	58
Carmarthen	1911–1914	100	100
	1921–1924	87	93
	1928–1931	56	67
Carnarvon	1911–1914	100	100
	1921–1924	65	100
	1928–1931	69	95
Denbigh	1911–1914	100	100
	1921–1924	76	83
	1928–1931	62	77
Flint	1911–1914	100	100
	1921–1924	73	69
	1928–1931	65	59
Glamorgan	1911–1914	100	100
	1921–1924	102	83
	1928–1931	95	84
Merioneth	1911–1914	100	100
	1921–1924	77	83
	1928–1931	70	63
Monmouth	1911–1914	100	100
	1921–1924	102	122
	1928–1931	110	89
Montgomery	1911–1914	100	100
	1921–1924	95	85
	1928–1931	85	85
Pembroke	1911–1914	100	100
	1921–1924	91	88
	1928–1931	62	74
Radnor	1911–1914	100	100
	1921–1924	117	102
	1928–1931	160	57
Wales and Monmouth	1911–1914	100	100
	1921–1924	93	87
	1928–1931	86	77

Rural divisions

Whilst there was no increase of mortality in the rural divisions of any county during the last period, nevertheless the trend of the death-rate in several of them was rather disappointing. In Brecknock the mortality during 1928–1931 was almost as high as in 1911–1914, and in Carnarvon where we have already seen (in Table IV) that the mortality was 75 per cent. in excess

of the standard the decline in 1928–1931 was only 5 per cent. In contrast with this, the experience in Cardigan was more satisfactory, as the death-rate which, in 1921–1924, had declined 24 per cent., again fell significantly in the last period.

The chief characteristic exhibited in the table may be briefly summarised by answering the following question. Generally, did those urban and rural divisions which experienced appreciable diminution in their mortality in the second period, 1921–1924, as compared with the first period, 1911–1914, continue to do so in the third period, 1928–1931? We can estimate the extent of the progression by correlating the percentage decreases that took place between 1911–1914 and 1921–1924 with the corresponding decreases between 1921–1924 and 1928–1931. In the urban districts the correlation coefficient was $+0.428 \pm 0.227$ and in the rural districts -0.277 ± 0.256 . Although the coefficient for the urban divisions of the counties is not quite significant as it does not exceed twice its standard error there is, nevertheless, in the two periods compared, evidence of an appreciable uniformity in the trend of the mortality. In the rural divisions the relationship is of a slightly inverse character—the counties which had a decrease in their death-rates in 1921–1924 experienced an increase during 1928–1931, and *vice versa*.

ENVIRONMENT

We have seen that there was considerable variation in the phthisis mortality in the urban and in the rural divisions of the counties of Wales. The mortality in the aggregate rural areas of Cardigan in 1911–1914 was 77 per cent. in excess of that for rural Wales, whereas in Monmouth there was a defect of 34 per cent. Similarly, in the urban districts, Carnarvon had an excess of 54 per cent. whilst in Radnor there was a defect of 31 per cent. What are the causes instrumental in producing these wide fluctuations in the mortality in the Welsh counties, and particularly in two counties like Cardigan and Radnor which are preponderantly agricultural? Is the influential factor mainly hygienic? If the standardised death-rate from all causes of death be regarded as an index of hygiene or environment, then by correlating the mortality from phthisis with that from all causes less phthisis we should be able to throw some light on the question asked. It does not of course follow that the correlation between the two variables will be linear. It is conceivable that a certain lack of hygiene will help to increase the incidence and possibly the mortality from any particular infectious disease, but an increased deterioration of sanitary conditions will not cause a *pro rata* increment in the prevalence of that disease. In other words, the relationship may be curvilinear rather than linear. This is probably truer of incidence than of mortality.

The question of the influence of hygiene on health was discussed at length by the late Dr Brownlee, who utilised the death-rates of the boroughs of London for the purpose. These divisions represent various grades of environment—from an overcrowded area such as Stepney to a residential district

such as Hampstead. He correlated the mortality from all causes less phthisis with that from phthisis in each borough during the period 1907–1911 and obtained a coefficient of +0.93. He regarded this result as of extreme importance. According to him: "It proves that for one district, namely London, a district, which has been shown to have practically no phthisis but the type affecting middle age, there is an absolute correlation between the degree of health in each district and the amount of phthisis." In view of this result for London it was of interest to measure the relation in the urban and rural divisions of the Welsh counties. Accordingly the standardised death-rates at age 5 years and upwards from all causes less phthisis and those from phthisis for each sex in the urban and rural divisions of the Welsh counties for the period 1911–1914 were correlated and the results were:

	Urban districts 1911–1914	Rural districts 1911–1914
Males	$r = +0.278 \pm 0.256$	$r = +0.122 \pm 0.273$
Females	$r = -0.143 \pm 0.272$	$r = +0.064 \pm 0.276$

There is little evidence that any defined relationship such as Brownlee found for London exists between the Welsh data. The disagreement is more noteworthy as, during the period 1911–1914, the middle-age type of phthisis prevailed in the urban and rural divisions of Wales—the age of maximum mortality amongst persons being 25–45 years. To test the matter further the mortality rates at specific ages for the two variables were correlated, and the values found for the age group 25–45 years were:

	Urban districts	Rural districts
Males	$r = +0.241 \pm 0.261$	$r = -0.154 \pm 0.271$
Females	$r = +0.383 \pm 0.237$	$r = +0.471 \pm 0.216$

Only one of these coefficients is statistically significant, that for females in the rural districts. In the other age groups the largest coefficients were mainly negative. There is thus nothing in these results to suggest that hygienic conditions which are inimical to health in general also materially affect the incidence of phthisis. This, of course, does not imply that the type of environment is immaterial to those suffering from pulmonary tuberculosis or that certain conditions of life will not lead to a high general death-rate and a high phthisis death-rate. What it does imply is the existence of other predominating factors which influence the amount of phthisis but leave practically untouched other forms of mortality or *vice versa*. It may be argued, however, that although the maximum mortality amongst persons in Wales was at age 25–45—the period in which middle-age type of phthisis prevails—this may not be necessarily representative of the individual counties, as the age incidence of the mortality in the whole country must inevitably be influenced by the large percentage of the total population living in the administrative counties of Glamorgan and Monmouth. We can best illustrate the extent, if any, of the correlation, or lack of correlation, between the general and phthisis death-rates by confining the tabulation to the four counties with excess phthisis—

Cardigan, Carmarthen, Carnarvon and Merioneth. Expressing the specific death-rates from phthisis in each county as percentages of the standardised death-rates from phthisis within each county, the results are given in Table VI in which the values for the whole country are also detailed. It will be seen from the table that the modal age which was previously shown to be at age 25-45 for persons varies for each sex. Amongst females, both in the whole country and in the urban and, to a lesser extent, in the rural divisions of the counties, the maximum mortality occurs at age 25-45; amongst males the age affected is 45-65 in Wales, but there is a fair degree of variation between the counties.

Table VI. *Showing the death-rates from phthisis in age periods expressed as percentages of the standardised death-rates (S.D.R.) from the disease, 1911-1914.*

County	Age group											
	Males						Females					
	S.D.R.	5-	15-	25-	45-	65+	S.D.R.	5-	15-	25-	45-	65+
Urban												
Wales and Monmouth	100	14	88	138	165	97	100	27	127	140	107	46
Cardigan	100	11	87	196	66	78	100	53	131	135	83	23
Carnarvon	100	26	87	150	135	69	100	35	102	154	99	59
Carmarthen	100	12	104	144	157	29	100	45	107	149	100	22
Merioneth	100	13	105	92	169	295	100	18	114	147	113	83
Rural												
Wales and Monmouth	100	13	96	141	144	116	100	25	132	144	95	49
Cardigan	100	12	100	149	128	110	100	30	140	136	89	61
Carnarvon	100	9	108	120	163	155	100	34	149	140	71	38
Carmarthen	100	22	108	138	117	130	100	29	132	142	90	62
Merioneth	100	12	97	137	179	30	100	26	133	138	106	41

If, as has been suggested by Brownlee, phthisis in middle age is highly correlated with environment, then one would expect that the relationship should be highly defined for females and less defined for males. The correlation coefficients were higher for the former than for the latter, but not to a significant degree. We can confirm the absence of any significant degree of association between the two variables under consideration by an examination from another angle. If we take the four counties given in Table VI and express their death-rates from all causes less phthisis in the all-ages group and at specific age periods as percentages of the corresponding values for Wales we obtain the results in Table VII. On the whole, it will be seen that the high mortality from phthisis in these counties is not due to bad environmental conditions, as the incidence of all other forms of mortality is in them no greater than that which exists in Wales generally.

Table VII. Showing the death-rate from all causes less phthisis in certain counties expressed as a percentage of the corresponding value in Wales and Monmouth during 1911-1914.

County	Age group											
	Males						Females					
	5-	15-	25-	45-	65 +	S.D.R.	5-	15-	25-	45-	65 +	S.D.R.
	Urban											
Wales and Monmouth	100	100	100	100	100	100	100	100	100	100	100	100
Cardigan	95	40	84	112	92	94	67	86	73	92	95	89
Carnarvon	87	76	95	92	103	96	94	80	76	83	95	88
Carmarthen	129	84	90	104	98	99	117	107	120	109	102	108
Merioneth	73	97	97	99	95	95	96	100	101	73	98	90
	Rural											
Wales and Monmouth	100	100	100	100	100	100	100	100	100	100	100	100
Cardigan	113	85	107	86	97	95	87	103	112	86	105	100
Carnarvon	114	92	103	98	107	103	130	123	97	98	102	103
Carmarthen	117	100	94	86	105	98	118	108	105	102	96	101
Merioneth	79	141	87	104	106	103	81	101	127	96	101	103

THE INFLUENCE OF OCCUPATION

Amongst the many factors which have been regarded as playing an important rôle in causing the high incidence of phthisis in parts of Wales, attention has been drawn by certain investigators to the influence of particular occupations. In the report of the King Edward VII Welsh National Memorial Association, June 1933, on the incidence of phthisis in the district of Gwyfrai in Carnarvonshire, the slate-quarrying industry was incriminated in the following terms:

1. In slate-quarrying districts males who find employment in this industry are more susceptible to tuberculosis than those not so employed.
2. The tuberculosis death-rate in these workers is highest in late life.
3. The duration of illness is short, suggesting that quarrymen suffer from an acute form of the disease.

The average specific death-rates from phthisis amongst slate miners and quarriers, as stated in the *Occupational Mortality Supplement*, England and Wales, 1921-1923, were as follows:

Age	20-25	25-35	35-45	45-55	55-65	65-70	70 +
Rate per 100,000	53	188	195	307	491	727	91

Although the high death-rate at age 65-70 confirms the previous conclusion (2) it seems rather remote to regard the mortality at this period of life as an occupational risk. If the conditions of the trade are deleterious to health, then one would expect to find evidence in an excessive mortality earlier than age 65-70.

Arising out of these considerations, however, it seemed desirable to study on fairly broad lines the effect of various occupations in the causation of phthisis throughout the Welsh counties generally. But, prior to any such

discussion, it is necessary to have some idea as to the type of occupation mainly pursued in each county. If we take the 1921 census as our guide, since it is intermediate to that of 1911 and 1931, and confine our attention to the principal occupations, we find that, in each administrative county and in the aggregate rural districts within each county, the proportions of the male population aged 12 years and upwards occupationally engaged were as follows (Table VIII). It is apparent from this table that, apart from the metal trade

Table VIII. *Showing the proportion per 1000 males age 12 and upwards for various occupations at the 1921 census.*

County	Agri- culture	Mining and quarrying	Coal and shale	Stone miners and quarriers	Slate miners and quarriers	Metal workers*
Anglesey, Adm. C.†	316	28	13	11	—	40
Aggr. of rural	474	39	18	15	—	22
Brecknock, Adm. C.	202	270	261	8	—	44
Aggr. of rural	268	278	266	10	—	42
Cardigan, Adm. C.	337	75	66	—	—	28
Aggr. of rural	460	92	82	—	—	20
Carmarthen, Adm. C.	163	222	217	—	—	144
Aggr. of rural	268	285	278	—	—	76
Carnarvon, Adm. C.	166	126	14	27	79	41
Aggr. of rural	277	179	16	28	127	32
Denbigh, Adm. C.	169	229	215	9	—	45
Aggr. of rural	223	314	296	11	—	41
Flint, Adm. C.	134	115	105	6	—	123
Aggr. of rural	192	138	122	10	—	125
Glamorgan, Adm. C.	21	339	336	—	—	99
Aggr. of rural	72	350	345	—	—	114
Merioneth, Adm. C.	280	147	15	15	110	30
Aggr. of rural	421	99	18	14	60	23
Monmouth, Adm. C.	46	356	354	—	—	108
Aggr. of rural	316	48	44	—	—	90
Montgomery, Adm. C.	413	41	24	9	—	30
Aggr. of rural	548	46	25	11	—	20
Pembroke, Adm. C.	240	48	39	—	—	85
Aggr. of rural	414	76	61	—	—	40
Radnor, Adm. C.	423	32	19	11	—	27
Aggr. of rural	547	36	22	14	—	20

* Metal workers do not include electro plate nor precious metal workers.

† Adm. C. stands for Administrative County.

in Carmarthen and Flint, and to a lesser extent in Glamorgan and Monmouth, the workers in Wales are employed in two main occupational categories: (1) agriculture, (2) mining and quarrying, the latter comprising miners of coal, stone, slate and quarriers. The variation in the proportion of agricultural workers in the rural areas of the counties is noteworthy. In the aggregate of the rural districts in Glamorgan 7.2 per cent. of the total employed were engaged in agriculture, the corresponding proportion in the rural areas of Radnorshire was 54.7 per cent.

To afford a more concise representation of the occupational distribution in Wales the counties may be grouped into five categories:

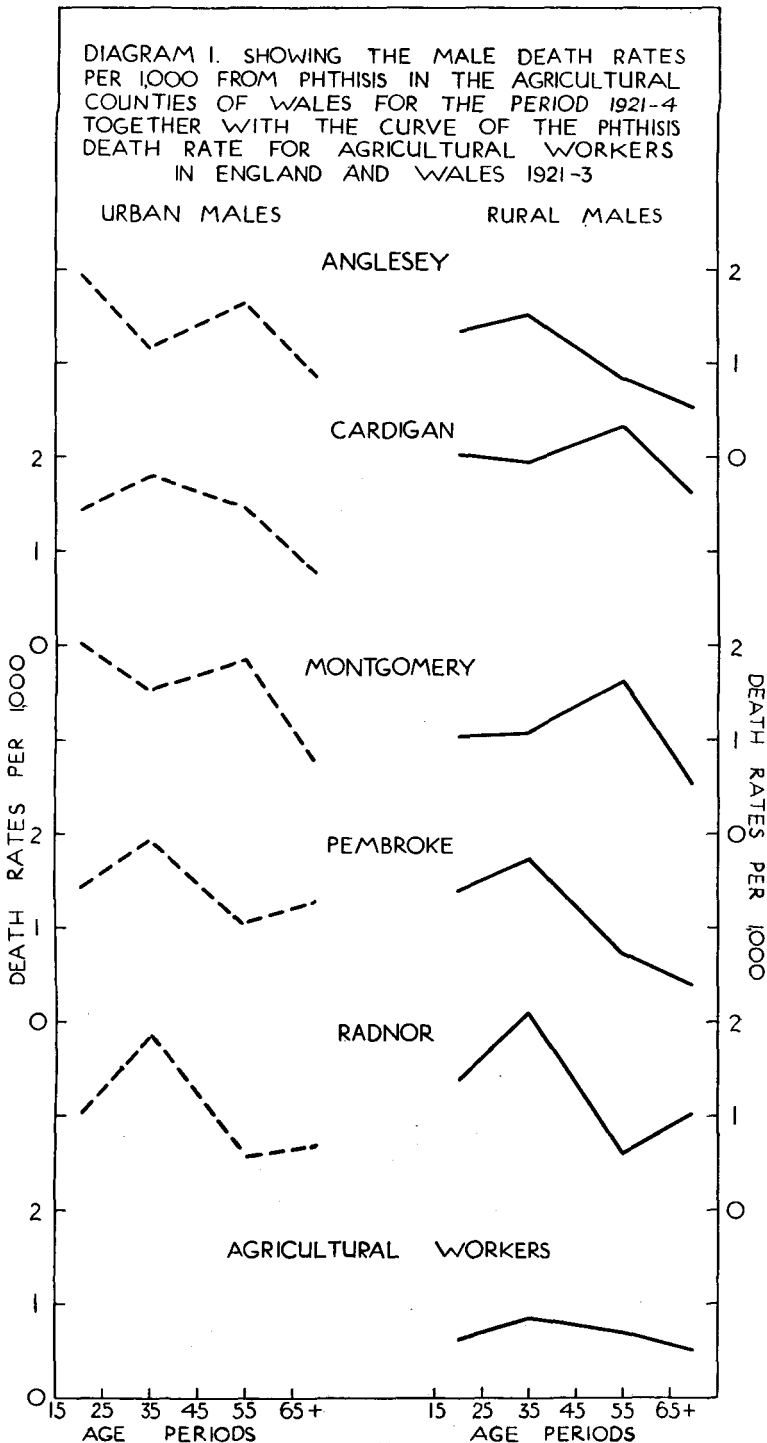
Pulmonary Tuberculosis in Wales

Occupation	Counties
(1) Agricultural (mainly)	Cardigan, Montgomery, Radnor, Pembroke, Anglesey
(2) Agriculture plus coal and shale mines	Denbigh, Brecknock
(3) Agriculture plus slate mines	Carnarvon, Merioneth
(4) Chiefly coal and shale mines	Glamorgan, Monmouth
(5) Agriculture, coal, iron and steel	Carmarthen, Flint

Since the counties composing group (1) are mainly agriculture, it would be expected that their phthisis death-rates at ages for the period 1921-1924 should approximate closely to those for agricultural workers as stated in the *Occupational Mortality Supplement* for 1921-1923. But, as will be seen from the diagram (Diagram 1), the graphs for the urban and rural divisions of the individual counties bear little resemblance to that for agricultural workers. Amongst agricultural workers generally the mortality from phthisis is at a maximum in the age group 25-45 and afterwards continuously declines. The graphs for the rural divisions of Cardigan and Montgomery, alike in themselves, both exhibiting the highest death-rate in adult life, are entirely dissimilar to the basic curve—that for all agricultural workers. In Anglesey and Pembroke the shape of the curves is in fairly close agreement with the expected type, whereas in Radnorshire, the most agricultural county in Wales, the mortality declined abruptly after age 25-45 but, in the old age, the curve pursued an upward direction. Is this lack of agreement in the trend of the curve for these counties with that for entire agricultural workers due to causes other than occupational, or are the residual occupations within each county so conducive to phthisis as to effect materially the shape of the curve? That there is a very close relationship between the incidence of phthisis and certain types of occupation is unquestionable. For example, according to the Occupational Mortality experience in England and Wales during the period 1921-1923, the standardised death-rate from phthisis amongst tin miners aged 20-65 when expressed in terms of that amongst occupied and retired males (the figure for the latter being represented as 1000) was 12,607; grinders in the cutlery trade, 7878; metal grinders, 4256. If we take the principal occupations in Wales then, on the same basis, we should expect to find that the relative incidence of their mortality from phthisis was:

Farmers	414
Agricultural labourers	588
Coal miners not including superintending staff	755
Stone miners and quarriers	949
Slate miners and quarriers	1594
Metal moulders	1070
Metal glaziers, polishers	2124
Metal grinders	4256

Hence, assuming that no other factor operated, the presence of these occupations, if on an extensive scale, would largely determine the total male mortality from phthisis in the county or the district in which they were located. We can approximately assess the influence of occupation on the phthisis mortality of any county during the period 1921-1923 by a comparison of the actual deaths with the calculated deaths. The calculated deaths in each county are those



which would occur if the male population employed in various occupations within the county experienced, according to age, the rates of mortality which prevail in England and Wales generally in these occupations. In the present instance the procedure necessary for their calculation was as follows:

In the 1921 census the number and age distribution of males in each of the thirty-one wide occupational groups was given for each county in Wales. The occupations enumerated were as follows:

- (1) Fishermen
- (2) Agricultural occupations
- (3) Mining and quarrying occupations
- (4) Makers of coke, lime, cement, etc.
- (5) Makers of bricks, pottery, glass
- (6) Workers in chemicals, paints, etc.
- (7) Metal workers
- (8) Workers in precious metals, etc.
- (9) Electrical appurtenances, makers, fitters, etc.
- (10) Makers of watches, clocks, etc.
- (11) Workers in skins, leather goods makers
- (12) Textile workers
- (13) Makers of textile goods and articles of dress
- (14) Makers of foods, drinks and tobacco
- (15) Workers in wood and furniture
- (16) Paper workers, printers, etc.
- (17) Builders, bricklayers, etc.
- (18) Painters and decorators
- (19) Workers in other materials
- (20) Workers in mixed or undefined materials (not elsewhere enumerated)
- (21) Workers in gas, water and electrical supply
- (22) Transport workers
- (23) Commercial and financial occupations
- (24) Public administration and defence
- (25) Professional occupations
- (26) Persons employed in entertainments
- (27) Persons employed in personal service
- (28) Clerks, draughtsmen, typists, etc.
- (29) Warehousemen, packers, etc.
- (30) Stationary engine drivers, etc.
- (31) All other occupations

In the *Occupational Mortality Supplement* for 1921–1923 the specific rates from certain causes amongst males in England and Wales were stated for 164 occupational groups. These 164 occupations were for the present purpose re-classified into 31 groups, corresponding roughly with the occupational grouping in each county as shown above, and revised rates of mortality from phthisis at ages 16–20, 20–25, etc., were tabulated for each of the new groups. Owing to the fact that the occupational grouping, as published in the census for each county, was too comprehensive—miners and quarryers, for instance, were tabulated under the single heading Mining and Quarrying—and furthermore since there is an appreciable difference between the death-rates from phthisis amongst miners in the varied occupational categories of coal, slate, stone, it follows that these new or revised death-rates can be accepted as *only rough indices of the mortality* at ages within each of the occupational groups. It was then assumed that the male population in age groups in each of the thirty-one occupational groups within each Welsh county experienced these new or revised death-rates. On this basis a certain number of deaths would be

expected to occur in each county. These were regarded as the calculated or expected deaths which form a comparison with the actual deaths. When the difference between the actual and calculated number of deaths in any county exceeded at least twice its standard error in a plus or minus direction (the standard error of the difference was regarded as equal to the square root of the calculated number of deaths), the result indicated an excess or deficiency in the phthisis mortality. The final results are given in Table IX. In interpreting this table it must be remembered that if (1) the male population within

Table IX. *Comparing the actual and the calculated number of deaths, the latter representing the deaths that would occur in each Welsh county if the workers in each occupation within each county experienced the rates of mortality which prevailed in these occupations in England and Wales, 1921-1923.*

County	Actual no. of phthisis deaths 1921-1923	Calculated no. of phthisis deaths 1921-1923	Difference	Standard error or Difference	
				$\sqrt{\text{Expected}}$	Standard error
Anglesey	69	58.48	+ 10.52	7.65	+1.37
Brecknock	62	70.84	- 8.84	8.42	-1.05
Cardigan	117	62.10	+ 54.90	7.88	+6.97
Carmarthen	280	205.31	+ 74.69	14.33	+5.21
Carnarvon	255	153.20	+101.80	12.38	+8.22
Denbigh	152	178.47	- 26.47	13.34	-1.98
Flint	142	130.94	+ 11.06	11.45	+0.97
Glamorgan	1850	1605.59*	+244.41	40.06	+6.10
Merioneth	86	49.66	+ 36.34	7.05	+5.15
Monmouth	481	565.43	- 84.43	23.78	-3.55
Montgomery	77	55.66	+ 21.34	7.46	+2.86
Pembroke	129	105.91	+ 23.09	10.30	+2.24
Radnor	34	24.71	+ 9.29	4.97	+1.87

* These deaths are underestimated since population referred only to administrative areas where number exceeded 50,000.

each county had been suitably distributed according to occupation, and (2) the death-rates at ages adequately represented the risk of death in each particular occupation, then, in the absence of any other causative agency, the number of the calculated deaths should agree closely with the recorded or actual deaths. It will be seen in the table that when allowance is made for the influence of occupation, although the method of assessment is, as has been stated, rather empirical, the four counties—Carnarvon, Cardigan, Merioneth and Carmarthen—are still associated with high phthisis mortality. In Carnarvon the ratio of the difference to its standard error is 8.22; in Cardigan 6.97. As regards Glamorgan it will be noted that the observed number of deaths significantly exceeds the calculated but, in this particular instance, the divergency does not represent a heavy phthisis incidence. The difference is due to the fact that the number of occupied males in Glamorgan was stated only for districts which had a population in excess of 50,000. Hence the number of calculated deaths attributable to occupational influence is not representative of the county, whereas the number of actual or recorded deaths is complete.

MIGRATION

Many investigators have from time to time studied the possible influence of migration on the health of a community. A detailed investigation of this factor was made in the County of Essex by A. B. Hill¹, who was mainly concerned with its effect upon the general death-rate. In any discussion on the mortality from phthisis the importance of migration as a contributory factor certainly must not be overlooked. The healthy young adults—some ambitious of success, others restless with the circumscribed aspect of rural life, may migrate from the country towns and villages to seek a possible fulfilment of their hopes in the large industrial centres. The residuals, who may represent a less physically fit section of the population, have the superadded defect that, in many instances, they live under impoverished conditions, and hence can offer little resistance to an infection like that of pulmonary tuberculosis. Furthermore, their ranks are often increased by the return of those who were unable to stand the stress of city life. To what extent the returned migrant, broken in health, adds to the phthisis mortality of a district is problematical, since there are no actual statistics on this specific aspect. But that the problem is of some importance is undeniable, as can be easily verified by a perusal of reports on the incidence of phthisis in certain local areas in Wales. In a report by the King Edward VII Welsh National Memorial Association we find the following statement. "Many of the females who are of the young adult class, come from homes heavily infected with tuberculosis, and it is only too common for these girls to break down under the strain of town life. They return home with active tuberculosis. Particulars of numerous cases of this nature have been obtained and one is struck by the frequency with which members of the nursing profession suffer in this respect. In almost every instance there is a family history of tuberculosis and it is probable that in these cases the change of environment and the long hours play their part in lowering the resistance."

That there has been a vast amount of migration from Wales is certain. The recruitment in the drapery stores and milk trade of London in the past alone bears some testimony of this fact. If the drainage of the best elements of the population acted more heavily in some counties than in others, this would partly explain the peculiar geographical distribution of phthisis mortality in Wales. What counties in Wales suffer most by migration of the population? To answer this question we utilised the following information: (1) the total increase or decrease of population, (2) the excess of births over deaths, (3) the gain or loss by migration; each figure expressed as a percentage of the population in 1901 is given in Table X, for each county in Wales for the period 1901–1911. If there had been no migration there would have been an increased population in each county, as the births exceeded the deaths in every instance, the increase ranging from 20 per cent. in Monmouth and Glamorgan to

¹ *Internal Migration and its Effect upon the Death Rates: with Special Reference to the County of Essex*. Medical Research Council Series, No. 15. 1925.

2.2 per cent. in Cardigan. But, when the migratory element is taken into consideration, that is, by deducting the natural increase from the actual intercensal increase, we find that, with four exceptions—Monmouth, Glamorgan, Carmarthen and Flintshire, mainly coal- and iron-mining centres—the population decreased in the remaining counties. In case the facts exhibited in the table were characteristic only of the 1901–1911 period, the data for the period 1891–1901 were also examined but, instead of using the registration counties as units, their component registration districts were employed. This allowed a more detailed representation of the facts. The percentage gain or loss by migration in each registration district for the period 1891–1901 was correlated with the corresponding value for the period 1901–1911, and the correlation coefficient was $r = +0.619 \pm 0.086$. This suggests that the areas from which the migrants were drawn in 1901–1911 were equally the centres of recruitment in the previous period. Knowing that the volume of migrants varied appreciably

Table X. *Showing the percentage increase or decrease of the population in each county of Wales, 1901–1911.*

County	Total percentage increase or decrease	Excess of births over deaths	Gain + or Loss - by migration
Anglesey	+ 1.6	7.0	- 5.4
Brecknock	+ 4.5	11.0	- 6.5
Cardigan	- 2.3	2.2	- 4.5
Carmarthen	+ 22.2	13.6	+ 8.6
Carnarvon	+ 3.3	6.9	- 3.6
Denbigh	+ 8.2	10.8	- 2.6
Flint	+ 15.2	12.6	+ 2.6
Glamorgan	+ 30.5	19.9	+ 10.6
Merioneth	- 6.2	6.8	- 13.0
Monmouth	+ 30.9	20.0	+ 10.9
Montgomery	- 2.8	7.5	- 10.3
Pembroke	+ 3.0	9.6	- 6.6
Radnor	- 13.5	9.6	- 23.1

from county to county it was of interest to discover if the counties with high rates of migration experienced high or low rates of mortality from phthisis. For this purpose the percentage gain or loss of population in each county for the period 1901–1911 was correlated with the corresponding standardised death-rate from phthisis at age 5 years and upwards in (1) the urban, and (2) the rural divisions of each Welsh county for the period 1911–1914. The variation in time or the lag between migration and the mortality rates takes into consideration the interval which must inevitably arise in any relationship between these two variables. It can hardly be expected that migration would have an instantaneous effect on the phthisis death-rate. The correlation coefficients between the two variables were as follows:

Urban districts	Rural districts
$r = -0.587 \pm 0.189$	$r = -0.399 \pm 0.243$

The result for the urban divisions is statistically significant, whereas the value in the rural districts is within the limits of chance. In both cases, however, the coefficient is negative in sign, which suggests that those divisions with negative percentages—divisions which had a loss of population through

emigration had on the average fairly high death-rates from phthisis, whereas the divisions with positive indices—the population increased by immigration, had fairly low death-rates. It may be argued that the standardised death-rate at age 5 years and upwards is too comprehensive a measure with which to assess the effects of migration, since the age incidence of migrants is between 15 and 45 years with the modal age usually between 20 and 25 years. For this reason it was deemed advisable to calculate the coefficients between migration and the mortality from phthisis at two specific age periods, 15–25 years and 25–45 years. The data for the age period 20–25 years were not available. The results were:

Age group	Urban division	Rural division
15–25	$r = -0.533 \pm 0.207$	$r = -0.311 \pm 0.261$
25–45	$r = -0.459 \pm 0.228$	$r = -0.502 \pm 0.216$

At both ages the values for the urban divisions are statistically significant, whereas in the rural divisions the coefficient in the age group 25–45 is the more important. The reversal of the magnitude of the coefficients with age in the rural as compared with the urban divisions is a point worthy of notice. A possible explanation of the occurrence is that in rural areas the effects of migration on the mortality from phthisis is experienced at a later age than in urban districts. In other words, living in the country helps to postpone a fatal issue.

MORTALITY IN SMALL AREAS

In discussing the incidence or the mortality from any disease, particularly from an infectious disease, there may be certain disadvantages in making an administrative county or even its divisions—the aggregate of urban and aggregate of rural districts—the unit of tabulation. The locus of infection or the “black spot” may be a specific area or a group of small areas, and their importance may be completely overshadowed in a statement of the mortality for the whole county. For this reason it seems desirable to have a detailed presentation according to the constituent parts of the county despite the fact that, in consequence of this subdivision, the population or the numbers exposed to risk will be smaller than when the larger area—the whole county—is investigated. The necessary allowance can, however, be made in the results for chance fluctuations due to the smallness of the population. In 1911, in addition to tabulating the data for the individual administrative counties with their associated county boroughs, the Registrar General also published the deaths for the smaller urban and rural districts, though not according to age. In this section the mortality from phthisis in these small areas will be discussed.

The method of analysis—a comparison of the actual and expected deaths—is similar to that previously employed in obtaining the occupational mortality in each county. It was assumed that the population at ages in 1911 in each urban and rural district experienced the death-rates which prevailed at those ages in urban and in rural Wales respectively during 1911–1914. The deaths

which were so obtained were regarded as the calculated deaths. These were then compared with the observed deaths during the same period, 1911-1914, and the difference between them expressed in terms of their appropriate standard errors. The regional distribution of these ratios is shown in the following Map. The category 2 to 4 indicates the administrative areas in which the difference between the recorded and calculated deaths was not less than twice and not greater than four times the standard error. The other groups bear a like interpretation. A similar analysis was made for each of the other periods—1921-1924 and 1927-1930—but, in neither instance, was it so nearly representative as that for 1911-1914, because the number of districts for which the Registrar-General published the deaths was considerably reduced in the later periods. The number of districts for which records were available during 1911-1914 totalled 185, of which 108 were urban and 77 rural.

The ratio

$$\frac{\text{Actual—Calculated deaths}}{\sqrt{\text{Calculated deaths}}} \quad \text{or} \quad \frac{\text{Difference}}{\text{Standard error of difference}}$$

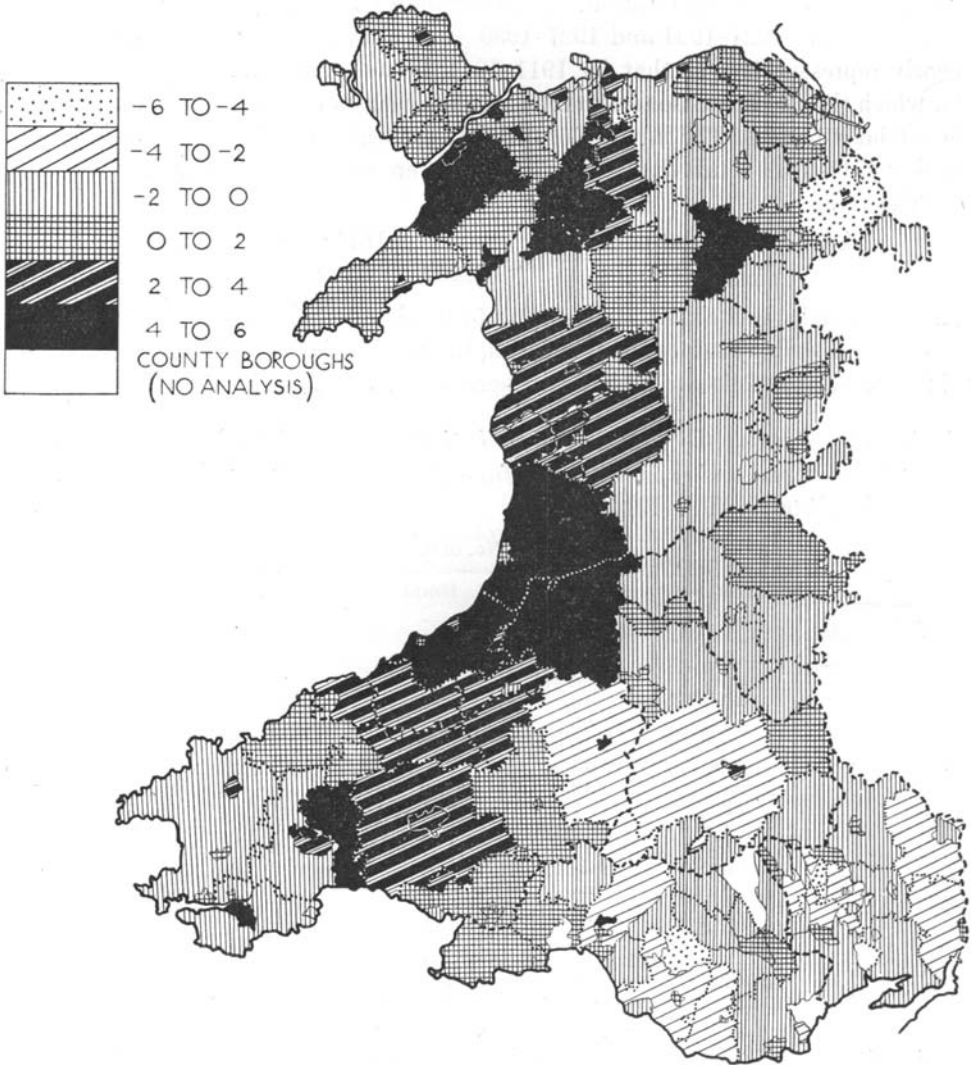
for each district was classified according to its sign and size and the resultant frequency distribution for urban divisions, the rural divisions and the aggregate of the two was as follows (Table XI). There were 72 districts in Wales in which

Table XI. *Showing the frequency distribution of the ratios of the difference between actual and expected deaths from phthisis to their standard errors in Welsh districts, 1911-1914.*

Ratios or Actual—Expected $\sqrt{\text{Expected}}$	No. of districts			Total		
	Urban	Rural	Urban and Rural			
-6	1	—	1			
-5	1	1	2			
-4	1	2	3			
-3	8	6	14			
-2	10	14	24			
-1	25	18	43			
0	19	10	29			
1	18	10	28			
2	10	5	15			
3	7	4	11			
4	6	3	9			
5	2	1	3			
6	—	2	2			
7	—	1	1			
	108	77	185			
	Within once S.E.	Between once and twice S.E.	Between twice and three times S.E.	Between three and four times S.E.	Four times S.E.	
Actual	72	52	29	14	18	185
Expected	126.30	50.28	7.94	0.48	—	185.0

the differences between the actual and calculated deaths were within the range of once their standard errors in a plus and minus direction. Assuming a normal distribution of the ratios we should expect 126 districts within this category.

SHOWING THE EXCESS OR DEFECT IN THE DEATHS FROM
PHTHISIS IN THE ADMINISTRATIVE DISTRICTS OF
WALES 1911-1914



Between the limits of once and twice the standard error, fact and theory agree closely, 52 districts as against a theoretical 50, but in the higher limits where the ratios of the differences to their standard errors exceed three there is no correspondence whatever. There were 32 districts in which the phthisis mortality differed completely from what might be expected. These 32 districts and the counties within which they are situated are stated in Table XII. In 15 urban districts and in 11 rural districts the mortality was excessive and in 3 urban districts and in 3 rural districts it was significantly in defect of the

Table XII. *Showing the urban and rural areas in which the phthisis mortality during 1911–1914 was greatly in excess (+) or greatly in defect (–) as indicated when the ratio of the differences to their standard errors exceeded 3.*

County	Urban district		County	Rural district	
Anglesey	Amlwch	3.6	Cardigan	Aberayron	4.8
Cardigan	Aberayron	3.0		Aberystwyth	5.9
Carmarthen	Carmarthen	3.3		Lampeter	3.3
	Llandovery	4.4		Tregaron	6.3
Carnarvon	Bangor	4.8	Carmarthen	Carmarthen	3.1
	Bethesda	4.9		Newcastle in Emlyn	3.6
	Carnarvon	5.5		Whitland	4.5
	Llanfairfechan	3.9	Carnarvon	Geirionydd	4.6
	Pwllheli	3.3		Gwyfrai	7.3
	Yngsnyhaiarn	4.1	Denbigh	Wrexham	–5.0
Denbigh	Wrexham	3.0	Glamorgan	Penybont	–3.8
Glamorgan	Neath	4.6	Merioneth	Dolgelly	3.1
	Ogmore and Garw	–4.0		Edeirion	6.1
Merioneth	Ffestiniog	5.2	Monmouth	St Mellons	–3.0
Monmouth	Abersychan	–3.4			
	Abertillery	–5.4			
Pembroke	Fishguard	3.3			
	Pembroke	4.3			

standard. The counties chiefly affected are Carnarvon, Cardigan, Carmarthen and Merioneth. In Carnarvon there were 8 districts with high phthisis mortality and in one of them, the rural district of Gwyfrai, the ratio exceeded 7. Cardigan contained 5 “black spots,” and it will be noted that they are mainly rural districts, whereas in Carnarvon the infected areas were chiefly urban in character. In Monmouth, on the other hand, there were 3 districts with a very low mortality; in the urban district of Abertillery the defect was reflected in a negative ratio as high as –5.4. Having seen the manner in which the phthisis mortality was distributed in Wales during the period 1911–1914, it was desirable to ascertain if the experience was consistent with that during each of the later periods. Accordingly the ratios, *i.e.*

The differences
Standard error of differences

in those districts for which the necessary information was recorded were correlated, the values in 1921–1924 and 1927–1930 were correlated each in turn with those in 1911–1914. The number of districts for which continuous records were available was greatly reduced, from 108 to 29 in the urban areas

and from 77 to 18 in the rural areas as, in the later periods, the Registrar-General restricted publication of the data to districts with a population exceeding 10,000. The results for the urban and rural areas were as follows:

Periods	Urban areas		Rural areas	
1911-1914 with 1921-1924	$N=29$	$r = +0.587 \pm 0.122$	$N=18$	$r = +0.930 \pm 0.032$
1911-1914 with 1927-1930	$N=29$	$r = +0.250 \pm 0.174$	$N=18$	$r = +0.856 \pm 0.063$

If there had been little or no alteration in the phthisis mortality during the periods under review the correlation coefficients should approximate to unity. In the urban districts there has been a material change. The ratios in 1911-1914 were positively correlated to a fairly high degree with those in 1921-1924 but, during 1927-1930, the mortality changed appreciably as the association between the indices of that period with those in 1911-1914 was statistically unimportant. In the rural districts, on the other hand, the position has been definitely static, as the coefficients have practically remained unaltered. Hence we can say generally that there are areas in Wales, particularly rural ones, in which during the periods under review the mortality from phthisis has been statistically consistent either in excess or in defect of the standard. An outstanding example of the former classification is the rural district of Gwyfrai in Carnarvonshire. In this area the facts were:

Period	Actual	Calculated	Difference
			Standard error of difference
1911-14	197	118	7.27
1921-24	192	91	10.60
1927-30	208	79	14.47

The question now arises—what are the operative factors which produce this excessive mortality in certain small areas of Wales? Housing, occupational risks, deficient nutrition, much inter-marriage, and the presence of certain anthropological characteristics in the population have all been mentioned as incriminatory factors by certain investigators in their examination of the incidence in specific areas. Much of the evidence, however, while interesting in itself, is not conclusive, as the possible relationship or the possible influence of these variables on the mortality from phthisis has been discussed in a rather generalised manner. There has been from a statistical view-point no satisfactory attempt made to elucidate the relative importance of each variable. In short, the incrimination has been general rather than specific.

HOUSING IN ADMINISTRATIVE AREAS

That bad or overcrowded housing may be a potent factor in the spread of infection few will deny. But because bad housing and a high phthisis mortality co-exist in a district or group of districts, we cannot necessarily assume a relationship of cause and effect. It may be that under exactly similar housing conditions in other parts of the country the incidence of the disease is unaffected. Are the conditions under which the Welsh people are housed, particularly as regards overcrowding, detrimental to their health? Accepting the index used by the Registrar-General to measure the prevalence and

distribution of overcrowding—the percentage of the population living more than two in a room—we find that at the 1911 and 1931 census the classification in 101 urban and 69 rural districts was as stated in Table XIII¹. In 1911 there were 46 urban districts in which less than 5 per cent. of the population lived in overcrowded homes, and 9 districts in which undesirable conditions prevailed. At the 1931 census a large improvement was recorded, as the number in the first category had increased to 63 and the “black spots” were reduced to 1 district. A similar improvement occurred in the rural areas. The mean

Table XIII. *Showing the incidence of overcrowding in the urban and rural districts in Wales in 1911 and 1931.*

Percentage of population living more than two persons per room	Urban				Rural			
	1911		1931		1911		1931	
	No. of districts	%	No. of districts	%	No. of districts	%	No. of districts	%
0-4	46	45	63	62	28	41	47	68
5-9	46	45	37	37	36	52	21	31
10-14	9	9	1	1	5	7	1	1
Total	101	99	101	100	69	100	69	100
Mean % of overcrowding	5.68		4.61		5.95		4.24	

percentage of the population living more than two in a room in the 101 urban districts was 5.68 at the 1911 census and 5.95 in the 69 rural areas. These proportions are certainly not excessive in view of the fact that the standard for England and Wales at the same period was 9.1 per cent., and the range in the English counties was from 1 to 30 per cent. and in the Welsh counties from 3 to 10 per cent. If we excluded the two English counties with an abnormal amount of overcrowding—Northumberland had 30 per cent. of its population under such conditions, and Durham 29.2 per cent.—the mean value for England alone drops from 8.9 to 7.6 per cent. The average for Wales was 6.1 per cent. The difference is slight and suggests that overcrowding, in terms of the index used, is not much greater in Wales than in England. Of course this statement does not imply that in isolated districts or parishes extreme instances will not be found. All that is maintained is that, in the official statistics of the administrative counties in 1911, there was little or no difference between the proportion of overcrowded homes in Wales as compared with England. This conclusion is also supported by the evidence available from the 1921 census. In view of this similarity and also the knowledge that the mortality from phthisis is higher in Wales than in England, one would expect

¹ The ratio of more than two persons per room was selected in the Census Reports for 1911 and earlier years as an approximate comparative index figure for the purpose of measuring the prevalence and distribution of overcrowding conditions. Since, however, that ratio has been commented upon as though it had been propounded as an absolute standard or a definition of overcrowding, it may be well to observe that its use in the census statistics implies no judgment whatever as to what in fact constitutes overcrowding.

that there would be but little association between overcrowding and the incidence of phthisis in Wales. Assessing the relative incidence by the standardised death-rate at age 5 years and upwards, the correlation coefficients between incidence and overcrowding were calculated for the urban and the rural areas for each of the three four-yearly periods, and were:

	Urban		Rural	
1911-1914	<i>N</i> = 108	<i>r</i> = - 0.173 ± 0.093	<i>N</i> = 74	<i>r</i> = - 0.078 ± 0.109
1921-1924	<i>N</i> = 45	<i>r</i> = - 0.502 ± 0.112	<i>N</i> = 36	<i>r</i> = - 0.499 ± 0.123
1927-1930	<i>N</i> = 35	<i>r</i> = - 0.260 ± 0.159	<i>N</i> = 21	<i>r</i> = - 0.246 ± 0.205

The result shows that the relationship is consistently of an inverse character; the mortality declines as the proportion of the population living under overcrowded conditions increases. Only the values for 1921-1924 are statistically significant. But the fact that the coefficients are negative in each instance supports the view that the results are not merely fortuitous. This result is so diametrically opposed to the general consensus of opinion and observation as to suggest an underlying fallacy. In case the index of overcrowding could be regarded as unsatisfactory, an additional test was made using the number of rooms per person. The resultant correlation was still negative. Corroboration of this lack of a positive relationship between the two variables can be demonstrated clearly in the rural district of Gwyfrai:

Period	The average standardised death-rate per 1000	Population more than two in a room %
1911-1914	1.927	4.2
1921-1924	2.148	2.2
1927-1930	2.338	2.9

The mortality from phthisis in this district is amongst the highest in Wales, yet the indices of overcrowding are superior to the general standard.

SIZE OF FAMILY

Reference has been made by many investigators to the unsatisfactory nature of the diet in these parts of the country where the phthisis incidence is excessive. To what extent is under-nutrition and dietetic maladjustment a factor in the progress of the disease? We have no quantitative nor qualitative data in the present instance to assess the importance of under-nutrition, but we can make a rough approximation. If we suppose that the number of children under 16 years of age per family is a measure of the strain on the family income, then we should expect that those areas with the largest families would show phthisis rates in excess of the average. This line of argument assumes an equality of income, but in a country like Wales where the dominating occupations are mining and small farming the assumption may not be unreasonable. In the 1921 census the average number of children under age 16 per family was stated for the individual counties, and the correlation was calculated between these averages and the standardised death-rates from

phthisis at age 5 and upwards in the urban and rural divisions of the counties for the period 1921–1924. The values found were:

Urban	Rural
$r = -0.466 \pm 0.218$	$r = -0.745 \pm 0.123$

The high negative coefficients, indicating a decreased mortality where the families are large, are surprising and no explanation suggests itself.

CONCLUSIONS

1. The mortality from phthisis is much higher in Wales than in England, and the difference is not due to any diagnostic differentiation as the incidence of all other forms of respiratory disease is also greater in Wales. The disparity in the mortality of the two countries is most accentuated in the rural districts in which the Welsh rate during 1928–1931 was 56 per cent. in excess of that in England.

2. The age incidence of mortality changed between 1911 and 1931. During the period 1911–1914 the maximum death-rate in the county boroughs was in the age group 45–65; in the urban and rural districts, 25–45. In 1928–1931 the age group affected was 15–25 years in the urban and rural districts, and 15–45 in the county boroughs.

3. The phthisis mortality both in the urban and in the rural parts of the individual counties is correlated inversely to a fairly high degree with the migration of the population. The counties affected by emigration had, on the average, higher death-rates from phthisis, whereas those whose population was increased by immigration had a lower mortality from the disease.

4. The high phthisis mortality is mainly concentrated in four counties—Cardigan, Carnarvon, Carmarthen and Merioneth. Within these counties there are individual areas with an exceptionally high incidence, *e.g.* the rural district of Gwyfrai in Carnarvon. In this district the difference between the recorded phthisis deaths and the calculated or expected deaths in each of the four-yearly periods examined was at least seven times in excess of its standard error.

5. The mortality is practically uncorrelated with the general hygienic conditions, such conditions being measured by the mortality from all other causes of death. This absence of correlation is corroborated by the fact that in each of the four counties with an excessive phthisis death-rate, the mortality from all other causes of death, both in the all-ages group and at specific ages, is no greater than that which exists in Wales generally.

6. Overcrowding, as measured by the proportion of the population living more than two in a room (the index used by the Registrar-General), is no greater in Wales than in England, and the correlation between this variable and the phthisis mortality is negative both in the urban and rural areas of Wales.

7. Utilising the size of family under 16 as an index of nutritional sufficiency—families with a high proportion of children under this age probably experiencing a greater strain on the family income than those with a small

number—the relationship is contrary to expectation, *i.e.* where families are large the mortality tends to be low. The coefficient for the urban divisions of the counties was $r = -0.466 \pm 0.218$, and in the rural $r = -0.745 \pm 0.123$.

8. The method of assessing occupational influence was, owing to the original classification of the data, somewhat crude, but at least capable of giving partial answer. There was, however, no conclusive evidence that occupation was the sole determining consideration, because in the counties with an excessive phthisis mortality there was still an excess when the possible influence of occupation had been taken into account.

9. Finally, in certain Welsh counties, there are urban and rural areas where the incidence of phthisis is excessive. This general enquiry into the possible causative factor suggests that it is only by making such areas the units of careful *ad hoc* enquiry that the reasons for this abnormality will be identified. In any such investigations particular attention, it is believed, should be paid to the anthropological characteristics of the populations since, in the present study, such factors as overcrowding, size of family as an index of nutrition, and occupation have not been shown to be a satisfactory explanation of the high phthisis mortality.

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